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ARCHITECTURAL IMPACT of 19th-CENTURY FIRE REGULATIONS: A Case Study of New York Tenement Houses

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Research Article

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Abstract

The primary concern for fire safety is the correct design of fire escape routes that enable users to safely exit in case of a fire. Besides cultural, social, and economic influences, the impact of historical fires and regulations established over time should also be considered in architectural design. The term "tenement house" refers to rental worker housing that emerged during the Industrial Revolution, particularly in England and other industrial cities. These structures initially spread without proper planning, resulting in overcrowded living conditions for large families in inadequate spaces. Moreover, the 19th-century fires caused substantial damage and loss, necessitating a design re-evaluation. Fire data related to worker housing underscores the risks of living in crowded spaces without fire escape routes and inadequate fire-resistant materials, which can lead to severe damage and fatalities in potential fires. The scope of the study involves examining the fires that occurred in 19th-century New York rental worker housing and exploring how changes in municipal construction laws due to these fires have influenced architectural design. The study examines reports from municipal inspection commissions, construction laws and regulations, books by social journalists and documentarians of the era (such as Jacob Riis), and historical newspapers like The New York Times to reveal changes in architectural design. It aims to highlight the impact of mandatory laws and standards during the building design phase. This article provides a foundation for future research, assessing how regulations and laws have influenced architectural design over approximately 100 years.

Keywords: New York Tenement Houses, fire-safe design, 19th-century fire regulations, tenement housing acts.

19. Yüzyıl Yangın Yönetmeliklerinin Mimari Tasarım Üzerindeki Etkisi: New York Kiralık Konutları Örneği

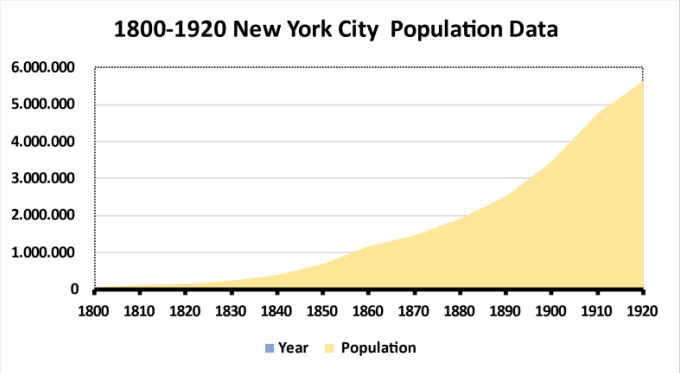
Özet

Yangın güvenlikli yapılarda gözetilmesi gereken hususlardan en önemlisi, yangın durumunda sağlıklı bir şekilde yapı dışına ulaşılmasını sağlayacak yangın kaçış yollarının doğru tasarlanmasıdır. Kültürel, sosyal ve ekonomik gelişmelerin yapı tasarımına farklı etkileri olmakla birlikte meydana gelen yangınlar ve sonrasında oluşturulan yönetmelik ve standartların yapı tasarımındaki etkisi de önemli görülmektedir. Sanayi Devrimi'nin etkisiyle ortaya çıkan işçi sınıfının başta İngiltere olmak üzere diğer endüstri kentlerine yoğun göç etmesiyle ortaya çıkan kiralık işçi konutlarına "tenement house" denilmektedir. Başlangıçta plansız olarak yaygınlaşan bu yapılar; hacim ve nitelik olarak yetersiz alanlarda kalabalık ailelerin bir arada yaşamasına neden olmuştur. Ayrıca 19. yy'da bu yapılarda çıkan yangınların meydana getirdiği hasarlar ve kayıplar yapıların tasarımlarının gözden geçirilmesini gerekli kılmıştır. Yangın gibi önemli bir afet açısından değerlendirdiğimizde işçi konutlarına ait yangın verileri kalabalık nüfusların; dar, yangın kaçış yollarının olmadığı ve malzemesinde yangın dayanımının gözetilmediği mekânlarda yaşamanın, olası yangınlarda ciddi zararlara ve ölümlere neden olabileceğini göstermektedir. Çalışmanın kapsamını 19.yy'da New York kiralık işçi konutlarında çıkan yangınlar ve bu yangınlara bağlı olarak belediye yapım yasalarındaki değişimin mimari tasarım üzerindeki etkisinin irdelenmesi oluşturmaktadır. Çalışmada, dönemin belediye komisyon raporları, yapım yasa ve yönetmelikleri, dönemin sosyal gazeteci ve belgeselcilerinin (Jacob Riis gibi.) hazırladığı kitaplar, The New York Times gibi konuya ilişkin tarihi gazeteler incelenerek tasarıma yönelik meydana gelen değişiklikler ortaya koyulmuştur. Çalışma ile binaların tasarım aşamasında kullanımı zorunlu olan yasa, yönetmelik ve standartların mimari tasarım sürecine olan etkisinin ortaya koyulması amaçlanmaktadır. Bu doğrultuda makale, sonrasında yapılacak çalışmalara bir altlık olabilecek, yönetmelik ve yasaların mimari tasarıma etkisini ortaya koyacak, yaklaşık 100 yıllık bir sürecin değerlendirmesini içermektedir.

Anahtar Kelimeler: New York Kiralık İşçi Konutları, yangın güvenlikli tasarım, 19. yüzyıl yangın yönetmelikleri, kiralık konut yasaları.

1. INTRODUCTION

The concept of “tenement” originated in the Middle Ages in the Europe of Ancient Rome, referring to multi-story residences containing numerous small and large apartments (Bogatan, 2014). In 19th-century New York, however, the term “tenement house” was applied to houses constructed for millions of impoverished immigrants. The population of New York State, influenced by the Industrial Revolution, increased approximately two-fold every 20 years from the 1800s, reaching approximately 5.0 million people by the decade of the 1910s (Figure 1), (URL-1).



Year	Population
1920	5.621.000
1910	4.767.000
1900	3.437.000
1890	2.507.000
1880	1.912.000
1870	1.478.000
1860	1.175.000
1850	696.000
1840	391.000
1830	242.000
1820	152.000
1810	120.000
1800	79.000

Figure 1. New York City Population Data (URL-1)

In the 1850s, the area known as Manhattan’s Lower East Side housed half of New York City’s population (URL-1). This neighborhood was constructed during the 19th century and remains a popular destination for immigrants, particularly those from low-income families. The concept of tenement housing also originated in this area.

The rooms within tenement housing units, where families resided, typically measure approximately 30 square meters and are characterized by single-chambered spaces where sleeping, living, heating, and cooking functions coexist (Figure 2). Even in the modern era, the term “tenement” is utilized in the United States to describe inadequately maintained buildings. Such structures frequently feature combined living and sleeping areas, insufficient sanitary amenities, neglected circulation spaces, and a dearth of fire escape routes (Bogatan, 2014).

Figure 2. Restored Tenement Apartment Photos from “New York Tenement House Museum” (URL-2)

The main goal in constructing these tenement housing units was maximum occupancy, often overlooking architectural design. They featured single-room layouts for all functions. In the 19th century, this design led to numerous devastating fires, often caused by stoves used for heating and cooking. These fires damaged structures and cost lives, exacerbated by combustible materials, narrow corridors, ground-floor tenements, gas lamps, and wooden staircases. However, the true underlying cause was a failure to evolve architectural design in step with the growing demand for tenement housing units. It was critical to recognize the connection between fire damage and designs that overlooked user and fire safety, as well as the construction laws of the time. Understanding how

housing design evolved after each legislative update is also key to grasping the impact of regulations and laws on architectural design.

