Architecture of Workplaces 1. Lecture 1

Questions of today and challenges of the future1760 – 1900

31-35. The new Kräuterzentrum (herb center) is situated like an erratic block in the midst of a landscape dotted with conventional industrial buildings. Its elongated shape echoes the pathways and the hedges that have long been a distinctive feature of this area. The length of the building also reflects the steps involved in the industrial processing of herbs, from drying and cutting to blending and storing. The new processing plant enables Ricola to integrate these important steps in the company's own in-house production.

The Kräuterzentrum is built largely out of locally sourced **earth**; it is like a geometrical segment of landscape with its dimensions and archaic impact heightened by the radical choice of material.

The delivery entrance and warehouse sections of the herb center's façade are monolithic, with the **loam** walls visible in the interior as well. The **prefabricated earth elements** are manufactured in a nearby factory out of ingredients extracted from local quarries and mines. **Loam, marl** and material excavated on site are **mixed and compacted in a formwork** and then **layered in blocks** to build the walls. Thanks to the plasticity of the loam, the seams can be retouched giving the overall structure a homogeneous appearance. To arrest erosion caused by wind and rain, a trass mortar achieved mixing volcanic tuff (trass) with lime, is compacted every 8 layers of earth directly in the formwork. Large round windows illuminate the rooms. The façade is self-supporting and simply linked to the concrete loadbearing structure of the interior.

Energy and Sustainability

Energy and sustainability are not simply treated as technical auxiliaries; they are built into the architecture and essential features of the project as a whole. **Earth as a material that regulates humidity** has a positive, sustainable effect on the **use of energy** and **overall climate control**.

53. The first consequent **multi-storey skeleton structure** on the European Continent. One of the first multi-storey buildings with a **steel frame** construction. Extension over the Marne River. Over the massive bridge piers a multi-storey iron skeleton frame is constructed. The steel frame is filled with non-bearing walls made of hollow bricks.

41-47. The project was realised as an extension of a small but remarkably successful vineyard. The wine producers wanted a **new service building**, consisting of a large **fermentation room** for processing grapes, a **cellar** dug into the ground for storing the wine barrels, and a roof **terrace for wine tastings** and receptions. Bearth & Deplazes Architects designed the project, and it was already under construction when they invited us to design its façade.

The initial design proposed a **simple concrete skeleton filled with bricks**: The masonry acts as a **temperature buffer, as well filtering the sunlight for the fermentation room** behind it. The bricks are offset so that daylight penetrates the hall through the gaps between the bricks. Direct sunlight, which would have a detrimental effect on the fermentation, is however excluded. **Polycarbonate panels** are mounted **inside** to protect against wind. On the upper floor, the bricks form the balustrade of the roof terrace.

The **robotic production method** that we developed at the ETH enabled us to **lay** each one of the 20,000 **bricks** precisely **according to programmed parameters**—at the desired angle and at the exact prescribed intervals. This allowed us to design and construct each wall to posses the desired light and air permeability, while creating a pattern that covers the entire building façades. According to the angle at which they are set, the individual bricks each reflect light differently and thus take on **different degrees of lightness**. Similarly to pixels on a computer screen they add up to a distinctive image and thus communicate the identity of the vineyard. In contrast to a two-dimensional screen, however, there is a dramatic play between plasticity, depth and colour, dependent on the viewer's position and the angle of the sun.

The masonry of the vineyard's **façade** looks like an **enormous basket filled with grapes**. At closer view – in contrast to its pictorial effect at a distance – the sensual, textile softness of the walls dissolves into the materiality of the stonework. The observer is surprised that the soft, round forms are actually composed of individual, hard bricks. The façade appears as a solidified dynamic form, in whose three-dimensional depth the viewer's eye is invited to wander. In the interior, the daylight that penetrates creates a mild, yet luminous atmosphere. Looking towards the light, the design becomes manifest in its modulation through the open gaps. It is superimposed on the image of the landscape that glimmers through at different levels of definition according to the perceived contrast.

48-50. Vogelensangh, a brick factory with a rich history and the only one left where bricks are produced in traditionally coal-fired kilns, commissioned Bedaux de Brouwer Architects to design a contemporary pavilion. This resulted in a design that both in its exterior and interior emphasizes the timeless beauty of the tradition of **hand-moulded brick**.
The pavilion functions both as reception and office space, and complements the adjacent factory, which has been operating since 1919. The design process started on site and the design reflects the purity and simplicity of manufacturing bricks.

