

## VERTICAL WALL STRUCTURES IN TENEMENT HOUSES AT THE TURN OF 20<sup>TH</sup> CENTURY

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### ABSTRACT

This article analyses the development of masonry, used extensively during the construction of tenement houses in Czech towns after the middle of the 19<sup>th</sup> century, peaking at the turn of the 20<sup>th</sup> century. The dimensions (wall thickness) were defined by architectural codes issued for Czech Crown Lands (i.e. Bohemia, Moravia & Silesia) in three waves – the first one taking place from 1833 till 1835, the second one from 1864 till 1884, and the third one from 1886 till 1894. Tenement houses belonged, without exception, to the so-called “below-threshold” buildings, where a wing was 6.32 m deep (later 6.5). These principles are presented in historical examples of selected works by students of the Prague Polytechnical Institute and architectural designs for Prague (Bubeneč and Nusle boroughs).

### KEYWORDS

Tenement house, 19th century, Masonry, Architectural order, Building codes

### INTRODUCTION

Tenement houses became a new phenomenon in the 19th century.<sup>1</sup> Tenement flats were, nonetheless, quite common in historic towns almost from the Middle Ages. But the situation was different in individual town categories.

Observing Prague at the beginning of the 19th century, we would see three-, or less commonly, even four-storey houses on the busiest streets. Two- or three-storey houses were typical on side streets; single-storey houses were exceptional. Houses had backyard wings; built space was often maximized. Aside from the landlord's flat, there were several other flats, sized from studios to multi-room flats; there were shops and quite often horse stables on the ground floor. Each flat had its own kitchen, at that time in the form of a scullery, with a hood and a crawl chimney. In adjacent rooms, Dutch stoves were fed from the kitchen.

### METHODS

A different situation existed in other bigger towns, (e.g. in Pilsen) where three-storey houses were rare and only on main squares. More common were two-storied houses and one-storied on side streets. Houses within fortified walls (usually 220 – 250 of them) in former historic royal towns

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<sup>1</sup> In terms of typology and, first of all, the layout of flats connected to practical features such as, daylighting, circulation, sanitary facilities, and other trends, Pavel Janák's excellent article A Hundred Years of Tenement House in Prague Styl, ed. XIII, Prague 1933-1934 page 15-18, 39-42, 55-65 dealing with tenement houses has still been absolutely valid.

were mostly single-storey. A two-storey house was an exception. At the same time, the smaller the town, the lower the number of tenement flats. The backyard wings of historic houses were an early step to later tenement houses; while the well-grounded foundation of a house with a vaulted ground floor was often preserved, even during a major rebuilding, entirely new backyards wings were connected to the old house by galleries.

Tenement houses differed from historical tenement building in several ways. The continuity of using the parcels of historic homes often dated back to the times of the town's origin. Some privileges were related to them - usually brewing rights and craft production. On the contrary, tenement houses were often new buildings. They were either built on the site of a demolished house where historic privileges had lost their meaning (were sold) and production was relocated, or built on different plots, ideally on the outskirts of the town.

The situation was specific in Prague, or more correctly, in close vicinity to the city. One urban agglomeration originated in Prague's historic suburbs – Karlín (1870), Smíchov (1838), Vyšehrad (1883) Holešovice-Bubny (1884), Libeň (1901), others enjoyed the status of an independent town: Vinohrady (1879), Žižkov (1881), Košíře (1896). And it was where the situation was favourable for building tenement houses. Outside Prague, the ideal area was established by tearing down the fortification walls and converting the reclaimed land into the parks or building plots.

The list presented above suggests that the 19th century brought an unusual construction boom that had to be regulated very soon. There were several reasons for it. Aside from the traditional worries about fires and thus, an understandable preference for the non-combustible structures, the loadbearing capacity of walls was critically important in multi-storey buildings.

Vertical structures were entirely linked to the height of buildings and their number of storeys. Although historically, as mentioned above, there were a few four-storey (Baroque) buildings in Prague, buildings were allowed to be only two-storey according to the 1815 Prague Building Code. Adding higher storeys had to be approved separately. To save space, the Building Code for the new Karlín suburb (1817), stipulated at least single-storey buildings; the Building Order for Brno from 1828 requested the same. Rooms or flats had to be at least 10 Lower Austrian feet high (3.16 m) in Prague; in its 1828 Building Order, Brno specified the height of the first and second storey as 10 feet (3.16 m) on the ground, and the third storey had to be at least 9 feet (2.84 m).<sup>2</sup>

Provincial building codes defined the design conditions since 1830s. They were published in three series; the code for Bohemia first and then the one for Moravia, circumstances in Silesia were more complicated (see below).