2. THE EMERGENCE OF FIRE RISK IN TENEMENT HOUSING AND THE HOUSING REFORM PROCESS

The New York housing reform movement began around 1834 and gained significant momentum after Dr. John H. Griscom's 1842 study as the City Health Inspector. In his report, titled "A Brief Examination of the City's Sanitary Condition", Griscom highlighted the poor living conditions, the influx of immigrants between 1810-1838, and the spread of diseases. This report led to a new housing act proposed to the City Legislative Council. The law prohibited living in cellars, required landlords and tenants to maintain indoor and outdoor spaces free from harmful elements, and introduced occupancy limits in dwellings (Veiller, 1900a; pp.5-20).

Looking at the period before the first legal commission in 1856; In the 1830s, wealthy homeowners living in New York's Lower East Side began to move further north, leaving behind their low-rise, masonry houses, and immigrants who came to the region in this process settled in these vacated houses (Palaiologou, 2014; p.3).

As immigration continued to increase the population between 1830 and 1860, the demand for tenement housing also rose. However, finding vacant land for new construction proved to be a challenge, resulting in the division of apartments within these masonry houses originally meant for single families. Consequently, more units were created on the same floor, and rooms were rented individually. As the existing structures and divisions became inadequate, starting in the 1850s, additional buildings were constructed in the rear yards within the boundaries of the existing property (Figure 3), (Riis, 1890; p.9).

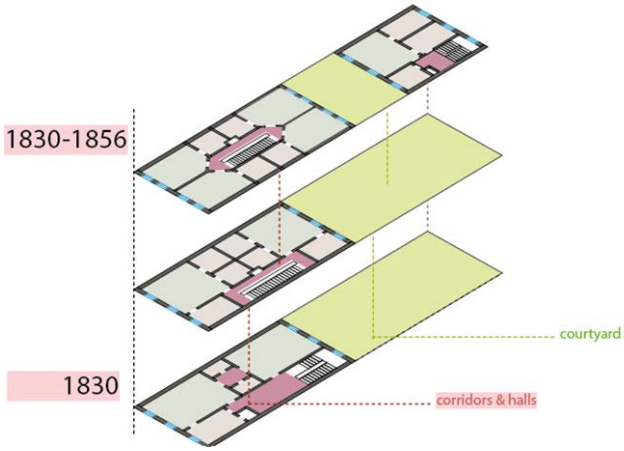


Figure 3. The Change in Tenement House Plans in Lower East Side, New York, 1830-1856 (adapted by authors - URL-19)

In that era, tenement housing underwent significant structural changes, resulting in confined spaces with subpar sanitation, lighting, and multifunctional sleeping, cooking, and living areas. Consequently, families with up to 10 members were compelled to cohabit in a single area. Furthermore, the population density in the Lower East Side surged to approximately 46,000 individuals per square kilometer in the 1840s, prompting a need for housing reforms during that time (URL-3).

In 1853, a committee was created to examine the state of tenement apartments. Their findings unveiled that roughly 1,200 tenement housing units in New York had poor living conditions and low quality of life. These units were inhabited by families with 8 to 10 members (Veiller, 1900a; p.9).

During that time, people not only tenement housing units but also used cellars and basements as living spaces. A report from the Health Inspectorate in 1842 revealed that 1,500 cellars were inhabited by 7,200 individuals. By 1856, the number of used spaces and the population living in them had tripled compared to earlier figures (Veiller, 1900a; pp. 5-7).

The primary reasons for the commission's examination reports focusing on issues within tenement cellars and basement apartments in terms of fire risk are as follows:

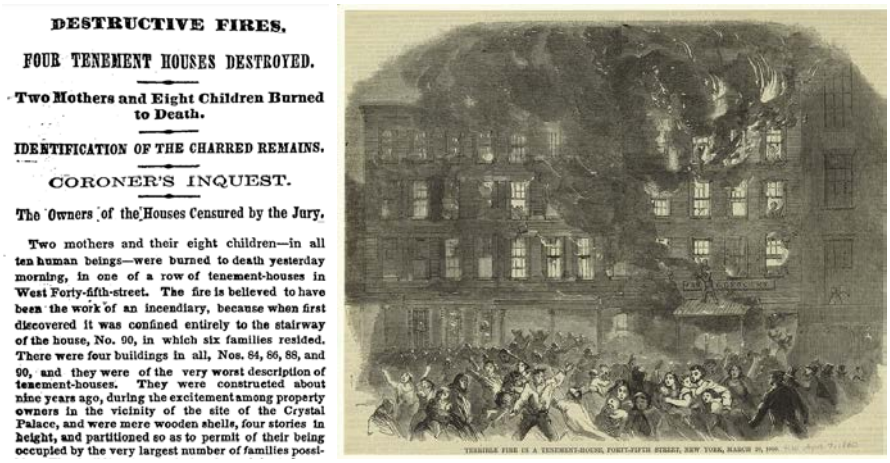
• Basement levels being situated below ground level without windows for lighting and ventilation,

• The use of spaces such as cellars/basements for both storing combustible materials such as wood, coal, and flammable oils and as living spaces, which pose fire and similar risks,

• In these dimly lit spaces, the escape corridors are narrow and unlit (Veiller, 1900a; p.11).

2.1. 1860-67 Tenement Houses Fires

In the aftermath of the commission's investigation into the adverse conditions of tenement housing in 1856, a fire broke out on February 2, 1860, at 142 Elm Street, in the basement of the building between 7:00 PM and 8:00 PM. This fire resulted in the burning of a six-story building, where 24 families resided, and claimed the lives of 30 individuals. The incident, which occurred in a narrow street characterized by wooden structures and densely populated tenement apartments where large families coexisted, was reported in The New York Times on February 3, 1860, under the headline "Calamitous Fire". The wooden staircases within the building had been consumed by the fire, rendering escape impossible, while the firefighting teams' ladders only reached up to the fourth floor. (URL-9). Another fire occurred on March 9, 1860, on West 45th Street, destroying four adjacent wooden tenement housing units and caused significant losses (Figure 4), (URL-10).



DESTRUCTIVE FIRES.

FOUR TENEMENT HOUSES DESTROYED.

Two Mothers and Eight Children Burned to Death.

IDENTIFICATION OF THE CHARRED REMAINS.

CORONER'S INQUEST.

The Owners of the Houses Censured by the Jury.

