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# INTEGRATION OF ARCHITECTURAL AND STRUCTURAL FORM IN TALL BUILDINGS BY RICHARD ROGERS

## INTEGRACJA FORMY ARCHITEKTONICZNEJ I KONSTRUKCJI W BUDYNKACH WYSOKICH AUTORSTWA RICHARDA ROGERSA

### Abstract

One of the greatest creators of high-tech architecture is Richard Rogers. Among the many works of this architect are tall buildings, including the icon building – the headquarters of the Lloyd's in London. This building, with extraordinary expression, still captivates with its originality. Its integral part are installations placed outside, as well as structural elements. The superstructure shaped in accordance with the principles of structural mechanics and material strength contributes to the architectural form of the building. Not hiding structural and installation elements can be used as a demonstration of “truth” in architecture, which is also noticeable in other Richard Rogers’ buildings.

*Keywords: tall buildings, high-tech, Richard Rogers*

### Streszczenie

Jednym z najwybitniejszych twórców architektury high-tech jest Richard Rogers. Wśród licznych dzieł tego architekta są budynki wysokie, w tym budynek ikona – siedziba firmy Lloyd's w Londynie. Budynek ten, o niezwyklej ekspresji, do dziś urzeka swoją oryginalnością. Jego integralną częścią są umieszczone na zewnątrz instalacje, a także elementy konstrukcyjne. Ustrój nośny, ukształtowany zgodnie z zasadami mechaniki budowli i wytrzymałości materiałów, współtworzy formę architektoniczną budynku. Brak ukrywania elementów konstrukcyjnych można uznać za demonstrację „prawdy” w architekturze, co jest również dostrzegalne w innych budynkach Richarda Rogersa, o czym jest mowa w artykule.

*Słowa kluczowe: budynki wysokie, high-tech, Richard Rogers*

## 1. INTRODUCTION

It can be said that the desire to build high has accompanied man for a long time, an example of which is the description of the Tower of Babel in the Book of Genesis.<sup>1</sup> The image of the Tower of Babel is known and disseminated through the painting of Peter Bruegel from 1563, although the tower itself was probably never built. The first erected tall buildings were defensive towers. The stone tower in Jericho is considered the oldest, dating roughly to 8300 BC.<sup>2</sup>

<sup>1</sup> *Biblia Tysiąclecia, Pismo Święte Starego i Nowego Testamentu*. Wydawnictwo Pallottinum, 2014. Old Testament, Genesis Book, 11:1–9.

<sup>2</sup> R. Barkai, R. Liran, *Midsummer Sunset at Neolithic Jericho*, Time and Mind, 2008, vol. 1, no. 3, pp. 273–283.

a time belonging to Neolithic. The tower was discovered during archaeological excavations in 1952. This tower was 30 feet high, or about 9 m. The lighthouse in Faros was the highest ancient building, measuring 130 m according to some sources.<sup>3</sup>

In later eras towers became an inseparable element of cities. The highest buildings in the Middle Ages were churches and cathedrals, whose towering towers were dominants and often exceeding more than 100 m in height. The tower was also an important element of the medieval town hall, an example of which is Torre del Mangia in Siena, 102 m high. Numerous residential towers in Bologna<sup>4</sup> were also erected. Two have survived to the present day: Torre Asinelli, 97 m high, and Torre Garisenda, 48 m high.

Regardless of the utility function, the towers were a reflection of the times in which they were erected, both in the stylistic layer and in terms of the technical possibilities of their construction. It is also a characteristic feature of contemporary high-rise buildings. The development of high-rise buildings did not take place until the end of the 19th century. Then architects established a group to be known as the Chicago School. A breakthrough moment was the development of the steel skeleton structural system. It was then that the Home Insurance Building<sup>5</sup> in Chicago in 1885 was built (arch. William Le Baron Jenney), which today is considered the first skyscraper. Since then, there has been a constant race aimed at construction the highest buildings which is accompanied by the development of the architectural form of high-rise buildings, as well as technological progress enabling their construction. Outstanding creators of modern architecture are taking part in the search for and shaping the architectural forms of tall buildings. One of them is Richard Rogers, one of the precursors of high-tech architecture, author of several pioneering tall buildings, including the iconic Lloyd's Building in London. Along with its construction Rogers strengthened his position as an artist who consciously exposes elements of the technical tectonics of the building – both structural and installation elements.<sup>6</sup> It was emphasized when the 2007 Pritzker award was granted:

Rogers combines his love of architecture with a profound knowledge of building materials and techniques. His fascination with technology is not merely for artistic effect, but more importantly, it is a clear echo of a building's program and a means to make architecture more productive for those it serves. His championing of energy efficiency and sustainability has had a lasting effect on the profession.<sup>7</sup>

## 2. THE LLOYD'S BUILDING

The Lloyd's Building is not a typical high-rise building. Its characteristic feature is the expressive form obtained through solutions called “inside out,”<sup>8</sup> that is placing structural elements and technical infrastructure outside which in typical buildings are hidden, not exposed.

<sup>3</sup> M. Twardowski, *Wieże mieszkalne*, Wydawnictwo Politechniki Krakowskiej, Kraków 2017, p. 16.

<sup>4</sup> *Ibidem*, p. 22.

<sup>5</sup> G. Peet, *The Origin of the Skyscraper*, CTBUH Journal, 2011, no. 1, pp. 18–23.

<sup>6</sup> D. Kozłowski, *Two faces of high tech architecture*, Czasopismo Techniczne, 2013, no. 1-A, pp. 29–35.

<sup>7</sup> Pritzker Prize, <https://www.pritzkerprize.com/laureates/2007> (access: 10.06.2020).

<sup>8</sup> R. Rogers, R. Brown, *A Place for All People: Life, Architecture and the Fair Society*, Canongate Books, Edinburgh 2017, p. 9. “Inside Out” – a retrospective exhibition dedicated to the work of Richard Rogers, organized at the Royal Academy of Arts in London, 18 July – 13 October 2013.

The Lloyd's Building in London was built in 1978–1986 for a company operating in the insurance segment. Richards Rogers and the project team won a closed competition to design a new company headquarters next to the existing Lloyd's Building from 1928. The competition was organized by the Royal Institute of British Architects RIBA. The presented project met the investor's guidelines, who expected the new headquarters to be functional in terms of flexibility and adapted to the needs of the company, both at the time of its completion and in the 21st century. There was also a postulate in the competition assumptions that the Lloyd's could operate during construction of the new headquarters. These functional assumptions had an impact on the shape of the building's form.

As mentioned, one of the main design assumptions was to obtain a building with open and flexible spaces. For this purpose, an unconventional spatial layout of the building was proposed. In the place where the core is traditionally located a multi-story open atrium was created. The communication and technical cores were placed in six external towers. The inspiration for such a spatial solution was the Larkin administrative building in Buffalo,<sup>9</sup> designed in 1903 by Frank Lloyd Wright for the Larkin Soap Company. Staircases, elevators, toilets and installation divisions were placed in the three external towers of the Lloyd's Building. The other three were designed as evacuation staircases and intended for firefighting. The spatial solution applied allowed for the total free space of individual floors.

Structural solutions also played a significant role in achieving the building's functional assumptions. Initially, the building structure was designed as steel but due to fire regulations the concept was changed to reinforced concrete structure. They were afraid of too monstrous cross-sections, so the design team took a study trip to the United States to learn about the latest solutions in the field of concrete structures. It is worth adding that a member of this team was Peter Rice, the greatest structural engineer of the 20th century. He designed among others the construction of the Pompidou Center building in Paris (the authors of the architectural design were Renzo Piano and Richard Rogers).