## THE FIRST SERIES OF BUILDING CODES

The oldest building codes for Bohemia, Moravia & Silesia were issued between 1833-1835<sup>3</sup>; they stayed valid, only slightly modified, until 1864 in Bohemia, until 1869 in Moravia and even until 1883 in Silesia, which is deep into the second half of the 19th century. To save space, one- and two-storey buildings were built in both bigger and smaller towns. Higher buildings had to be approved by the gubernium later replaced by the office of the steward (Imperial-Royal Governorate of Bohemia); factories were exempted. Buildings had to be founded on raft foundations or even piles, if built on an unsuitably sandy or damp sub-base. The thickness of masonry was calculated from the number of storeys and was derived from the highest storey – it had to be 1 ½ feet thick on the topmost storey (47 cm); walls had to be by 3 to 6 inches (8-16 cm) thicker for lower storeys, foundation

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<sup>2</sup> The Building Code for Prague dated 11 May, 1864. The Building Code for Czech Lands No. 20/1864. The Building Code for Moravia, the Code for the Margraviate of Moravia No. 1/1870 dated 20 December 1869. The Building Code for Silesia 1883, the Code for Upper and Lower Silesia dated 2 June, 1883.

<sup>3</sup> The 1833 Building Code for Bohemia; the instructions of the Czech governorate, dated 17 May, 1833. The Building Code for Moravia and Silesia; the instructions of the Moravian governorate, dated 12 September, 1835. The 1845 Building Code for Bohemia; the instructions of the Czech governorate, dated 27 March, 1845.

masonry had to be at least 6 inches (16cm) thicker than on the ground floor. For fire-prevention purposes, adjacent houses had to be fitted with party walls extending high above the ridge. The norm for a firewall (party wall) was specified in Moravia as protruding 12 to 15 inches (32 – 39 cm) above the roof of the higher building.

In Bohemian towns, the floor had to be at least 6 inches (16 cm) above grade on the ground floor; the Moravian Code from 1835 specifies at least one foot (32 cm), the Building Code for towns from 1845 specifies 6 inches as a minimum or, better, double that (16 and 32 cm).

The ideal height of vaulted rooms was also specified – 10 feet (3.16 m); it had to be 10 feet in non-vaulted habitable rooms (3.16 m), at least 9 feet (2.84 m); rooms in village homes could be by as much as 6 inches lower (16 cm).

