Architecture of Workplaces 1 Lecture 2

History of Industrial Architecture 2.
(1860) 1900-1945

2. New building materials and new manufacturing processes characterize the development in second half of the nineteenth century.

3. A typical process: birth of Clydebank near Glasgow.
At the start of the 1870s, however, the growing trade and industry in Glasgow resulted in the Clyde Navigation Trustees needing additional space for shipping quays in Glasgow.
Gradually, as **the shipyard grew, so did the cluster of buildings grow nearby**. More houses, a school, a large shed which served as canteen, community hall and church.
In 1882 a railway line was built running from Glasgow out to the new shipyard (the Glasgow, Yoker and Clydebank Railway). This was followed by the Lanarkshire and Dunbartonshire Railway during the 1890s. Then, between 1882 and 1884, the Singer Manufacturing Company built a massive sewing machine factory in Kilbowie, less than half a mile north of the Clyde Bank shipyard. **More people moved into the area**, and finally, in 1886, the local populace petitioned for the creation of a police burgh, on the basis that the area now qualified as a "populous place". The petition was granted, and the new town was named after the shipyard which had given birth to it – Clydebank.

4. Industry's **increasing demand for workers** and the lack of means of transport led to **locating production facilities, factories near existing settlements,** which developed extremely through the influx of population. This development caused **chaotic social and infrastructural conditions**.
The high concentration of industrial settlements and the immigration of workers have lead to enormous urban problems. **Need for flats lead to a building-boom** in an amount never seen before. Beginning in the second half of the 19th century urban planning and city building regulations were necessary.
In the **nineteenth century** enterpreneurs focused primarely on providing local services, so **industry was mostly settled in town centres.**
Later larger **industrial operations** were made **on the outskirts of of the towns**. They recognized the possibilty of later **expansions**.

5. The general headquarters of an american coorporation in Europe. It was to bombed to ruins in the World war II. Between 1882 and 1884, the Singer Manufacturing Company built a massive sewing machine factory in Kilbowie, less than half a mile north of the Clyde Bank shipyard. More people moved into the area, and finally, in 1886, the local populace petitioned for the creation of a police burgh, on the basis that the area now qualified as a "populous place". The petition was granted, and the new town was named after the shipyard which had given birth to it – Clydebank.

6. Typical pictures from factories near Glasgow on the Clydebank.
At the beginning of the twentieth century, **the modern factory** was seen as **the perfect functional building**, with improved materials, building technology, and was designed to work with the organisation of the industrial process. The **construction** may have been **the latest reinforced concrete system**, or have up-to-date **iron beam technology**, ensuring open spans of up to 16feet 4,88m (1900), even lit by the latest carbon arc electric light.

8. A two-storey high **empty glass-covered hall.** The structure: steel trussed pitch roof above the hall, trussed iron columns.

13. The emergence of newer industries surrounding the **automobile, electrical and chemical industries** meant a shift from the now declining textile base of the north to the newly created estates in the midlands and south, especially around London. The same happened in the USA.
A **change** was also starting **from the pure use of engineers as factory designers** to the **emergence of the architect** engineer and the architect alone.

14. The development of infrastructure; traffic, electric lighting, pavement…

15-16. Industry's **increasing demand for workers** and the lack of means of transport led to **locating production facilities, factories near existing settlements,** which developed extremely through the influx of population. This development caused **chaotic social and infrastructural conditions**.
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18. Reinvention after roman times. Concrete is a composite construction material made primarily with aggregate, cement, and water. Roman concrete (or opus caementicium) was made from quicklime, pozzolana and an aggregate of pumice.
Monier was a French gardener and one of the principal **inventors of reinforced concrete**. As a gardener, Monier was not satisfied with the materials available for making flowerpots. Clay was easily broken and wood weathered badly and could be broken by the plant roots. Monier began making **cement pots** and tubs, but these were not stable enough. In order **to strengthen** the cement containers, he **experimented with embedded iron mesh**.