Two mothers and their eight children—in all ten human beings—were burned to death yesterday morning, in one of a row of tenement-houses in West Forty-fifth-street. The fire is believed to have been the work of an incendiary, because when first discovered it was confined entirely to the stairway of the house, No. 90, in which six families resided. There were four buildings in all, Nos. 84, 86, 88, and 90, and they were of the very worst description of tenement-houses. They were constructed about nine years ago, during the excitement among property owners in the vicinity of the site of the Crystal Palace, and were mere wooden shells, four stories in height, and partitioned so as to permit of their being occupied by the very largest number of families possi-

Figure 4. March 9, 1860, New York Times Newspaper (URL-10), and the Sketch Depicting the Fire (URL-17)

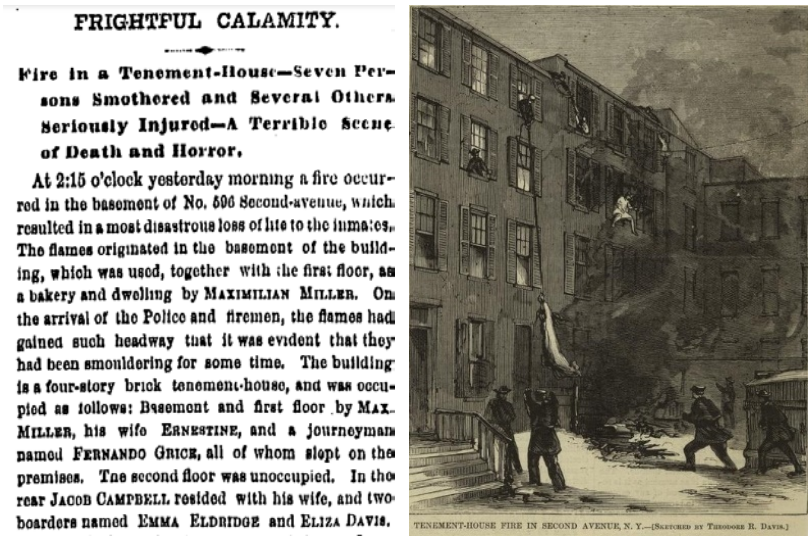
In this time period, tenement housing units were constructed on plots measuring approximately 7.6 meters in width by 30.5 meters in length. In the case of the four houses where the fires occurred, they were built across three parcels. These houses featured entranceways of approximately 1.20 meters in width, and the staircases were constructed from wooden materials, not exceeding 60 cm in width. Unfortunately, this meant that in the event of a fire, occupants were left with no alternative but to escape through the windows.

During the period before the intervention of rescue teams, a significant portion of the fatalities resulted from the smoke generated by the fire. As a consequence of the staircases being engulfed in flames, many individuals attempted to escape the fire by jumping from windows, resulting in severe injuries upon discovery. In total, 10 lives were lost in the fire, including two women and eight children (URL-10).

Examining the period before the "First Tenement Housing Act" of 1867 reveals that laws concerning fire escapes were being discussed. On April 17, 1860, the New York Building Act became the first law to include the mandatory provision of "fire escapes for all tenement housing units". In 1862, an additional law was enacted, stipulating the following conditions for buildings with a height exceeding 40 feet (approximately 12 meters, averaging four-story structures) and with more than eight families residing above the ground floor:

• The addition of fire escapes connected to the front facade, providing refuge for tenants.
• The presence of fire escape balconies made of non-combustible material, interconnected by metal fireproof stairs on the exterior of the building, along with interconnecting doors between rooms on the same floor for access to escape routes.
• Requirement for continuous corridors within the building to have unobstructed access to openings with dimensions no less than 60 cm x 90 cm leading to the roof (Spivack, 2016; pp. 34-36, Veiller, 1900b; p.12).

Another fire incident during the period of 1860-1867 occurred on December 16, 1867, at 596-2nd Avenue. The four-story building made of masonry brick and wood, was used for tenement housing and had a bakery on the basement and ground floor. The fire started at 2:00 AM (Figure 5). The wooden staircase quickly burned, forcing people to escape through windows. Some jumped, while others on the upper floors were stranded as the rescue ladder reached only the 4th floor (URL-11). Investigation revealed non-compliance with 1860 fire safety rules, including no fire escape, a weak roof ladder, narrow halls, and flammable materials, contributing to tragic loss of life.



FRIGHTFUL CALAMITY.

Fire in a Tenement-House—Seven Persons Smothered and Several Others Seriously Injured—A Terrible Scene of Death and Horror.

At 2:15 o'clock yesterday morning a fire occurred in the basement of No. 596 Second-avenue, which resulted in a most disastrous loss of life to the inmates. The flames originated in the basement of the building, which was used, together with the first floor, as a bakery and dwelling by MAXIMILIAN MILLER. On the arrival of the Police and firemen, the flames had gained such headway that it was evident that they had been smouldering for some time. The building is a four-story brick tenement-house, and was occupied as follows: Basement and first floor by MAX. MILLER, his wife ERNESTINE, and a journeyman named FERNANDO GRICK, all of whom slept on the premises. The second floor was unoccupied. In the rear JACOB CAMPBELL resided with his wife, and two boarders named EMMA ELDRIDGE and ELIZA DAVIS.

TENEMENT-HOUSE FIRE IN SECOND AVENUE, N. Y.—[SKETCHED BY THEODORE R. DAVIS.]

Figure 5. December 17, 1867, New York Times Newspaper Fire (URL-11), and the Sketch Depicting the Fire (URL-18)

3. 1867 THE FIRST TENEMENT HOUSE ACT

In the 1835s, health inspectors documented the dire living conditions plaguing the Lower East Side. This spurred the Association for Improving the Condition of the Poor to commission research reports, which coincided with a rash of tenement housing fires. As a result, legal regulations were implemented. In 1866, the Metropolitan Board of Health was established, and the first tenement housing act was passed the following year. This law defined “tenement house” as “apartments where three or more independent families reside and can prepare their own meals” (Veiller, 1900a; p.17). The law required all existing and future houses constructed before July 1867 to meet specific criteria in order to be categorized as “tenement house”. Among other things, tenement housing units had to be equipped with approved fire escapes, as inspected by building officials (Veiller, 1900b; p.13).

The 1867 law introduced certain conditions regarding ventilation and lighting. It was expressly forbidden to occupy cellars that did not meet the required standards for light and air. However, in basement levels where some degree of air and light could be provided, their use as tenement housing was permitted. According to the law, cellars were defined as spaces where more than 50% of the facade height was situated below street level, while basement levels were those where more than 50% of the facade height was positioned at or above street level (Spivack, 2016; p.69).

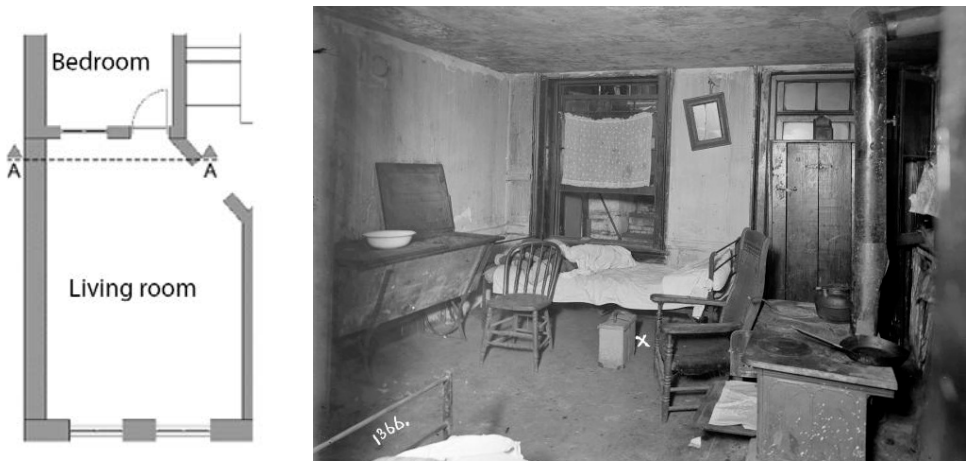
This legislation aimed to regulate the use of spaces like basements/cellars, which were the initial focus of the 1856 Legal Commission’s inquiries into tenement housing. It specified that basement levels could not be used as sleeping quarters without the Board of Health’s approval. To obtain this approval, rooms needed a minimum height of 2.1 meters, with ceilings elevated at least 30 cm above ground level (Veiller, 1900a; p.18).