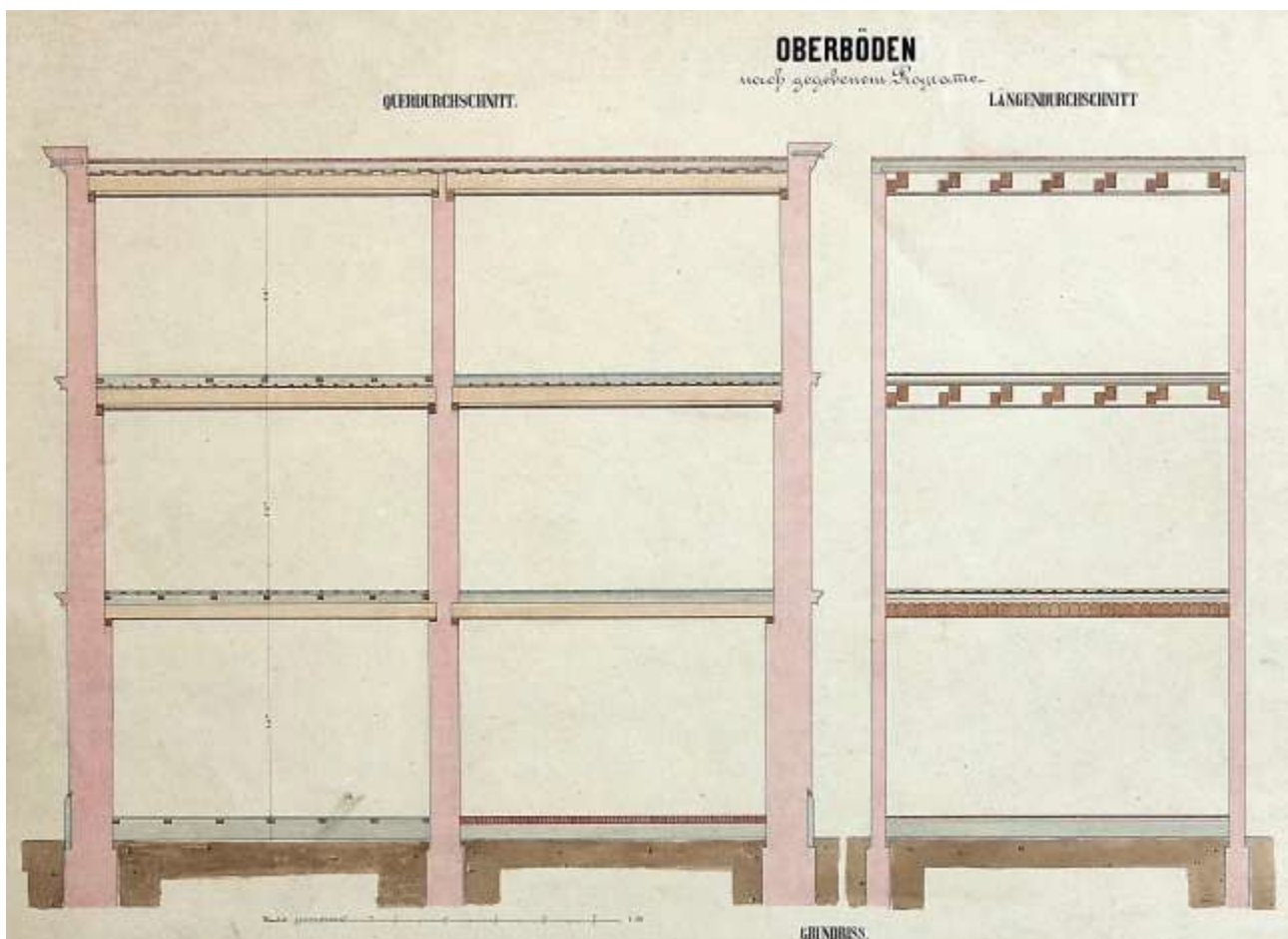


Fig. 1 – Student work by Quido Bělský from Prague Polytechnic; second half of the 19th century. The thickening of masonry is well demonstrated in this section. There is a side-by-side timber log floor above the ground floor (we call it “typlový” to distinguish it from round or half-round floors); on higher storeys, there are floors supported by joists with attached smaller secondary joists not transferring the movement into the plastered soffit below. [NTM, ANTM, D8/55, 357.]

## THE SECOND SERIES OF BUILDING CODES

Another wave of Building Codes was based on those from the year 1864 for Bohemia, and in 1896 for Moravia.<sup>4</sup> They introduced the approved number of storeys – a house could have a maximum of four storeys above the ground floor and one mezzanine; in Moravia, it was either three or four storeys, plus a mezzanine. The construction authority had the right to limit the number of storeys in both cases, if warranted. The maximum front height of new buildings was 12 fathoms (22.75 m) for Moravia. The 1883 Silesian Building Code allowed three storeys plus a ground floor.

The section regarding the wall thickness underwent major changes. Buildings started to be divided into less deep ones – wings with rooms up to 20 feet deep (6.32 m) – and deeper ones exceeding this limit. If the wing was within the limit, the main brick walls complied if 1 ½ foot thick (47 cm); stone walls conformed if 2 feet thick (63 cm). If the walls were deep beyond the limit, stone masonry had to be thicker, up to 2 feet 3 inches (71 cm in total); brick masonry had to be 2 feet thick (63 cm). Main walls had to be thicker by 3 inches (8 cm) on every lower floor and foundations 6 inches thicker than walls on the ground floor. The building authority could request even thicker masonry, if necessary.

Other details differ in municipal versions. The Czech version specifies that in case of side-by-side log (timber) floors, masonry must be thicker on every lower story by 6 inches. Middle pillars had to be rectangular prisms or preferably made of iron, rather than brick. In Bohemia and Moravia, rooms between two masonry walls had to be divided by a plastered wooden partition (timber or timber-framed); it was not allowed to place a stove next to the partition.