The pavilion, that materializes as an elongated volume with a fairly closed, brick-built entrance wall, is located on top of an elevated plinth. The bricks, that are produced on site, have purposely been laid in a simple **bond** that refers to the rational way bricks are stacked during fabrication.
On the inside, the building opens up to its surroundings through a glass facade that stretches over the entire width of the building. The clear view on the monumental factory, the busy site and the rural scenery offers an impressive panorama. The interior is characterized by **vaulted brick ceilings**, inspired by the traditional ring kiln. Just like this ring kiln, the pavilion exists of a rational sequence of rooms, each with its own purpose. Utility rooms have been located next to the closed wall, the other rooms are located at the 'open' side of the building. All in all, a pavilion that is closely related to its environment, not only designed for, but also materialized with and inspired by the client.

57-60. 101m long, 24m wide, 9m high volume corresponding with the rows of wines. A long massive volume of stones. From a distance a rather monolithic view, getting closer differs from partly transparent to fully glazed fields of the interiors. The density of the wall varies according the function behind, changing the degree of transparency.
The envelope is made of stone to store the heat and protect from cold, thus making the best use of the climatic conditions. The façade is made of gabions; a typical construction of retaining walls. Prefabricated meshes form baskets and are filled with basalt stones from the region. Mock-ups were built on the site before constructing in order to test the appearance of the wall, to which degree it allows light into the building.

62-65. The first bridge made totally out of iron with a span of 30 meters. Assembled of prefabricated iron elements cast in Darby's local foundry. A pressed arch construction that follows the principle of brick arches.

38. The sample of pressed arch construction of Coalbrookdale bridge was followed by a number of iron bridges assembled of cast iron elements.
Telford was a Scottish civil engineer, architect and stonemason, and a noted road, bridge and canal builder. The bridges, viaducts, factories and warehouses of the eighteenth and nineteenth century were on the whole the work of **practical men and engineers**. Architects as such didn't deal of such mundane work. Their work had often been limited to adorning/ decorating an engineered building.

67-70. Round 1800 the **better quality** of iron enables the production of **wrought-iron elements** that can be used for **tensile force**. Suspension bridge, Menai, Island of Anglesey, Wales, Thomas Telford, 1819-1826
biggest span: 177 metres, total length: 521 metres, height: 30 metres

71. English mechanical and civil engineer, the most determining engineer of the 19th century. His designs revolutionised public transport and modern engineering.

72. Today still is a mainline station, was the London terminus of the Great Western Railway. Brunel astonished Britain by proposing to extend the Great Western Railway westward to North America by building steam-powered iron-hulled ships. He designed and built three ships that revolutionised naval engineering.

73-74. The bridge (of bowstring girder, or tied arch construction) consists of two main spans of 139 m, 30 m above mean high spring tide, plus 17 much shorter approach spans.

75-77. Round 1800 the **better quality** of iron enables the production of **wrought-iron elements** that can be used for **tensile force**. So the possibilty of **chain bridges**, like the bridge Conway, Wales 1826.
The Clifton bridge is an important trendsetting example in bridge-building, the longest span of any bridge in the world at the time of construction. Roller-mounted "saddles" at the top of each tower allow movement of the three independent **wrought iron chains** on each side when loads pass over the bridge. The bridge deck is suspended by 162 **vertical wrought-iron rods** in 81 matching pairs.

78-79. The use of **steel cables** enabled significant increase of the bridges' span. Wire rope suspension bridge designs. At the time, it was the longest suspension bridge. It was **the first steel-wire suspension bridge** constructed.
In the USA transportation between eastern industrial hubs and frontier farming markets had become a matter of both national and popular interest. Many transportation projects were underway near the location Roebling chose for his colony, but instead of continuing an engineering profession, he took up farming. In 1837, after the death of his brother and the birth of his first child, he returned to engineering as a vocation.
Roebling's first engineering work in America was devoted to improving river navigation and canal building. Roebling began **producing wire rope** at Saxonburg in 1841. At that time canal boats from Philadelphia were transported over the Allegheny Mountains on railroad cars to access waterways on the other side of the mountains, so that the boats could continue to Pittsburgh. The railroad cars were pulled up and down the inclines by a long loop of thick hemp rope, up to 7 cm thick. The

hemp ropes were expensive and had to be replaced frequently. Roebling remembered an article he read about wire ropes. Soon after, he started developing a 7-strand wire rope at a ropewalk that he built on his farm.
Roebling's next project, starting in 1851, was a railroad bridge connecting the New York Central and Great Western Railway of Canada over the Niagara River, which would take four years. The bridge, with a clear span of 825 feet (251m), was supported by four, ten-inch (25 cm) wire cables, and had two levels, one for vehicles and one for rail traffic.

80-81. The very first example of **industrialized construction** is not a real industrial building, it is a huge exhibition hall for industrial products. It was built for the 1st World Exhibition and is the main representative of **cast iron architecture**. Competition for designs for the London International Exhibition of 1851.
Paxton was neither an architect, nor an engineer, but he was the chief gardener of a prince. Joseph Paxton as a learned gardener had used experiences of greenhouse-building. He planted and carried out several palm houses according his own design. The Crystal Palace had a construction made of cast iron, covering surface totally made of glass, a 92 000 m2 basic area.