In the 1867 law, the fundamental issues addressed from the perspective of health and fire risks include:

- Tenement housing units having poorly ventilated interior rooms,
- Hallways and staircases being inadequately designed with materials unsuitable for escape during fire emergencies,
- The absence of additional secure fire escape routes within the building and the lack of plumbing systems in these dwellings.

When reviewing the law's provisions:

• It is required that interior rooms without windows have a minimum of a 30 cm^2 window or an opening that connects to external ventilation above the door (Figure 6 (a) and (b)).
• While specific design dimensions are not outlined, fire escape routes must be included.
• Additionally, the law mandates that stairs be properly maintained, have repaired materials, and be built with railings (Figure 7 (a) and (b)), (Veiller, 1900a; p.18).



a b

Figure 6. (a) Window plan opening from dark inner rooms to the living room (drawing by authors), and **(b)** Minimum 30 cm^2 opening above the door and minimum 0.90 m^2 window opening from the dark room to the front room (URL-4)

a b

Figure 7. (a) Historical tenement apartment interior staircase from the New York Tenement Museum (URL-2), and **(b)** Condition of keeping staircases clean according to the 1867 law (a photo of a residential interior staircase that does not meet the criteria after a fire), (Marques, 2019)

The year 1871 saw the introduction of the NYC Building Code, which was a follow-up to the 1867 law. As per this new legislation, any building with more than one family residing on a single floor and a height of over two stories was legally required to have fire escape routes, fire stairs, fire doors, and fire alarms. It also included a new provision that explicitly prohibited placing any objects on the fire escapes that could hinder evacuation. As early as 1871, it required non-combustible materials for ground floors, like basements or entry-level floors, due to their known role in fire propagation (Veiller, 1900b; p.13).

Between 1850 and 1860, rapid population growth resulted in new buildings on existing lots. Regrettably, the 1867 law did not limit land usage for these structures, despite the potential hazards during disasters like fires. This lack of regulation could be attributed to the common practice of constructing buildings with a typical height of four stories and occupying 60% of the land during that period (Veiller, 1900b; p.74).

In 1873, a fire broke out in a building that was built in the backyard of a factory. The building was originally intended to be used as a factory store but was being rented out as housing. Unfortunately, the building was constructed with wood, which was against the building code's clear stipulation that the basement and ground floors should be made with non-combustible materials (Veiller, 1900b; p.13). Furthermore, the building only had one exit point- a narrow 90 cm-wide hallway that opened onto the front facade, which posed a significant risk to the renters' safety in the event of a fire (URL-12).

According to a published article in The New York Times, on May 4th, 1874, a fire started at approximately 2:30 AM on the third floor of a three-story brick tenement building. The cause of the fire was a burning candle that fell over and ignited bedspreads and furniture coverings. This incident highlights the potential dangers of using candles for lighting in tenement housing units with narrow corridors, where fire hazards can easily occur. It is worth noting that during that era, artificial lighting was not yet widely available in residential structures (URL-13).

Between 1876 and 1879, Alfred Tredway White led design experiments to address issues with tenement housing (URL-5). The housing units known as the "Mr. White Model Houses" were thoughtfully designed to maximize natural light, and each room is equipped with its own toilet and plumbing. Shared bathrooms are situated in the basement for convenience. The buildings are arranged in a courtyard style, utilizing only 49% of the land for construction. The remaining space is dedicated to green areas, including parks and playgrounds (Figure 8), (URL-6).

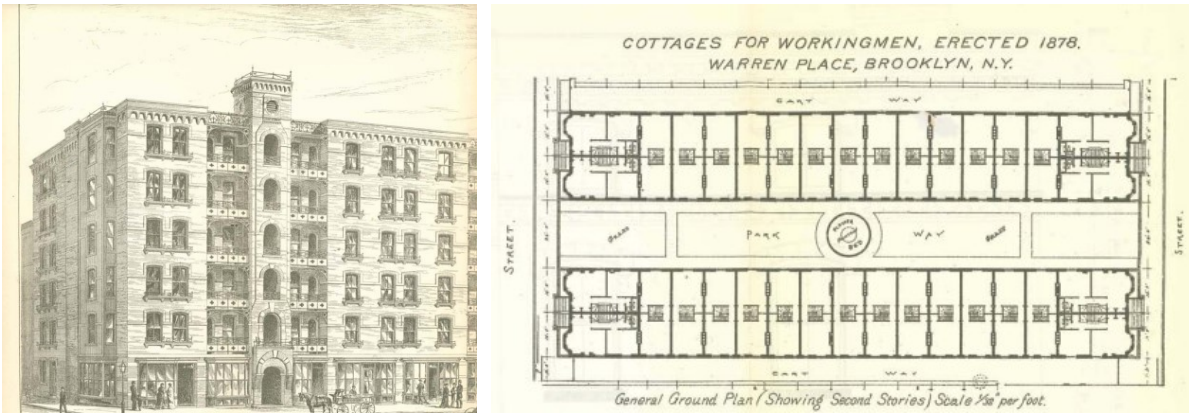


Figure 8. Mr. White Model courtyard tenement house design (URL-6)

The "Mr. White Model" for tenement housing prioritized safety at its core. Every unit was constructed with its own separate escape hall and staircase to ensure that everyone could safely evacuate in the event of a fire. This innovative model also took into account the limitations of the 1867 Tenement House Act which had no regulations regarding the percentage of land that could be used for buildings.

4. 1879 THE SECOND TENEMENT HOUSE ACT (OLD LAW)

Tenement House Act of 1901 is commonly referred to as the "new law" in literature, and it superseded the 1879 law, also known as the "old law" The 1879 law was implemented due to the increasing population density caused by migration. During the period of the 1867 First Tenement Housing Act, there were reported to be 15,000 tenement housing units, which increased to approximately 22,000 units within the subsequent 15 years, accommodating about half a million people (DeForest & Veiller, 1903b; p.77-78).

Back in 1867, the issue of ventilation was tackled by introducing interior windows into the legal framework. However, the cramped and elongated hallways connecting the lined-up rooms were incapable of providing adequate ventilation. Consequently, the 1879 law mandated the inclusion of a "ventilation shaft" to address this issue.

In December 1878, The Modern Plumber & Sanitary Engineer magazine organized an award-winning "tenement house" design competition. The competition criteria emphasized the design of non-combustible fire escapes, ventilation, and sanitary installations opening to the exterior of the building as a primary priority.

Mr. James E. Ware's winning design in the competition laid the foundation for the "dumb-bell" plan type that became prominent in the 1879 law and for which he was awarded the first prize. The proposed plan, shown in Figure 9 had a building width of 7.6 meters and a depth of 30.5 meters (DeForest & Veiller, 1903a; p.101).

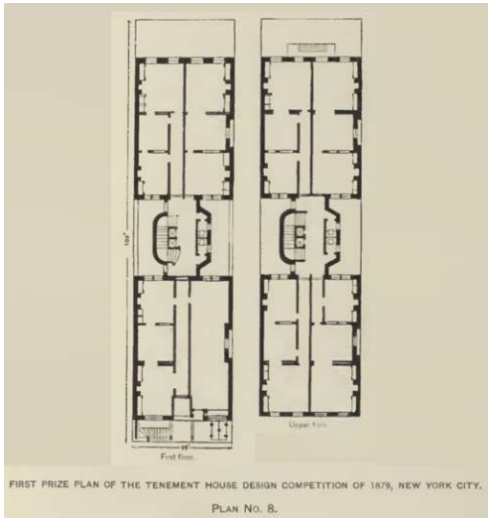


Figure 9. The award-winning plan design by Mr. James E. Ware in the competition (Gould, 1895; p.128)

Upon closer examination of the plan type, it becomes clear that having just one ventilation system, as seen in Figure 10, resulted in insufficient ventilation shafts between buildings. This approach failed to effectively address the issue of poorly lit bedrooms. Regrettably, the "1879 prophecy" only worsened the situation, as these airshafts were discovered to have a negative impact on the living conditions (DeForest & Veiller, 1903a; p.28).