The Silesian Building Code following this trend was not published until 1883- thirteen years after the introduction of the metric system. Below-threshold houses with shallower wings were approximated to 6.3 metres in depth. Their main stone-masonry walls had to be 60 cm thick, brick walls 70 cm thick; above-threshold stone-masonry walls had to be 70 cm thick, brick walls 60 cm. Each lower storey had to have walls that were 15 cm thicker. If there were no floor structures bearing on these walls, they could be 60 cm thick (stonework), or 45 cm (brickwork). Foundations had to be 15 cm thicker than ground-floor masonry. The Silesian Building Code had sophisticated provisions allowing 70 cm thick (stone) or 60 cm (bricked) main (load-bearing) walls carrying ceiling joists or ceilings vaulted into I beams to be of the same thickness on two storeys when stacked. Central walls had to be 60 cm thick (stone) or 45 cm (brick) on the topmost floor; walls on each second floor below were required to be 15 cm thicker; walls supporting the so-called side-by-side timber log floor structures<sup>5</sup> had to be by 15 cm thicker on each floor as they descended. The minimum thickness of partitions had to be 25 cm.

This series of Building Codes naturally also addressed fire gables with strengthened pillars. Czech Codes do not specify their exact parameters; Moravian Codes require them to protrude 9 inches (24 cm) above the roof, the Silesian ones request 25 cm. Moreover, there is a new element in the Silesian Code from 1883 – fire gable walls had to be installed every 30 meters within the house.

The Czech and Moravian Codes from the 1860's specified different requirements than the older ones, in the section regarding the height of the ground floor above grade. Flats in new buildings were allowed 12 or more inches (32 cm) above the ground in Bohemia; this height was allowed to be lower, only if the flats were perfectly dry, day lit and ventilated and in the event one side was at least 4 feet (1.26 cm) above grade, if built into a slope. Basement workshops were allowed only if their ceiling was at least 2 feet (63 cm) above grade and sufficiently ventilated. The Moravian Code approved floors in a flat if installed lower, if it did not contradict health codes. If a building was built

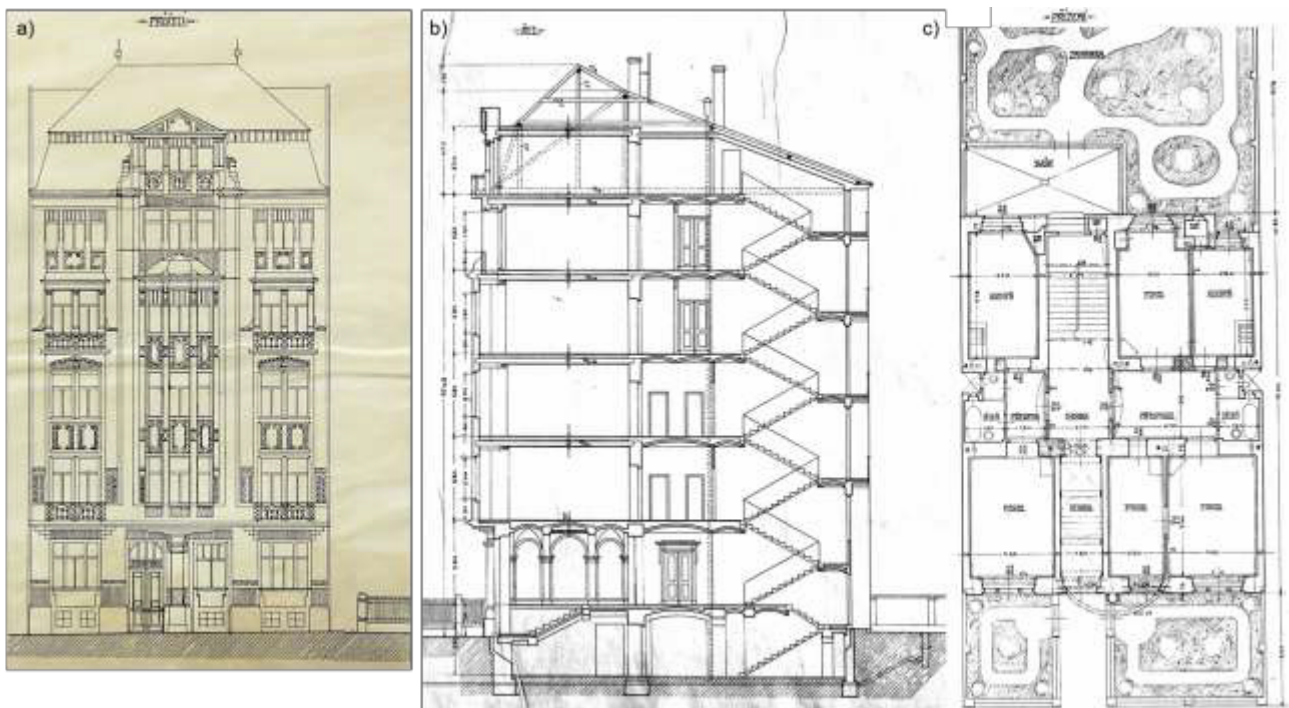
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<sup>4</sup> The Building Code for Prague dated 11 May, 1864. The Building Code for Czech Lands No. 20/1864. The Building Code for Moravia, the Code for the Margraviate of Moravia No. 1/1870 dated 20 December 1869. The Building Code for Silesia 1883, the Code for Upper and Lower Silesia dated 2 June, 1883.