Looking at the typical floor plan of the building the main structural elements are columns and slab structure. The columns with a circular cross-section and a diameter of 1 m were arranged circumferentially along the edge of the slab structure and centrally around the atrium. The slab structure with a span slightly exceeding 18 m are only spread between these columns. Due to the span, a waffle slab was supported on post-tensioned inverted girders.<sup>10</sup> A characteristic feature is the detail of supporting the slab structure on the columns by ring shape precast concrete brackets, which was displayed in the building facade (Ill. 2).

The central place in the typical floor plan is occupied by an atrium, which the roof is a reference to the neighboring Leadenhall Market building. When the atrium has been designed, Richard Rogers was also inspired by the Crystal Palace in London, the Kew Palm House in Richmond, and the Galeria Emanuela II in Milan.<sup>11</sup> The atrium roofing is a barrel vault system formed by arch-shaped truss, made of steel and painted white (Ill. 3). The role of the atrium is to illuminate the interior, as well as to shape the central space with galleries arranged around directly open to the atrium or with a view through the glass walls.

In terms of material solutions, the Lloyd's Building was shaped using three materials: concrete, steel and glass. Concrete was used in the main structure of the building and steel in

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<sup>9</sup> *Ibidem*, p. 177.

<sup>10</sup> J. Thornton, M. Hall, *Lloyd's redevelopment*, The Arup Journal, 1982, vol. 17, no. 2, p. 4.

<sup>11</sup> R. Rogers, R. Brown, *op. cit.*, p. 185.

the roof structure of the atrium. There is also stainless steel as a cladding in external towers (Ill. 1). Glass was used in the atrium and facade. The inspiration for glass façade solutions were buildings from the 1930s: the headquarters of the Salvation Army Paris and the Cité de Refuge designed by Le Corbusier and the Maisson de Verre designed by Pierre Chareau<sup>12</sup>. A “self-breathing” façade was designed with textured rolled glass specially developed by Pilkington (Ill. 2). This rolled glass was made using a die engraved on case-hardened steel wrapped. Each element in the building was thought out in detail according to the author’s opinion: “the Lloyd’s building was designed as a flexible machine for a financial market place, but also as a carefully considered expression of those activities, designed both for the user and for the enjoyment of the passer-by.”<sup>13</sup>

### 3. THE LEADENHALL BUILDING

The Council Tall Building and Urban Habitat CTBUH in 2019, announced a list of The 50 Most Influential Tall Buildings of the Last 50 Years.<sup>14</sup> This list includes two buildings designed by Richard Rogers: the Lloyd’s Building and the Leadenhall Building. In justification both buildings appreciated their significant contribution to the development of skyscrapers structures.<sup>15</sup>

The Leadenhall Building was built opposite the Lloyd’s Building almost 30 years later and already represents the next generation of tall buildings. However, there is a common feature of both of these skyscrapers – special attention to construction solutions from the system to the structural detail. In the case of the Leadenhall Building skyscraper, a close integration of the architectural form of the building with its structure is noticeable. The building form with a tapered profile<sup>16</sup> was designed taking into account detailed analyses regarding the context of the skyscraper. Examined were spatial relations concerning other tall buildings in the City and the view protection of the St. Paul’s Cathedral.

The Leadenhall Building was divided into eight sections separated along its height. The lowest part is a largely open space known as the “gallery,”<sup>17</sup> above which the office floors are located. At the top of the skyscraper, in the highest section known as the “attic”<sup>18</sup> there is a technical floor.

Richard Rogers together with structural engineers from the ARUP office decided to use a perimeter-braced diagrid structure (Ill. 4) as a main structural system of the Leadenhall Building. This solution was used by Norman Foster in the nearby Swiss Re tower. However,

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<sup>12</sup> M. Wigginton, *Glass in architecture*, Phaidon, London 1996, p. 150.

<sup>13</sup> R. Rogers, R. Brown, *op. cit.*, p. 8.

<sup>14</sup> The 50 Most Influential Tall Buildings of the Last 50 Years, <https://ctbuh2019.com/other-info/50-influential-buildings/> (access: 20.05.2020).