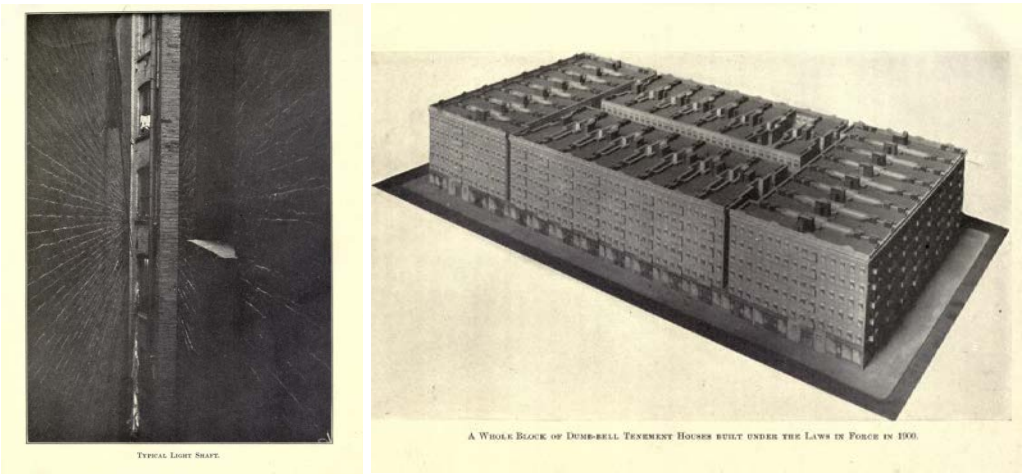


Figure 10. Narrow shafts resulting from the dumb-bell plan (DeForest & Veiller, 1903a; p.14&10)

According to historical records, the law enacted in 1867 did not provide specific guidelines for land occupancy percentage. However, in 1879, a subsequent law imposed a limit of 65% (Veiller, 1900b; p.74).

When looking at the fire incidents of the era, sadly, on the night of November 26, 1881, a fire broke out in a three-story wooden addition located within a tenement property courtyard. The incident caused significant property damage and loss of life due to the building's construction with wood and limited access to the main street for fire escape (URL-14).

In the examined fire reports, it has been observed that the lack of development in building design parallel to the increasing population can lead to fatal consequences in the event of a fire. On August 29, 1884, a blaze of unknown cause erupted on the fourth floor of a five-story tenement building at around 02:15 AM. The building accommodated 71 people, including 38 children and 13 families, but the escape routes proved insufficient during

the fire. Some occupants tried to flee through the windows using fire escapes, while others used the roof or interior stairs (URL-15).

On the evening of May 24, 1885, at around 9:00 PM, an instance of fire outbreak occurred in a five-story building where nine families resided. It was indicated that the fire originated on the second floor due to the explosion of a gas lamp. The fire subsequently extended to the upper floors through the chimney shafts, enveloping the entire building. Residents on the lower floors utilized the fire escape stairs located at the rear facade to evacuate the building, while those on the upper floors accessed the roofs of adjacent houses, thus escaping the fire. The fact that the timing of the fire's outbreak did not coincide with bedtime hours also played a significant role in preventing fatalities (URL-16).

4.1. 1901 New Tenement House Act Preparation Period

The 1901 legislation marked the end of a process that began with the 1856 legal commission. In 1884, a second commission investigated tenement houses, leading to height limits of 21.3 meters in 1885 and 24.3 meters in 1887. In 1897, new regulations linked the maximum height of fire-resistant buildings to street width: over 24 meters allowed up to 46 meters, while under 24 meters limited it to 30.5 meters (Figure 11), (Veiller, 1900b; p.57).

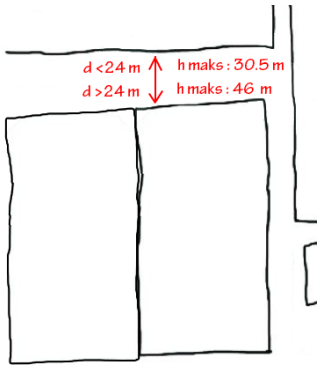


Figure 11. Building height criteria based on the width of the street the facade faces in 1897 Regulation (drawing by authors)

In 1899, buildings could reach 26 meters if the first and second floors used fire-resistant materials. If only the first floor met this standard, the limit was 23 meters. Full fireproof construction allowed a remarkable 46-meter height (Figure 12), (Veiller, 1900b; p.58).

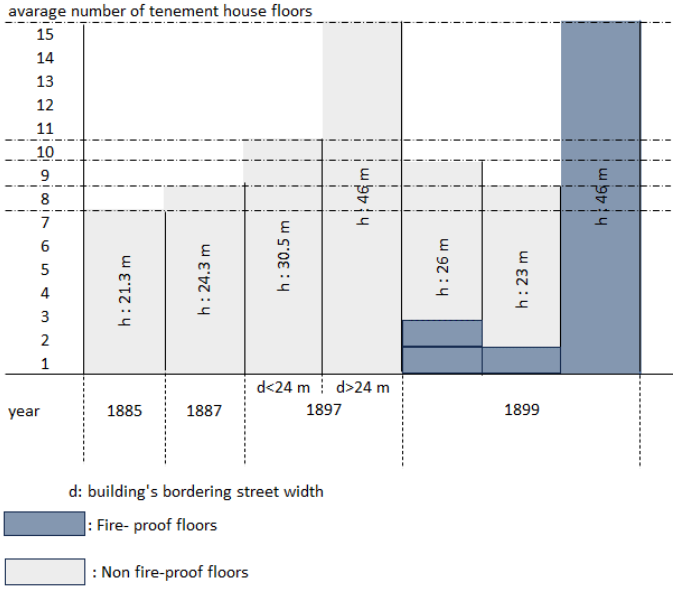


Figure 12. The maximum building height criteria based on the width of the facade and fire-resistant floor design (drawing by authors)

One of the primary challenges that tenement housing often faced issues when secondary structures were built on the same land. Maintaining a minimum gap between these structures for proper ventilation and light was crucial. Specifications dictated gaps of 3 meters for single-story, 4.5 meters for two-story, 6 meters for three-story, and 7.5 meters for taller buildings (Veiller, 1900b; p.65).

In May 1894, a third legal commission was formed to assess tenement housing safety. They examined 8,441 homes, especially those with basement apartments, focusing on fire risks. Their findings highlighted the connection between poor living conditions and fires, leading to recommendations: raising basement apartments at least 60 cm above the ground and adding artificial lighting in hallways for safety.

According to examinations conducted by the Tenement Housing Commission, it was observed that the vast majority of fires during that period originated from the frying oils used in basement areas for baking bread. To enhance building safety, it became mandatory to block access from areas where frying occurred to the tenement apartments, used for residential purposes via hallways. This was achieved by installing fire-resistant partition walls to close off such passageways (Veiller, 1900b; p.62).

