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# BRICK BY BRICK REDRAWING
## A Digital Approach to Dismantling and Reconstructing a Historical Building

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**Abstract:** This article reflects upon the methods I used to investigate the relationship between the structure and the facade construction of industrial architecture. In Berlin in particular, iron and brick have been a constructive characteristic of the first third of the 20th century. The tool of technical drawing proved particularly effective in the preliminary investigation. After choosing to investigate buildings that still exist today by means of a critical redrawing, fragments were gradually dismantled and the construction hypotheses took on the character of a redesign of the elements. With the help of recent drawing technologies it was possible to reconstruct a »technical style«, obtained by comparing different fragments represented in the same way. Three-dimensional modeling allowed the physical reconstruction of portions of the buildings digitally, brick by brick.

**Keywords:** Redrawing; Iron Architecture; Brick Architecture; Construction Techniques.

## Introduction

In September 2019, I was traveling to Berlin for the first time as part of my doctoral research whose theme is the construction techniques of industrial architecture that was built between 1913 and 1926. It would give me the opportunity to compare the work carried out up to that point by analyzing historical and bibliographical sources with the buildings object of my case studies. The relationship between two materials, iron and bricks, is expressed in different ways in the period that goes from the construction of the Loewe *Maschinenhalle* by Alfred Grenander (1906), to the completion of the *Wernerwerk Hochhaus* Siemensstadt by Hans Hertlein (1928). Anyway, the hybridized grammars of the constructive system find their synthetic expression in the AEG *Großmaschinenhalle*, built in 1911 by Peter Behrens (Buddensieg

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1978: D76–81) or the *Umspannwerk* Kottbusser Ufer, built in 1924 by Felix Thümen and Hans Heinrich Müller.[1]

From a theoretical and constructive point of view, the German experience at the turn of the 19th and 20th centuries has contributed significantly to a more precise definition of the issues in the relationship between form and construction. Although the topic has been the subject of several publications, analytical studies concerning the construction of these buildings are still missing. Identifying the characteristics of industrial construction in Berlin, I focus deeply on the study of the techniques and technologies employed. Exhaustive introductory research into Berlin's industrial architecture has already been carried out by Julius Posener (1979) and Miron Mislin (2002).[2]

The industrial building represents an interesting form of architecture stretched between the abstract and the functional space. The construction associated with it is often elaborated on principles of economy and functionality, as well as on experimental choices, and is sometimes influenced by the work machines that are placed inside. Starting from the 1910s, industrial architectures built in Berlin became a way to research a valid alternative to the historicist facades that were prevalent in industrial design during the 19th century (Mislin 2002: 249). Until the beginning of the 20th century, industrial buildings were composed of two parts: the structure, generally designed and built for functional purposes only, and conceived by engineers; and the shell, often full of decorations, with the sole purpose of presenting the building in an aesthetic form, often designed by architects (Mislin 2002: 201–228). The change in the sensibility of the architectural context generated a different approach to industrial architecture. Architects and engineers worked simultaneously, influencing each other. In this way, the engineering struc-

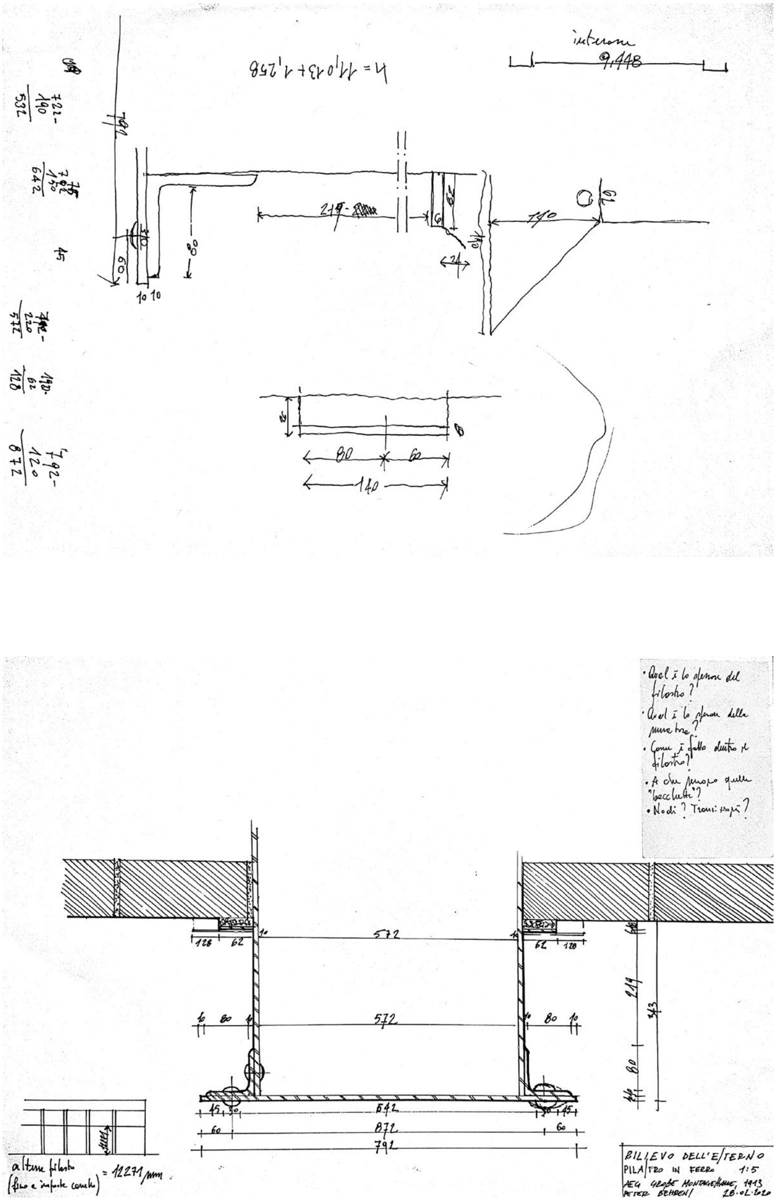
1 The following buildings should also be mentioned: the *Schaltwerk Hochhaus* Siemensstadt, built in 1926 by Hans Hertlein (Hertlein/ Schmitz 1927; Hertlein 1928; Ribbe/Schäche 1985: 657); the *Großkraftwerk Klingenberg*, built in 1925 by Waltar Klingenberg and Werner Issel and the AEG construction department (Klingenberg 1926; Laube 1927; Rein 1928; Lorenz/May/Staroste 2020: 294–297).