<sup>5</sup> It means the so-called "typlový" (side-by-side log floor structure) according to the current terminology.

in a flood-prone area, floors of houses had to be 12 inches (32 cm) above the highest flood level. The requirements for basement workshops were the same. In Silesia, since 1883, floors had to be a minimum of 30 cm above grade, or above the highest flood level in a flood-zone; basement workshops had to have a ceiling at least 90 cm above grade. The clearance is slightly modified. In Bohemia, vaulted rooms had to be at least 10 feet (3.16 m) high, those with flat ceilings a minimum of 8 ½ feet (2.69); in Moravia, it was 9 feet (2.84.m), and in Bohemian and the Moravian countryside, the minimal clear height of living rooms was only 8 feet (2.53). The 1883 Silesian Building Code specified the lowest clearance of habitable rooms to be 2.8 m; all rural rooms and cattle sheds were 2.5 m high.

With respect to the increasing depth of new buildings, a passage was implemented [in codes] defining the form of a light shaft (their existence was prohibited before). A light shaft had to rest on solid walls reaching above the roof, with an iron frame; naturally, they had to be, fire-resistant and structurally separated from the attic.



*Fig. 2 – The undated proposal (from the early years of the 20th century) for a new building of a four-storey apartment building in Prague's Bubeneč by architect Václav Řezníček is one of the top productions of this type of house. In the entrance to the house there are alternating two-barrel vaults with segments with a flattened vault in the middle, in other roads there are relatively simple segmented vaults into traverses. On the first and second floor there is one five-room apartment, on the upper two floors of two-room apartment, all are equipped with bathrooms. [NTM, AA, Fund 197, 20090909/02]*

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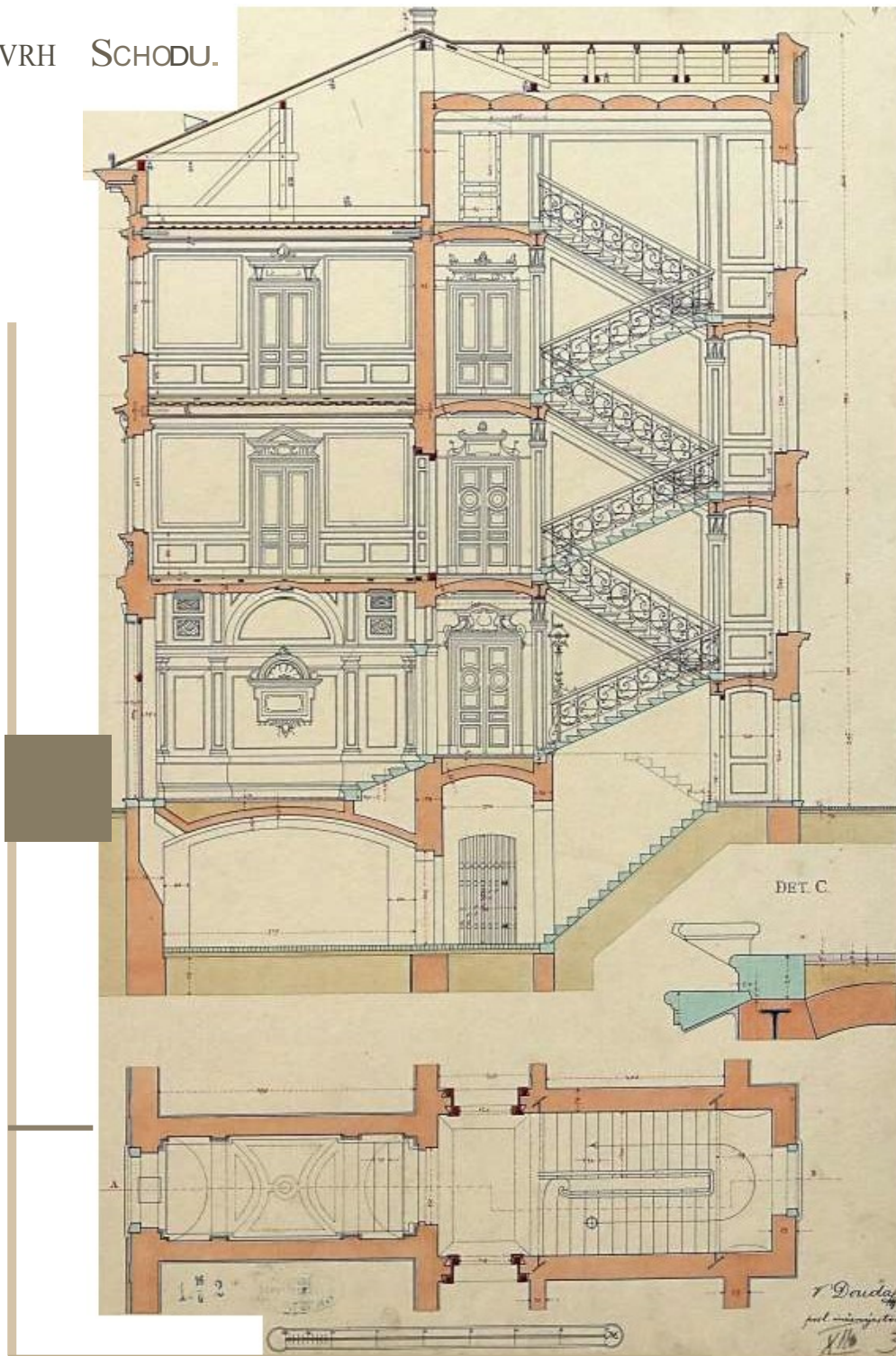