To reduce fire risks, it was crucial to understand their spread, implement safety measures in high-risk areas, and set robust construction standards for new tenements. To this end, an investigation was carried out on fires that transpired during the first half of 1898-1899-1900, culminating in a thorough report. The report revealed that over this period, a total of 16,948 fires had occurred, with nearly half of them (47%, or 7,943) transpiring in tenement housing. Among these fire incidents, roughly 4% were designated as significant fires that fully engulfed the entire structure (Table 1), (DeForest & Veiller, 1903a; p.264).

Table 1. The analysis of fires that occurred in tenement housing between 1898 and 1900 (the first 6 months of 1900). (DeForest & Veiller, 1903a; p.264)

TENEMENT HOUSE FIRES IN GRATER NEW YORK - 1898-1900

DATE	Region	Total Fires	Total Tenement Fires	%	Tenement Fires			Course of Fire Through Buildings in the Extended Fires																			
					Confined to Point of Starting	Extended through Building	%	Light Shafts		Dumb-walter and Elevator Shafts		Halls and Shafts		Shafts and Stairs combined		Partitions and Flooring		Space around Pipes		Windows (out-side of building)		Other ways		Not recorded
								Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total
1898	Manhattan and Bronx…	4.239	2.220	52	2.142	78	4	25	36	8	11	7	10	0	0	15	21	4	6	1	1	10	14	8
	Brooklyn and Queens…	2.203	623	28	599	24	4	6	26	2	9	4	17	3	13	5	22	0	0	1	4	2	9	1
	Total…	6.442	2.843	44	2.741	102	4	31	33	10	11	11	12	3	3	20	22	4	4	2	2	12	13	9
1899	Manhattan and Bronx [2]…	4.872	2.551	52	2.445	106	4	18	19	10	10	25	26	3	3	18	19	10	10	9	9	4	4	9
	Brooklyn and Queens…	2.660	930	35	888	42	5	14	34	2	5	11	27	0	0	11	27	0	0	2	5	1	2	1
	Total…	7.532	3.481	46	3.333	148	4	32	23	12	9	36	26	3	2	29	21	10	7	11	8	5	4	10
1900 [1]	Manhattan and Bronx…	2.974	1.619	54	1.540	79	5	13	20	7	11	12	18	8	12	21	32	0	0	3	5	1	2	14
	Total…	16.948	7.943	47	7.614	329	4	76	26	29	10	59	20	14	5	70	24	14	5	16	5	18	6	33

1: first six months 2: Eleven months

After analyzing the information provided in the table, it was found that 25% spread from shafts, 20% from corridors and staircases, and another 25% from floors and ground levels. Consequently, it has been concluded that fire shafts pose the greatest danger during such events, and it is recommended that they be banned (DeForest & Veiller, 1903a; p.265).

According to fire data for the 11-month period in 1899, despite “tenement house” constituting 37% of the regional building stock, 52% of the reported fires occurred in these structures. When considering the entire city, “normal housing with less than three families” makes up 42% of the buildings, yet the fire incidence rate in these buildings is only 14%.

In order to emphasize the importance of fire-resistant corridors and staircases, two fires were examined within 24 hours. The first occurred in a 25-year-old tenement with wooden hallways, stairs, and partitions, tragically causing 11 deaths and 5 injuries as the fire rapidly spread, trapping tenants. Contrastingly, the second fire occurred in a building that was constructed in 1899, with non-combustible staircases and hallways. Doors separated the common corridor from individual floor hallways. Despite this happening at night, with the fire spreading from the first floor to the roof, only one person lost their life due to smoke exposure (Bonner & Veiller, 1900; p.12).

Upon analyzing the fires that took place in June 1900, it was noticed that the main reasons behind these incidents were careless handling of matches, faulty gas lamps, objects such as clothing and furniture being too close to stoves, and the ignition of piled up garbage in basements, as stated in Table 2 (DeForest & Veiller, 1903a; p.265).

Table 2. Analysis of the causes of tenement housing fires that occurred in June 1900 (DeForest & Veiller, 1903a; p.266)

TENEMENT HOUSES FIRES - THE MONTH OF JUNE 1900																											
DATE	Region	Total Tenement Fires	Careless Use of Matches		Clothing and Furniture Too Near Stove		Carelessness With Candle		Cellar Rubbish Igniting		Gas Explosion		Bedding and Sofa Fires		Foul Chimney		Fire-Crackers		Upsetting of Kerosene Lamp		Gas Jet		Fat Boiling		Electric Wire & Incendiary & Spark From Locomotive		Not Known	
			Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
1900 *	Manhattan and Bronx…	235	32	14%	22	9%	18	8%	13	6%	11	5%	11	5%	10	4%	6	3%	4	2%	5	2%	3	1%	3	1%	97	41%
* : Fires in tenement houses the month of June 1900																											

Historical records show that fires have been a common occurrence in basements, cellars, and ground-floor shops. Yet, another factor contributing to fire outbreaks is the use of matches in poorly artificial lighting hallways and corridors during nighttime. In the early 1900s, a total of 1619 fires were reported, with 53% occurring during the day and 47% occurring at night (Figure 13), (DeForest & Veiller, 1903a; p.267).

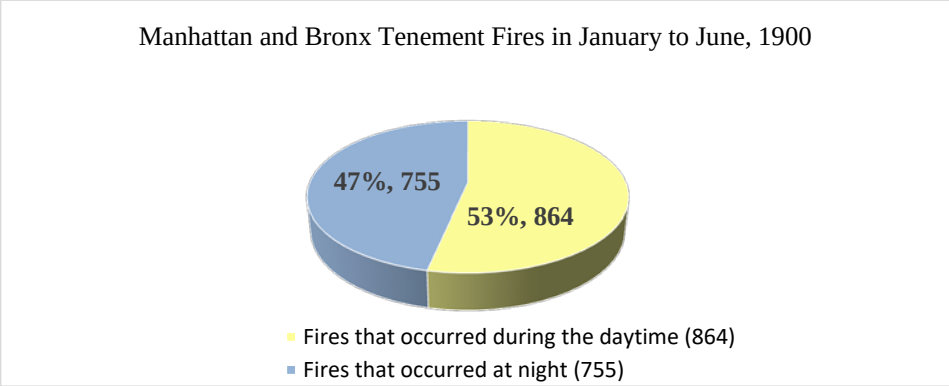


Figure 13. The ratio of day and night fires in tenement houses for the first 6 months of 1900

5. 1901 TENEMENT HOUSE ACT (NEW LAW)

In the 1890s, there were 37,358 tenement house units in the Lower East Side, with around two-thirds of the population (approximately 1.2 million people) living in these tenement units. Due to the rapid population growth, additional construction within parcels became evident, with buildings occupying around 90% of the parcel area. It has been documented that 2,391 of the 37,358 housing units were comprised of additional structures built in the rear courtyards. The new constructions carried significant risks in the event of a fire disaster. The 1901 law, known as the New York State Tenement House Act of the Progressive Era, prohibited the construction of dumbbell-shaped buildings and established optimal design conditions for tenement housing. Additionally, the legislation mandated regulations concerning the design and lighting of staircases and corridors, particularly in relation to fire escape routes. The law required that fire escape routes be arranged on both sides of the building, providing access from all units to the ground. Moreover, fire escape stairs had to be open steel/iron staircases on the facade, interconnected between floors via balconies (Figure 14), (DeForest & Veiller, 1903b; p.170).