19. He continued to find **new uses** for the material, and obtained more **patents** — iron-reinforced cement pipes and basins (1868); iron-reinforced cement **panels for building façades** (1869); bridges made of iron-reinforced cement (1873); reinforced concrete beams (1878). In **1875 the first iron-reinforced cement bridge** ever built was constructed at the Castle of Chazelet. Monier was the designer.
The important question of strength in tension: **Modern structural concrete differs from Roman concrete** in two important details. First, its **mix consistency is fluid and homogeneous**, allowing it **to be poured into forms** rather than requiring hand-layering together with the placement of aggregate, which, in Roman practice, often consisted of rubble. Second, **integral reinforcing steel gives modern concrete** assemblies great **strength in tension**, whereas Roman concrete could depend only upon the strength of the concrete bonding to resist tension.

20. 1892 the engineer François Hennebique obtains the **patent for reinforcing of slab beams of reinforced concrete**. 1902 the „System Hennebique" gets the patent as **a certified construction method**.
For tension, tensile forces, reinforcing bars of steel embedded.

21-22. A number of **advantages** of reinforced concrete construction's like **higher resistance of fire, of machine caused vibrations, of wet-agressive climatic conditions** of the of chemical or textile industry beside the **great load-bearing capacity** were reasons of wide-spread use.
A skeleton of pillars or columns enabled great free spaces, spans, free facade.

23. A French architect and a world leader and specialist in reinforced concrete construction
At the Rue Franklin apartment the reinforced-concrete frame is for the first time clearly expressed, if not exposed, on the exterior. The frame is covered with smooth ceramic tiles, whereas the nonstructural wall panels are covered with tiles bearing a foliate pattern. The structural frame, in addition, creates point supports that eliminate stationary, load-bearing partitions within the apartments, and this results in potentially flexible, open plans.

24. In his later works, Perret used concrete in imaginative ways to achieve the functions of his buildings, while preserving classical harmony , symmetry and proportions. an extraordinary concrete church, Notre Dame du Raincy (1922-23), where the interior columns were left undecorated and the concrete vaults of the ceiling became the most prominent decorative feature.
Perret raised the material to architectural distinction in such buildings as the three upon which his reputation principally rests: an apartment building at 25b Rue Franklin (1903) and a garage at 51 Rue de Ponthieu (1905), both in Paris, and the Church of Notre Dame (1922) at Le Raincy near Paris.

25-26. The church at Le Raincy is perhaps Perret's most impressive design. Nave and side aisles of nearly identical height are separated by tall, very slender reinforced-concrete columns sustaining overhead thin concrete vaults. The exterior walls surrounding this light, open hall are mere screens of precast, concrete latticework filled with colored glass that changes from yellow at the entrance to purple behind the altar.

27-29. The development of surface structures of reinforced concrete enabled roofing large halls. An early example is Eugene Freysinnets' Orly airport hangar (1921), where he demonstrated with the parabolic catenary arch the impressive dimensions that reinforced concrete could achieve.
This technical complex consists of two vaulted aisles over 300 meters long 60 height, formed by parabolic arcs along a longitudinal directrix.
Structure: thin-shell reinforced concrete parabolic shells
The two hangars were 175 meters long, 91 meters wide and 60 meters high and were constructed on a small airfield. The building envelope was made up of a series of parabolic arches, each formed in the shape of a vault, that when connected, created an undulating pattern, similar to that of corrugated cardboard. Each individual arch was made from separate stacked

components, 7.5 meters wide. These components tapered in depth and measured 4.4 meters deep at the arches' base and 3.4 meters at the crown. The complete span from base to base measured 86 meters.

30. Meeting between the lower supports and shuttering formwork

31. Process placement and removal of the side part of the giant formwork
For its implementation would use a sliding formwork system placed in position by hydraulic jacks Freyssinet group would design specifically as reusable building blocks. Thereby, tried to simplify, and thus cheapen, throughout the construction process and application of materials necessary for such spaces.