Fig. 3 – The design of the stairs, listener of engineering V. Douda, 1902. The drawing clearly shows the widening masonry in accordance with the building code from 1886. In the basement there are barrel segmented vaults, barrel vaults with sectors in the entrance, mirrored vaults corridors, barrel vaulted barrel, barrel vaulted bar above the staircase. Reed ceilings in the room (reed beams are not so well visible from this section). [NTM, ANTM, D6 / 55, 263]

## THE THIRD SERIES OF BUILDING CODES

Newly reviewed Building Codes were issued between 1886 and 1894 for Bohemia and Moravia (this update did not include Silesia). In towns, the maximum allowed height of buildings was 25 meters, measured to the cornice; the top floor level could be maximum of 20 meters above the ground. Houses in large Czech towns could have a ground floor, plus four storeys above; outside these towns, only three storeys were allowed. Moravian towns were regulated differently – an overly high storey could be divided horizontally, but only if each storey still measured three meters.

This edition also recognized buildings with narrower and broader leaves – the borderline was 6.5 m. The wall thickness had to be pre-determined, based on structural calculation without the plaster. The topmost storey a maximum of 6.5 m deep had to have main walls 45 cm thick (brick) and 60 cm (stone); wings over this limit could have brick walls a minimum of 60 cm thick and quarry-stone walls 70 cm thick. The 1886 Czech Code for large towns required that the main wall is by at least 8 cm thicker on every lower floor, or by 15 cm every second lower floor. Codes from 1889 and 1894 for all of Moravia (and the Czech countryside) required walls on the second from last floor to be 15 cm thicker; two storeys below, the walls had to be thicker by 15 or more centimetres. Moravia specified thickening the walls as they descended by 15 cm on every lower floor, for the loose placement of side-by-side timber log floor structures. Generally, main walls not loaded by floor structures that would weaken them sufficed if 45 cm thick. Central walls in buildings up to two storeys had to be 45 cm thick; three-storey buildings had to be 60 cm thick on all floors. A four-storied Moravian houses had to have walls 75 cm thick on the ground floor and 60 cm above. Moreover, in the Czech countryside, middle walls in three-storied buildings carrying a floor on only one side and light shaft walls were only 45 cm thick. Middle walls in two-storey buildings and party walls next to adjacent buildings had to be only 30 cm thick. Partition walls were generally acceptable if built 15 cm thick (an exemption was partitioning in flats in Moravia, as local codes required 30 cm).

Each wall with chimneys or pipes always had to match the thickness of the brick. In Moravia, outer staircase walls complied if 30 cm thick in buildings up to two storey high; outer walls in higher buildings or buildings with suspended steps had to be at least 45 cm thick. Partition walls had to be a minimum of 15 cm thick and 30 cm between two flats. In the case of vaulted and timber floors on steel beams, load-bearing stone or iron columns or pillars, the wall dimensions were determined by structural calculations.