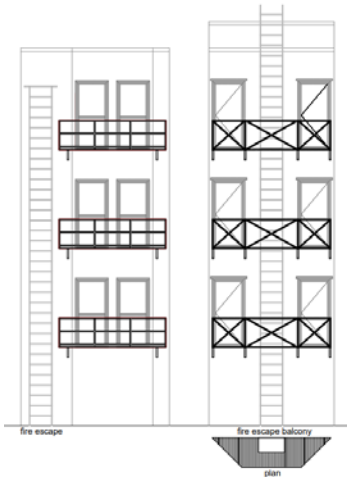
Figure 14. Fire escape balconies before the 1901 law and "Z-shaped metal stairs" after the act. (DeForest & Veiller, 1903a; p.278 & 287)

It was explicitly stated that, prior to this law, buildings constructed earlier should also have fire escape staircases added, providing access to each apartment. It was also noted that wooden balconies or staircases would not be considered part of the fire escape route and must be replaced with steel or iron counterparts (DeForest & Veiller, 1903b; p.173).

According to recent legislation, balconies must meet certain requirements. Specifically, the balcony must be at least 90 cm wide and feature an opening or window on the balcony flooring that connects it to the floor below. Furthermore, the balcony flooring must consist of steel or iron slats and the access opening to the floor below must remain unsealed at all times, in accordance with the guidance (DeForest & Veiller, 1903b; p.170).

A regulation was implemented mandating tenement dwellings to have a courtyard at the back, covering the entire width of the property. Consequently, newly constructed homes were restricted from occupying their entire space. For corner parcels, the maximum occupancy was capped at 90%, while mid-block parcels were limited to 70% (DeForest & Veiller, 1903b; p.178).

In accordance with the latest regulation, fire escape stairs that are fixed, located at the balcony's edge, and at a specific distance from the balcony are no longer considered suitable for use during a fire incident because they can hinder escape speed. Such stairs are only permitted in buildings with a small number of occupants and low-rise structures, as illustrated in (Figure 15-a). Conversely, the straight inter-floor staircase system was prohibited by the 1901 law as it poses difficulty during fire emergencies, particularly for children and women in panic situations, as shown in (Figure 15-b).



a b

Figure 15. (a) Fixed fire escape staircase model on the balcony edge (Andre, 2006; p.144), and **(b)** Fire escape staircase model connecting between floors through balconies (Andre, 2006; p.133)

In the early 1900s, the New Law era saw the implementation of a courtyard plan aimed at enhancing fire safety and promoting a balanced distribution of building density. The innovative floor plan featured separate fire escape staircases for every unit, replacing the earlier narrow, long, and poorly lit corridors. Instead, a building core strategy was implemented, prioritizing fire-resistant stairs and flooring, complemented by artificial lighting.

Prior to the implementation of the 1901 Tenement House Act, tenement units in New York's grid-based urban planning underwent various design changes.

These changes included:

- Repurposing standalone houses by adjusting internal staircases and partitioning rooms,
- Constructing additional rear structures within courtyards to meet population needs,
- Increasing building areas up to 90% within parcels,
- Creating narrow and dark internal corridors to reach all rooms as tenement unit numbers grew,
- Adding fire escape staircases on a single façade due to insufficient internal corridors for fire escapes, and
- Implementing the "dumb-bell plan" to reduce parcel occupation ratios and create inner courtyards.

However, post 1901, a new approach to tenement unit design emerged, characterized by a courtyard/open space planning, separate fire escape stairs serving each unit, and the merging of two parcels in the grid system to design tenement units (Figure 16).

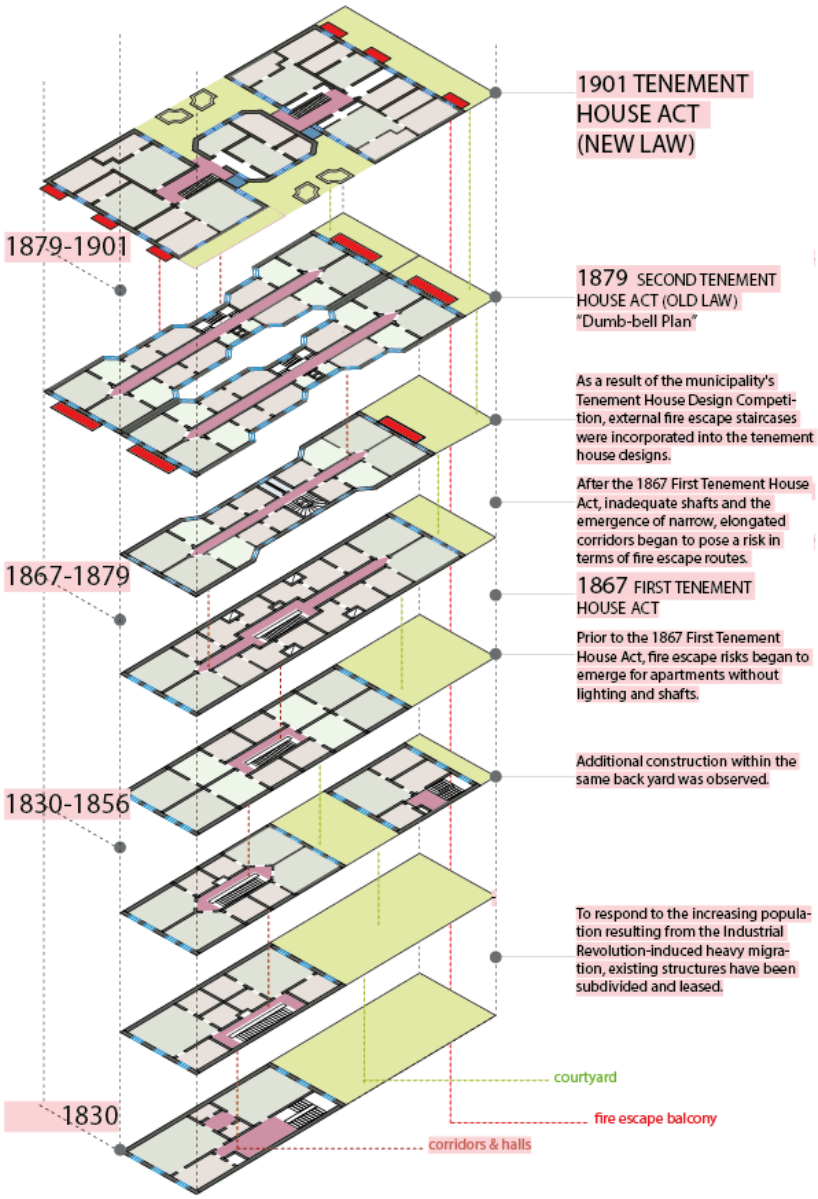


Figure 16. The architectural changes of tenement houses until the period of the 1901 New Law (adapted by authors - URL-19)

The 1901 law marked the onset of an urban renewal process, where old tenement houses were demolished, and new ones were constructed. The house design defined in the 1901 tenement house act can be examined in more detail through Jonah Coe-Scharff's model drawings (Figure 17).