32. **Swiss** civil **engineer** who **revolutionized the use of structural reinforced concrete** with such designs as the three-hinged arch and the deck-stiffened arch for bridges, and the **beamless floor slab and mushroom ceiling for industrial buildings**.
Zurich’s Giesshübel warehouse was the first of Robert Maillart’s buildings to be constructed with his patented beamless slab floors supported on **‘mushroom’ columns**. The original warehouse has been much extended and refurbished and now has a mix of commercial and residential uses.
In 1909, Swiss reinforced concrete pioneer Robert Maillart (1872-1940) patented his system of flat slabs supported on columns with enlarged capitals (and sometimes enlarged bases). The following year his company, Maillart & Cie, structurally designed and built a three-unit warehouse on Giesshübel Street in west Zurich.
Inside, the octagonal section columns are formed with hyperbolically curved capitals. The reinforced concrete floors and columns were cast in situ — the impressions of the straight timber planks used as formwork are still clearly visible and highlight the building’s intended functionality. The ground floor columns are much wider than those in the storeys above and the capitals of all columns have a top width more than four times the stem diameter.
The success of the design, which was much more economical to build than conventional floor, beam and column arrangements, led to the construction of another 51 buildings using the same techniques.

33-36. Technology of reinforced concrete in extreme weather conditions.
deck-stiffened arch for bridges, completed Salginatobel (1929–1930) and Schwandbach (1933) bridges changed the aesthetics and engineering of bridge construction dramatically and influenced decades of architects and engineers after him.

37. The Centennial Hall Wrocław, Poland. It was constructed according to the plans of architect Max Berg in 1911–1913, when the city was part of the German Empire. Max Berg designed Centennial Hall to serve as a multifunctional structure to host exhibitions, concerts, theatrical and opera performances, and sporting events.
The cupola was made of reinforced concrete, and with an inner diameter of 69 m and 42 m high, it was the **largest building of its kind at the time** of construction.

38. First with the **invention of surface structures in reinforced concrete** building became possible to find a material appropriate solution for **spanning great halls and this with just a few centimeter thick structure**. With the development of **shell structures** and forms were emerging that had been never seen before.

40-41. **Structural architecture** was emerging in the end of the thirties and characterized the industrial building of the forties and the fifties. Pier Luigi Nervi achieved remarkable span widths through the **addition of small, prefabricated concrete elements**. Nervi was mostly dealing with reinforced concrete. He resolved/took apart the monolythic reinforced concrete in **industrially prefebricated elements**, that were **joint together** and **cast with a thin concrete layer to one on the building site**. The form of the elements and of the whole construction suited the acting forces.

44. Louis Sullivan is widely considered **America's first truly modern architect**. **Instead of imitating** historic styles, he created original forms and details. Louis Sullivan believed that the **exterior of an office building should reflect its interior structure and its interior functions**.
The bearing construction skeleton appears on the facade and gives the proportion of the facade with glazed fields (typical lying form openings).
Ornament, where it was used, **must be derived from Nature**, instead of from classical architecture of the past.
The building served as a major retail destination until Carson's closed in 2007. The building is a **steel structure, allowing for wide, horizontal windows providing natural light** and handy spots to showcase merchandise. Its beautiful rounded tower at the building's corner entrance features cast iron ornamentation.

45-47. An important office building that influences for decades. The building’s exterior is a simple **cliff/cube of brick** with an external expression of the central aisle. Staircases, the building service facilities, pipe shafts are all placed outside the main building at the four outer corners, so that the **entire area might be free for working purposes**. The staircases are toplighted.

The interior of the main building forms a **single large room in which the main floors are galleries, open to a large central court, which is also lit from above**. The general dispositon of the entire plan, working in open galleries looking into a light court, brought a **new sense of working together** without private offices. Moduled office furniture has been designed.

48. As by the Larkin Building Wright wanted to create a closed, **sealed space lit from above**. Emblematic bulding.

49. The main workroom is determined by **white concrete columns forming a forest**. At the top they spread and end in circles, with **skylights** in between. At the corners the walls stop short of the ceiling and so glass tubes continue up, and connect to the skylights.