This series of Building Codes featured many substantial improvements. In selected big Czech towns and all of Moravia, a building had to have a special fire separation wall as high as the attic on the side facing the neighbour; this wall had to be solid without any opening and if rafters bore on these walls, 30 cm of solid masonry had to be left unloaded. Firewalls had to stretch at least 15 cm above the roof and be plastered. If a firewall was on a property line, it had to be built up to half of its height, according to the conditions for a wall on a property line; a wall above this limit could be 30 cm thick or 15 cm, if strengthened by 15 cm pilasters. Similar fire-separation walls at least 15 cm thick, with required reinforcement pillars and isolated from rafters, had to be built in buildings 25 m long in the Czech countryside and over 30 meters long in all of Moravia. Passages through these walls had to be fitted with iron doors in an iron or stone doorframe.

Floors in ground-floor flats had to be at least 45 cm above the street in large Czech towns and 30 cm above the highest flood level in flood-prone areas. The Czech Country Order and both

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<sup>6</sup> The 1886 Building Code for Prague, the Building Code for Czech Lands No. 40/1886 dated 10 April, 1886. The 1887 Building Code for Pilsen, the Building Code for the Czech Kingdom No. 16/1887 dated 22 February, 1887. The Code No. 71/1888 dated 26 December, 1887. The Building Code for České Budějovice, the Code for the Czech Kingdom No. 5/1889 dated 8 February, 1889. The 1893 Building Code for Bohemia (aside from the specified towns), the Code for the Czech Kingdom No. 5/1889 dated 8 February, 1889. The 1894 Building Code for Brno, the Code for the Margraviate of Moravia No. 63/1894 dated 1 June 1, 1894. The Building Code for Moravia, the Code for the Margraviate of Moravia No. 64/1894 dated 16 June, 1894.

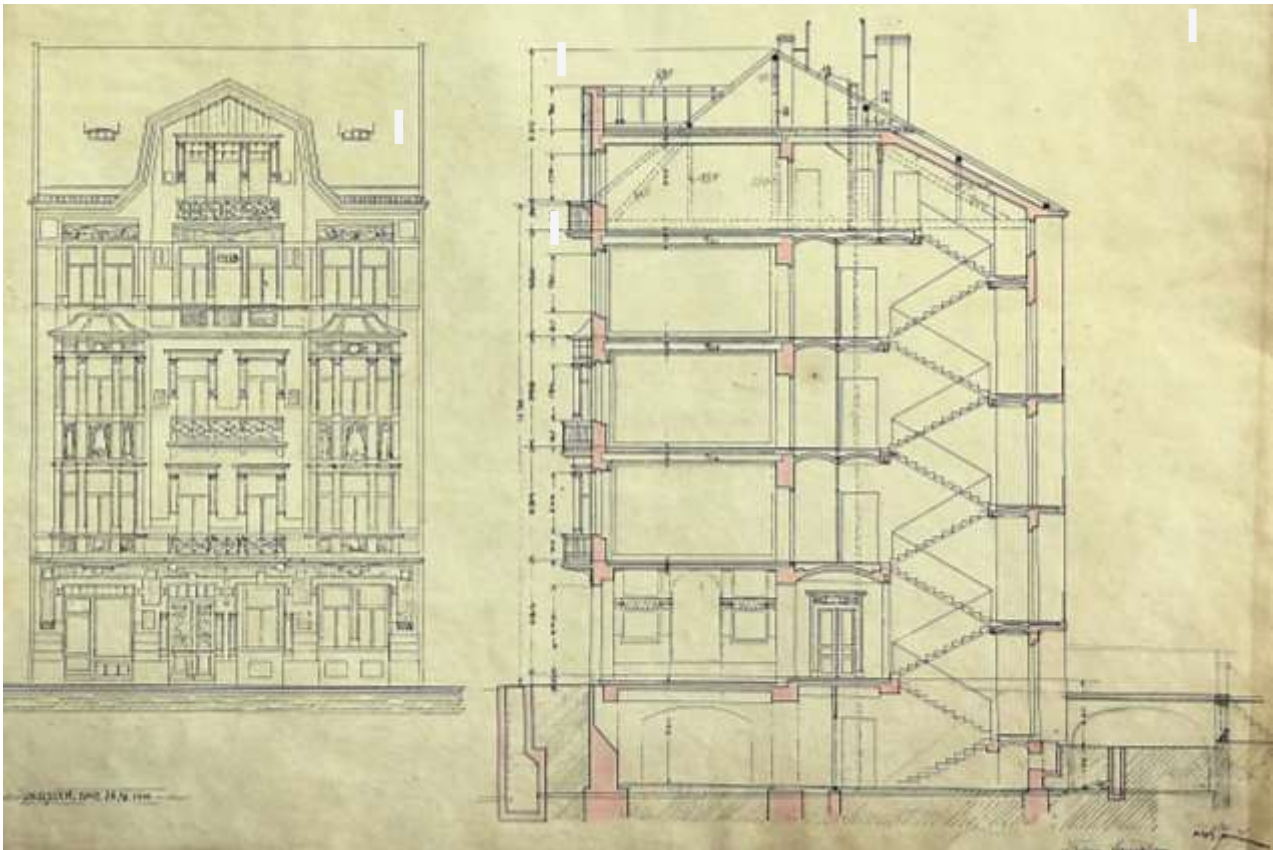
Moravian Orders stipulated that floors in ground-floor flats were at least 30 cm above grade and for churches at least 15 cm, and 30 cm above the highest recorded flood level in flood areas. It was legally possible, under certain circumstances, to establish flats and workshops below grade. Such flats had to be damp-proofed, their clear height was at least 3 meters; 2.75 m sufficed in the Czech rural areas. If a room was 4 m high, at least half of it had to be above grade; moreover, the size and dimensions of the outer space were complexly determined based on how and where the basement rooms received daylight. The lowest floor level below grade was 2 m in Bohemia and 1.5 m in Moravia. A second parallel cavity wall with a 30 cm wide gap was required in big Czech towns and