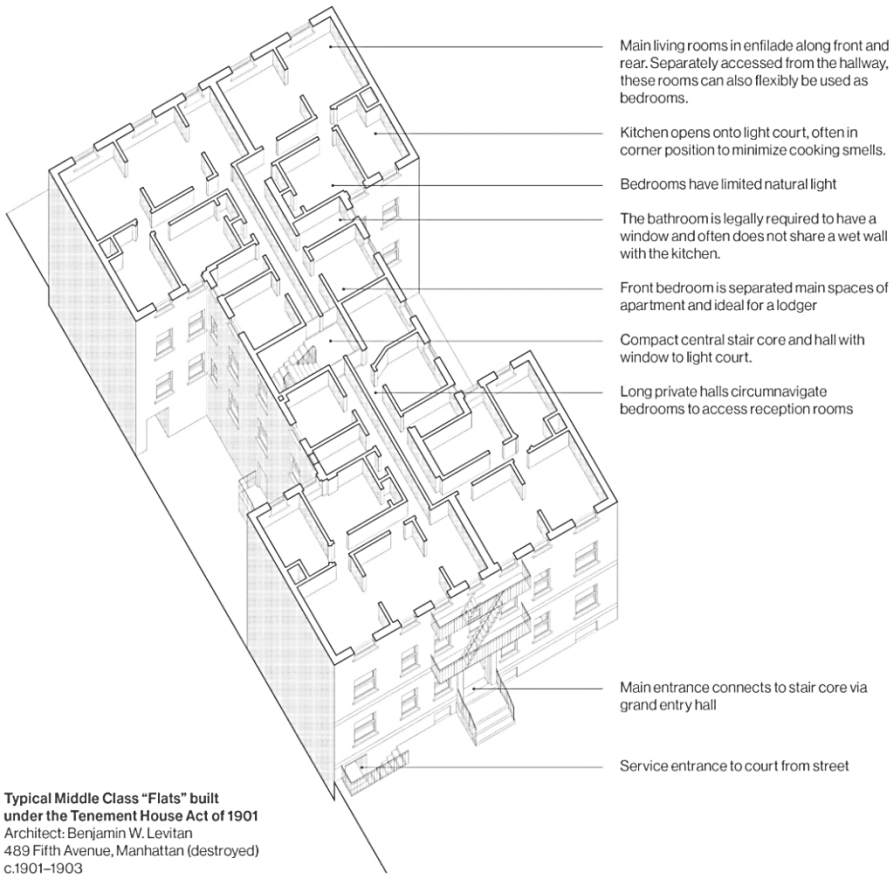


Figure 17. Model of Tenement House under the Tenement House Act of 1901 (URL-7)

In 1901, the New Law mandated the installation of fire escape stairs on building facades for each unit. The crowded populations viewed these spaces as additional volume. However, it was discovered that in the event of fires, the building material, design dimensions, and misuse of these spaces had material and fatal consequences.

Simplifying the main aspects of tenement housing acts and their fire safety measures into a single table, similar to Table 3, provides a clear timeline of the changing regulations in New York City. The table offers a chronological perspective on the development of fire safety regulations in response to the challenges posed by tenement housing, ultimately encompassing the provisions that influenced housing design.

By the 1930s, new legal regulations and fire department reports revealed that metal/iron fire escape stairs were no longer a safe means of escape. The 1929 "Multiple Dwelling Law" introduced new provisions that were the initial steps toward modern fire escape routes.

This law has several provisions included:

• For tenement apartment buildings that are taller than two stories, a minimum of two independent exits is required.
• In addition, the hallways for fire escape must have a minimum width of 90 cm.
• The construction of partition walls in these hallways must be made of standard fire-resistant bricks and have a minimum width of 10 cm, capable of withstanding a 3-hour fire test.
• Lighting must also be installed in the hallways, with a minimum of 15 watts every 6 meters.

This law passed in 1929, marked a significant development in fire escape staircases as they evolved into not only an additional metal/iron structure but also as a hallway and "escape route" within the building (URL-8).

Table 3. Evolution of Tenement Housing Laws and Fire Safety Provisions (reproduced by authors)

Year	Legal Regulation	Fire-related provisions
1867	The First Tenement House Act	* Tenement housing units must have approved fire escapes (dimensions were unspecified), * Interior rooms with windows or ventilation openings (minimum 30 cm²), * Properly maintained stairs with repaired materials and railings,
1879	Second Tenement House Act (Old Law)	* Introduced the "ventilation shaft" as a solution to inadequate ventilation problems, * Conducted a tenement house design competition and introduced the "dumbbell plan", * Imposed a maximum limit of 65% on the occupancy of land parcels,
1901	1901 Tenement House Act (New Law)	* Prohibited dumbbell plan building construction, * Regulated staircase and corridor design for fire escape, * Required fire escape balcony (min.edge 90 cm) on both sides of buildings, * Required older buildings to add fire escape stairs to improve safety, * Replaced wooden balconies with steel/iron for fire escape, * Required courtyards at the back of tenement buildings, * Implemented fire-resistant stairs and flooring with artificial lighting, * Imposed maximum occupancy limits of 90% for corner parcels and 70% for mid-block parcels,

The development of fire escape staircases can be traced back to the 1929 Multiple Dwelling Law, which mandated that iron fire escape staircases could not operate as standalone escape routes. This requirement was reinforced by subsequent Building Construction Codes in 1938 and 1968. Consequently, fire escape staircases, once suspended from building facades as independent structures, have now evolved into fully integrated fire escape hallways within contemporary buildings.

6. CONCLUSION AND IMPLICATIONS

Examining the roughly 100-year historical trajectory of New York, a city deeply affected by the mass migration triggered by the Industrial Revolution, it becomes evident how building regulations and fire codes have profoundly shaped the design of “tenement houses”. In this fast-growing and initially unplanned metropolis, these structures, primarily occupied by laborers, gave birth to the concept of “tenement houses”. These tenement housing neighborhoods faced challenges stemming from insufficient housing stock and regulatory gaps, which often resulted in catastrophic events such as fires causing substantial material and life losses.

The process was based on an examination of the indirect correlation between the health reports of the City Health Inspectors and the adverse conditions in these tenement houses. Subsequently, the establishment of voluntary associations triggered the formation of a municipal commission to investigate the conditions in these neighborhoods. In the 1850s, the problems that initially caught the attention of these commissions included the use of basements and cellars as tenement housing, the construction of additional structures in the rear backyards within the same courtyard, and related issues. Fires in tenement housing triggered updates in construction regulations and fire codes, while each new law, in turn, influenced the design of housing with provisions related to fire resistance.

Not all legislative amendments yielded favorable consequences. The fact that building regulations did not always yield positive outcomes is exemplified in the case of the “ventilation shafts” introduced by the 1879 Old Law with the “dumb-bell plan”. These shafts had become unpleasant spaces used for dumping garbage, emitting foul odors, and creating a fire risk.

The 1901 New Law improved tenements’ housing by ensuring adequate courtyard and staircase width while adding fire escape stairs and balconies. However, tenants in tenement units with limited living space misused fire escape stairs as additional living areas, leading to non-functional stairs during fires and fire spread throughout buildings. Following the 1901 law, the concept of “tenement houses” was replaced by the term “Multiple Dwelling”. In 1929, with the “Multiple Dwelling Law”, fire codes introduced a more comprehensive concept of “fire escape routes” instead of just “fire escape stairs”.

In summary, this analysis of New York’s tenement housing history spanning nearly a century demonstrates that fires and ensuing legal regulations have played a crucial role in shaping the development of building designs. The proportional distribution of the space occupied by the building within the parcel and the allocated courtyard space, building materials, and design dimensions, as well as every alteration made in the law regarding fire escape halls and stairs, have significantly influenced building design. Local administrations’ establishment of standards

through laws and regulations for fire protection in buildings constitutes one of the most important factors in the development and standardization of building design.

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