50. The development in building with reinforced concrete begun in Europe and the USA at the same time. In the USA 1902 **Ernest L. Ransome obtains the patent for reinforced concrete slab construction**. This is a complete system of formwork, reinforcing and grouting. The forming of the "Modern" factory movement in Europe and the forming of the "Model" factory idea in the USA proceeded parallel.

51. The Ingalls Building, built in 1903 in Cincinnati, Ohio, was the **world's first reinforced concrete skyscraper**. The 15-story building was designed by the Cincinnati architectural firm Eizner & Anderson and was named for its primary financial investor, Melville E. Ingalls. The building was considered a daring engineering feat at the time, but its success contributed to the acceptance of concrete construction in high-rise buildings in the United States.
Before the construction of Cincinnati, Ohio's Ingalls Building, the tallest reinforced concrete building was a mere six stories in height. This made the use of reinforced concrete for a **64m** tall building a controversial decision in 1902. The architect for the Ingalls project, W.P. Anderson of Anderson and Eizner, decided to go with concrete construction despite the fact that detractors feared a concrete building would not be able **to withstand wind and concrete shrinkage**. Legend has it that people were so sure the building would collapse that a local reporter once stayed all night outside the building, waiting for it to fall down.
Before the first bucket of concrete was poured, a major battle took place just to get the necessary permits to build the structure. Melville E. Ingalls, president of the Big Four Railroad and the building's namesake, and Anderson **fought for two years** with Cincinnati's building department before finally **convincing** them **of the building's stability and durability**. Anderson chose concrete **because** it was **fireproof and it would be less expensive to build a structure of this size with concrete than with steel**. They **employed methods perfected and patented by Ernest L. Ransome**.
The Ingalls is a massive structure, consisting of solid columns and foundations reinforced with the square-twisted steel bars that Ransome patented. According to the American Portland Cement Manufacturers Association, the Ingalls Building accounted for about one-half of one percent of all the cement used in the United States in 1902 to 1903.

52. In the USA 1902 Ernest L. **Ransome obtains the patent for reinforced concrete slab construction**. This is a complete system of formwork, reinforcing and grouting.
The reinforced concrete system in the USA was **developed by the Kahn brothers in Detroit**. The "Kahn system" as it was patented, was marketed by the newly formed "Kahncrete" company and its subsidiary "Trussed Concrete Steel Company", or "Truscon" as it was often known.
Albert Kahn completed a factory for the Packard Motor Company, Detroit (1903), **the first American reinforced concrete building** and the first with **steel windows** imported from England. These elements produced a lighter building than ever before.
The United Shoe Machinery Factory, Ransome, 1903 and the Packard Motor Company in Detroit, Albert Kahn, 1905 were the first examples built with the new system. **The bearing construction skeleton appears for on the facade and gives the proportion of the facade with glazed fields.**

53. Kahn was then commissioned by Henry Ford to build a new four-storey plant in Highland Park Detroit. It was a huge hall of 288,0 x 22,5 meter, grid of 6,0 x 4,5 m, with a **totally free ground floor plan, while the staircases, elevators, toilets were bound together in outer blocks**. The **elevators** served the **transport of row materials and products on the certain levels**. The parts were transported **from above to bottom to the end assembly using gravitation force**. Putting together first the parts on the upper levels, end assembly on the lower level.

54. Three years later Kahn built the factory to house **the world's first moving assembly line**. This was for the "Ford model T." Ford demanded a building with the focus on **open space, adaptability, free areas suitable for production flow lines** where the planned integrated processes, from the arrival of raw materials to the finished product, could all take place on one level. 1913 **introduction of the assembly line** (production belt) instead of gravitation transport.

56. His next commission was the Ford Rouge plant (1916), a mammoth plant, its **assembly line ran through a series of single storey units**. Here Kahn introduced the use of steel rather than reinforced concrete for its structural framework.