<sup>15</sup> *Two RSHP projects on the CTBUH’s most influential tall building list* [in:] RSHP. Rogers Stirk Harbour + Partners, <https://www.rsh-p.com/news/two-rshp-projects-on-the-ctbuhs-most-influential-tall-building-list/> (access: 20.05.2020).

<sup>16</sup> A. Young et al., *Case Study: The Leadenhall Building, London*, CTBUH Journal, 2013, no. 2, pp. 13–17, <https://global.ctbuh.org/resources/papers/download/19-case-study-the-leadenhall-building-london.pdf> (access: 20.05.2020).

<sup>17</sup> N. Annereau, D. Eley, J. Thonger, *The Leadenhall Building*, The Arup Journal, 2012, no. 2, pp. 67–76.

<sup>18</sup> *Ibidem*.

there is no central core in the Leadenhall Building. The core was placed along the northern facade. Its structure is steel, and the main structural elements have been painted yellow. It is characteristic of Richard Rogers buildings.

In the facade of the Leadenhall Building skyscraper, there are visible lattice grids (Ill. 5) which are also part of the building facade drawing. An additional visual effect was obtained by using a double facade. Bars and nodes as structural elements were placed between two layers of glass (Ill. 6). Transparency plays a special role here. Not without significance is the reflectivity of the glass using different drawings of reflection depending on the intensity of light. Delicate intersections of glazed surfaces in the form of steel profiles were introduced between the sections (Ill. 6).

Individual floor plans in the Leadenhall Building have a rectangular shape with a maximum dimensions of 48x43 m. With each floor its plan depth decreases by 0.75 m. The main internal structural module based on a grid of 16x10.5 m remains constant. Proposed axis system means that there are only six internal structural columns on the lower floors. On the upper floors, these columns were reduced. This solution gave great flexibility in the layout of individual floors for office work.

The storeys of the building consist of two zones: the main one intended for office space and the core where elements of vertical communication (elevators, stairs), toilets and technical shafts are located. Both zones are connected by a narrowed walk link. Additionally, the fire staircases were designed in the north-east and north-west corner in the office area. This is accented in the facade with additional, stiffening trusses (Ill. 5).

#### 4. THE 88 WOOD STREET

The building located at 88 Wood Street in London, like the Lloyd's Building, is not a typical tower block with a towering shape. It is also not too high which is due to its location near London Wall. The height of the building also results from the view protection due to the St. Paul's Cathedral. The typical floor plan consists of three segments connected to each other by separating bays. The segments have respectively: 10, 14 and 18 floors. The highest segment reaches a height of 78 m. From the 88 Wood Street side, the required building height was not exceeded and the lowest segment was located here.<sup>19</sup>

The execution of the building did not proceed as planned. The first concept presented in the competition won by Richard Rogers was not implemented. It was not until almost 10 years later that the building was completed after it was thoroughly redesigned. The investor of the building was the Japanese bank Daiwa. Due to the slowdown in the Japanese economy they abandoned construction of their headquarters in Europe. The conditions for the building concept were changed later. The investor proposed to increase the nettable office space by 30% but reduced the investment budget by half. The building was to be designed not as a representative office of the company but as an office building with space for rent.

The new conditions required a change in concept in the field of design solutions. The spatially reinforced concrete frame is the basic element of the load-bearing structure of the

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<sup>19</sup> D. Barker, *88 Wood Street by Richard Rogers*, [http://www.architectureweek.com/2001/0516/design\\_1-1.html](http://www.architectureweek.com/2001/0516/design_1-1.html) (access: 15.05.2020).

building. To obtain a larger usable area it was decided to limit the number of columns. It was not easy due to the segment span of 18 m. After detailed analyses, there was adopted the option of removing intermediate columns and leaving the columns only on the perimeter of the slab structure. It was assumed that the optimal grid would have dimensions of 15x6 m. It meant a distance of peripheral columns from the edge of 1.5 m on each side.<sup>20</sup> However, a considerable span of 15 m was created. For this reason it was necessary to design the post-tensioned concrete slabs using ribs. Limiting the number of columns on a storey increased the possibilities of planning the office function.