15 cm in rural locales to keep the rooms dry; the space between the walls had to be ventilated. Workshops in cellars had to be vaulted; half of the height had to be above grade, the floor had to be partly concrete, 15 cm thick. If the area was in a flood zone, installing partially basement flats and workshops was not allowed.

According to Building Codes from the end of the 19th century (starting with the Prague's from 1886), the minimum clear height of flats and workspaces was 3 meters; 2.9 m were enough in rural areas.

Building codes related to light wells were further developed. Light wells had to be installed only where necessary. According to all codes, their basic area had to be at least 12 m<sup>2</sup>. This figure was valid for three-storey buildings in all of Moravia; for higher buildings, 1 m<sup>2</sup> had to be added per each meter of height within a light well. If a light well daylighted only corridors, 6 m<sup>2</sup> were enough. This figure was valid for two-storey buildings in all of Moravia; for higher buildings, a half square meter had to be added per each vertical meter of a light well. The minimum profile of vents for ventilating toilets had to be 1 m<sup>2</sup>. This figure was valid for two-storied buildings for all of Moravia; for higher buildings, 0.1 m<sup>2</sup> had to be added per each vertical meter of a vent. Air had to be supplied to each light well and a vent on the ground floor level. If a light well daylighted a staircase, it had to have an iron frame bearing on masonry. A light well then had to terminate above the roof – at least 15 cm in large Moravian towns and 5 cm in the countryside. Rooms daylighted from above were not allowed to be connected to the attic. Ventilation openings had to be on the top below a glazed roof.





*Fig. 4 – Design for a three-storey apartment building in Nusle by architect Václav Řezníček. The house in the style of geometric Art Nouveau from 1910, its concept corresponds to its time. Again, the masonry is increasing downwards. The house is in comparison with the previous lower category, most of the apartments are two-roomed and have a private bathroom, in one-room apartments is only a toilet. Cellars still have segmented vaults with passports (which is very archaic), on the ground and in the corridors these vaults are as usual into traverses, the ceiling construction is drawn rather without reed beams as a cheaper solution with reed ceiling and plaster directly on the ceiling. [NTM, AA, Fund 197, 20060808/03]*

## CONCLUSION

The article presents a summary of development of the construction of vertical walls of tenement houses from the mid-19th century to the beginning of the 20th century. The period was influenced by three gradually issued building codes, which reflect the building boom of this period. Raising of buildings forced the issuance of precise rules for variously tall and deep buildings of the observed period. Thanks to these regulations, which were based on long-term construction experience, practically no serious defects occurred in new buildings. The vertical constructions are closely related to the used ceiling constructions, both in the combustion and non-combustion variants.

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