57. After the introduction of the **assembly line** (production belt) in 1913 the **single-storey halls became the industrial building type**. So **by better lighting conditions a more flexible arrangement of machines and manufacturing process** was enabled.
These buildings became known as “Model factories” and their design as the **“Kahn Daylight system”** being based on a **regular grid of column, beam and slab**. Concrete sections were fully exposed and **external wall spaces were glass filled with slender glazing**. Kahn was to develop this design in numerous subsequent factories, all **single storey, all lit from above to enable the floor to be kept clear** for machinery and processes. **Services** such as lavatories and offices were placed at a higher, often **mezzanine level**.

58. Cadillac Place rises 15 stories to a total height of 67 m, with the top floor at 57 m. The building has 31 elevators. It was originally constructed with 110,000 m2 and expanded to 130,000 m2.
Designed by Albert Kahn, the structure consists of a two-story base with four parallel 15-story wings connecting to a central perpendicular backbone. Kahn used this design **to allow sunlight and natural ventilation** to reach **each of the building's hundreds of individual offices**. The entire building is faced in limestone and is crowned with a two-story Corinthian colonnade. In 1923, it opened as the **second largest office building in the world**.
Albert Kahn worked on more than 1,000 commissions from Henry Ford and hundreds for other automakers.

59. In the early part of the twentieth century architects who were starting to react against the superficial historical revivals of this time were **taking note of the potential of new materials, steel and concrete, and construction methods available in industrial building**. The two came together with the partnership between the German firm of AEG and the industrial designer/architect Peter Behrens. Industrialization in Germany was barely thirty years old and the electrical industry spearheaded by AEG was particularly new and full of enthusiastic ideas.
1907 Peter Behrens was comissioned for the **senior engineer of AEG**. He was asked to **design products** for AEG, the packaging, the advertising and the buildings, in short a “corporate image”. The result, building was the AEG turbine factory in Berlin (1909), often claimed as the “first modern building”.
The Turbine factory is standing on the **turning point from historismus to modern architecture**. Behrens understood **construction as form**. The monumentality of the **gable facade** is very strong, **still** from an engineer’s point of view it was **unconsequent**, as the solid butt piers, **heavy gable and cornice have nothing to do with the three-pin frame steel construction behind.**

60. The construction is a consequent **three-pin frame of trussed girders**.
It is a hall with almost **monumental proportions constructed of steel and concrete**, its **sides of glass slope inwards as they rise** which gives it a heavy solid stance on the ground.
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Behrens’ turbine hall was **the first industrial building reaching a status of wide consideration like representative public buildings.**
Beginning in June 1907, Peter Behrens' pioneering industrial design work for the German electrical company AEG successfully **integrated art and mass production** on a large scale. He designed consumer products, standardized parts, created clean-lined designs for the company's graphics, developed a consistent corporate identity, built the modernist landmark AEG Turbine Factory, and made full use of newly developed materials such as poured concrete and exposed steel. Behrens was a founding member of the Werkbund, and both Walter Gropius and Adolf Meyer worked for him in this period.

62. A young assistant in Behrens office at the time was Walter Gropius. Other notable junior members at this time were Mies van der Rohe and Charles-Edouard Jeanneret later known as “Le Corbusier”. They held positions in the **Deutsche Werkbund** who promoted the AEG turbine hall to iconic status and published it in their yearbook of 1913 along with Kahn’s “daylight factories” built in reinforced concrete. The publication **argues for a new architecture that reflected the spirit of the age, that of mass production.**
Also involved with the Werkbund was Carl Benscheidt Sr., a client of Fagus, a shoe last company, in Alfeld an der Rhein. They had already had a reinforced “daylight” concrete factory built by the English agricultural engineer Ernest Ransome and had already started to design the main body of a new factory with the architect Eduard Werner.
Just after withdrawing from Behrens’ office and becoming independent, **Walter Gropius** receives the **comission for the Fagus last factory.**
They asked Gropius in the spring of 1911 to add modern exterior elevations to promote a progressive image. The result was that Gropius imbued a strong delineation to the facade, marked by an emphatic two-storey brick entrance with its apparently floating staircase.