82. The construction had a basylican system with several bays. Paxton utilized bravely the **constructional and formal opportunities** hiding in the new materials: **iron and glass**. He built a **semi-transparent glass-hall** with walls rising fast weightless. Looking out from the enterieur the boarder becomes indistinct between inside and outside. The **massive wall architecture lost its validity** from here on. The example had an **effect of a revolution**.

83. The demand for planning and erecting a huge exhibition hall within less then twelve months (!) required **new methods** for production and assembly. It was the first time that **standardized elements were prefabricated in series production**. Certain groups of workers were responsible only for certain work phases, as an early sample of **organization of work**.
Paxton **moduled the dimensions**. He planned according to a module which was convenient with the dimensions of the glass boards in English industry. So he reached that the production works of the building could be divided between several factories and the whole work was finished in 6 months. He demonstrated that the methods of mass production are useful in architecture too.
Later the Crystal Palace was settled on a new place, where it existed until 1937, then it was burnt.
The series of exhibition halls started with Paxton's Chrystal Palace.

84. The series of exhibition halls started with Paxton's Crystal Palace. The World Exhibitions in the second half on the nineteenth century promoted the development of steel structure halls, the largest example of which was the Galerie des Machines in Paris of Contamin and Dutert, built for the World Exhibition Paris, 1889.
That time experiments were made with the new materiel: steel. The Machine-hall, Paris represents the results achieved. The Galerie des machines formed a huge glass and metal hall with an area of 115 by 420 metres and a height of 48.324 metres, it was free of internal supports. The framework consisted of twenty trusses. The structure incorporated the **three-pin hinged arch**, developed for bridge building.

85. The biggest span achievable had been round 40 m in architecture so far. (Pantheon, later the domes of Dom in Florence and S. Pietro in Rome) This dimension was not altered, exceeded by cast iron constructions either. But here the span of **three-pin frame of trussed arches with a span of 115m**! (48 m high). Even the shape of the frames was estonishing, quite new.

86. Following the static principle, the trussed arches were **tapered at the supports**. In traditional stone architecture the law was common that the load bearing support thickers smoothly dawn-wards, according to the net weight. Here the section of the construction was –vica versa- the smallest at the support – so gaining a feeling that it spans the huge distance without effort, without load. Most part of roof and facade were glazed.
This example helped architecture **to get rid of historical forms** an make a step forward to modernism.

88-90. Construction: twelve 100 m-high support towers: steel masts of space truss, suspended steel trusses. The canopy is made of PTFE-coated (Poli(tetrafluoretilén)=teflon) glass fibre fabric, a durable and weather-resistant plastic, and is 52 m high in the middle - one metre for each week of the year. Its symmetry is interrupted by a hole through which a ventilation shaft from the Blackwall Tunnel rises.
Externally, it appears as a large white marquee with twelve 100 m-high yellow support towers, one for each month of the year, or each hour of the clock face, representing the role played by Greenwich Mean Time. In plan view it is circular, 365 m in diameter — one metre for each day of the year — with scalloped edges.

91-92. Reinvention of concrete 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.

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.

99. **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, 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**.
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.
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100-102. 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.

104. **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.

105-107. 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.

108-109. a French architect and a world leader and specialist in reinforced concrete construction

110. 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.
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.

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113-115. 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.
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**.

116-117. 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.

118-123. Technology of reinforced concrete in extreme weather conditions.
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**.
His 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.

124-126. **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.

127-134. 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.

137-142. The entire region is part of the Balaton Highland National Park, whilst however the upper section of the wine route belongs more to the natural landscape (as well as to the cultivated and terraced vineyard hillsides), the processing building on the lower site form part of the single level free standing style of the town. Whereas the urbanising process is only characteristic of recent decades, in general the viticulture of the Balaton Highland, (fundamentally rooted in its character, by its nature,") has to connect more with nature.
An important question then is with what formal method can the building which is of a relatively large-scale compared with its environment be managed. The single reference point can only be the earthbound architecture of the vine (the press house and the retaining wall) as well as nature itself.
The building is composed of connected **panel** elements, which were cast as **monolithic visible concrete**. The neutrality and rigidity of this is primarily detectable in the internal spaces and their relationship. There were two places where the dressing of the model, thus the addition of secondary ornamentation was necessary: when meeting the outside and at the cellar section for barrel maturation. For the former, following the principle of being like a model, the differentiation of the facades and the roof is missing; their homogenous covering is made up of **prefabricated fine concrete facing panels**, with a slightly transformed pattern of grapevines climbing and twining around them. If natural lighting needs to be provided in the inside spaces, the bands in the reinforced concrete model, following its geometry, were replaced by a light structure and glass cladding and the facing panel by a **perforated metal sheet**. Naturally the same grapevine pattern continues on this latter one, pulling it together into a unified surface.