Another action to increase the usable area was to properly locate vertical communication. In this case Richard Rogers reached for the solution used in the Lloyd's Building. Also, in the 88 Wood Street building six external communication shafts were designed and located at the edges of the slab structure. While the building was mainly designed in a concrete structure, staircases with lifts were made by steel structure and were fully glazed. It contrasts with the form of the building giving it the impression of lightness. The steel structure elements have been painted yellow, which is visible from the outside through the glass façades.

Steel bracing in concrete-framed structure were also used in the building facade (Ill. 7). These braces at the base of the building are led through two floors, higher in four-storey rhythms. Macalloy crossing steel strands are intended to stiffen the frame, but they are also elements influencing the visual perception of the building from the side of London Wall (Ill. 7).

An additional accent placed at the entrance to the building are colorful “funnels” – red and blue referring to the steam ship, which in addition to installation functions is to be an element that attracts the attention of passers-by.

## 5. MERANO TOWER

Richard Rogers and the team also designed high-rise residential buildings. One example is the Merano Tower in London, completed in 2017. The tower was located on Albert Embankment on the River Thames. The building consists of three connected towers. The highest has 28 storeys and is 85 m high. As in other projects by Richard Rogers, here too the visibility of structural elements is noticeable, as well as attention to material solutions used.

The load-bearing structure of the building is made of reinforced concrete frames which allowed to limit the number of columns per plan to twelve. The frame was made of pre-fabricated elements to achieve their intended visual effect. Above all, efforts were made to obtain a smooth concrete surface which would not be possible if these elements were made on site. The frames have been stiffened by bracing in perpendicular planes. Steel bracing, especially visible in the southern facade of the building (Ill. 8), adds an expression to fairly simple rectangular blocks of the building. The applied solution evokes association with the 88 Wood Street building.

The structural system used in the tower block allowed the ground floor to be freed and public space to be introduced here. This solution was used in the southern tower, which is a special accent from the side of the neighboring Victorian building.

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<sup>20</sup> R.M. White, T.P. Roe, S.D. Smith, *88 Wood Street, London – stressful City office design*, The Structural Engineer, 1998, vol. 76, no. 22, pp. 427–437.

In the skyscraper, with a flat layout on the east-west axis, prefabricated steel balconies were used. The steel hangers system supports the structure of balconies and provides a clear visual effect in the facades, which has been emphasized by the colorful borders and bottom of the balcony platforms: red, blue and green, assigned separately to each of the towers.

## 6. CONCLUSION

The integration of architectural and structural form can be a source of search for new solutions in contemporary tall buildings. Richard Rogers consistently exposes the building's structural and installation elements outside the building, which has become characteristic of his work. The superstructure shaped in accordance with the principles of structural mechanics and material strength, contributes to the architectural form of the building. Not hiding structural and installation elements can be used as a demonstration of "truth" in architecture. It is worth emphasizing that the introduction of the expression effect is not only intended to achieve a specific aesthetic reception, but above all is the result of detailed analyses and thoughtful design solutions: "from primitive hut to the soaring skyscraper, architecture seeks to solve problems in three dimensions. It combines scientific analysis with poetic interpretation, using technology and order to create aesthetic impact and functionality. It transforms the ordinary and the mundane by giving order, scale and rhythm to space."<sup>21</sup>



Ill. 1. The Lloyd's Building in London, photo by author

Ill. 2. Structural column and installations outside the building, photo by author

<sup>21</sup> R. Rogers, R. Brown, *op. cit.*, p. 63.



Ill. 3. Atrium in the Lloyd's Building – view from The Garden at 120, photo by author



Ill. 4. The Leadenhall Building opposite the Lloyd's Building, photo by author



Ill. 5. Structural elements in facade of the Leadenhall Building, photo by author

Ill. 6. Detail of structural node in the glass facade, photo by author



Ill. 7. The 88 Wood Street in London, photo by author

Ill. 8. The Merano Tower in London, photo by author

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