63-64. Possibly **the first use of glass in this way**, Gropius emphasised the glazing and apparently **structural innovation of the pier free corners** seemingly throwing away all means of support.
Gropius reacted to the **requirement of being well-lit by providing a glass facade** and dissolving the corners of the building. He used the **possibility of the skeleton structure for developing the building's corner free of columns**. With this he made an **enormous step from the symbolic architectural language** using heavy columns at the corners of the building – like by Behrens' Turbine hall.

65-66. Bauhaus was an art school in Germany that combined crafts and the fine arts, and was famous for the approach to design that it publicised and taught. It operated from 1919 to 1933.

67. In parallel with structurally oriented architecture another Werkbund architect Hans Poelzig designed a factory of brick masonry. It is a consequent building in construction, as the **outer brick walls are filling the skeleton strucure**. This is strengthened by **setting the windows planar with the brick walls**. As an industrial building type the arrangement followed the production process, still more reacting on the local North German building tradition.

68. Erich Mendelsohn was commissioned to design several branches of the Shocken Department Store. In the one at Stuttgart (1926) he emphasized the horizontal by using continuous-ribbon windows separated with bands of brick. The rounded staircase at the corner of the asymmetrical structure was cantilevered over the entrance.
It constituted an impressive ensemble of modern architecture, and was damaged only lightly in World War II. In 1960, the city of Stuttgart demolished the store, despite international protest.

69. A factory based on Ford's principles, semi-finished products on the differents floors, a racetrack on the topmost floor to test the new cars.

70. **New construction** techniques followed on from Gropius in Europe, which allowed **glass to be used to full effect**. An important example is the Van Nelle Factory in Rotterdam. The **different volumes** of the packing facility and the administrative building **set next to each other, the regular order of the facade** are characteristic.

71. The **glass curtain wall** determine the external appearance. So **the facade entirely of glass shows the structural system**. The interior is articulated by the striking **mushroom ceiling**.

72. Another representative of expressionism is Sir Owen Williams, an early employee of Truscon, who extended possibilities of the use of concrete to Britain. After Truscon, he set up his own company "Williams Concrete Structures ltd" to market his own patent "Fabricrete".
The American company, Jesse Boots commissioned him to build possibly his most noted factory, the Boots "Wets" building in Beeston, near Nottingham. It was a green field site and he was working to a precise brief with production flow lines and required accommodation for precise operations and the links between these operations. The result was a **highly glazed building set around two huge atria** with the production process areas. It was an immense **four-storey slab structure building, set upon mushroom columns set back to allow the outer glass and steel curtain walling to sit uninterrupted.**

73. The result was a **highly glazed building set around two huge atria** with the production process areas. It was an immense **four-storey slab structure building, set upon mushroom columns set back to allow the outer glass and steel curtain walling to sit uninterrupted.**
The production floor was lit from a huge span of bulls eye glazing panels. As yet, nothing had been seen like it in Britain and it could only be compared with the Van Nelle Factory in Rotterdam (1928-30). Both buildings, it should be noted, display no decoration outside.

70. Albert Kahn worked on more than 1,000 commissions from Henry Ford and hundreds for other automakers. Kahn's firm designed a large number of the **army airfield and naval bases** for the United States government. By World War II, Kahn's 600-person office designed the **Willow Run Bomber Plant, Kahn's last building**, located in Ypsilanti, Michigan, where Ford Motor Company mass produced **B-24 Liberator bombers**.
"In 1928 the Soviet Government, after combing the U.S. for a man who could furnish the building brains for Russia's industrialization, offered the job to Kahn. Twenty-five Kahn engineers and architects went to Moscow. They had to start from scratch.„ Kahn's firm's **Moscow** office built **521 factories between 1930 and 1932** in the Sowiet Union.