2 The latter in particular has provided a classification of construction techniques by comparing the different types of buildings and inserting the technical problem in a broader system of historical and theoretical knowledge. A few researchers have recently addressed specifically the evolution of the historical and technical context after 1910, among them the contributions on Berlin »Elektropolis« (Dame 2011; Dame et al. 2014), on iron structures techniques (Prokop 2012), the compendium of structures »Ingenieurbauführer« (Lorenz/May/Staroste 2020), and the study on the brick construction techniques (Potgeter 2021).

tures acquire an architectural value with proportional and volumetric studies, while using the engineering knowledge to express the new »technical form« (Poelzig 1911).

In Berlin, the introduction of iron as a fundamental element for the load-bearing structures of large-scale industrial buildings is dated to the first half of the 19th century (Mislin 2002: 158). The ability of this material to respond statically to various stresses and the practicality of its use during construction had accelerated experimentation in the technical field. This technological push had created a fracture between the structure of technical buildings and the envelope (Posener 1979: 369): the former was conceived and built with the sole purpose of serving its function; the latter, on the other hand, had an aesthetic function. The design of the latter was for a long time the only field of action of architects in the industrial context (Lindner 1978; Poelzig 1911). A change in sensibility, mainly due to the desire to move beyond the styles, occurred at the end of the 19th century when some attempts to synthesize the structural and facade systems began to be made (Posener 1979: 387). Most of Berlin's industrial buildings produced between 1898 and 1928 consist of a masonry structure and an iron structure, which, depending on the case, are built subordinately or coordinated in static operation. Given the need to free up space for production, the element of synthesis of the relationship between form and structure is identified in the facade. Attempts to codify a language led to the spontaneous emergence of a style in industrial architecture. This »technical style« owes its grammar to structural and functional needs. Recent research on the subject has demonstrated a continuity in the constructive conception of these industrial buildings, which also suggests the existence of a sort of »collective design« obtained with the contribution of several professional figures and the fruitful collaboration of different technicians (Dame 2011). The cooperation of architects, engineers, and construction firms, coordinated through the work of their technical offices, caused the language of industrial construction to develop from certain recurring characteristics in the designs of Berlin's technical architectures.

In order to understand the dynamics that led to the construction of these buildings, I set myself the goal of disassembling them, in digital drawings, and analytically studying their individual technologies and materials to reconstruct the architectural artifact starting from a »ground zero« of the construction. The disassembly of these buildings is carried out through the description of the individual parts and, as a whole, the return to drawings that allow us not only to understand and study the problem of the relation-




*1.*

*Survey sketches of the 1913 AGE Große Montagehalle by Peter Behrens: Franco Davide, 2020.*

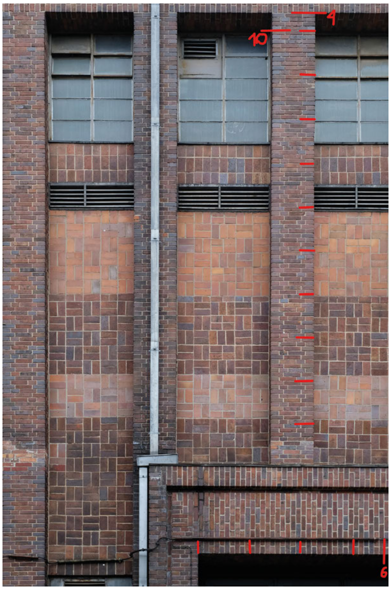
ship between technique and technology, but also to present it and make it intelligible.

## Research Focus

To understand the relationship between technique and construction, it is necessary to investigate its material components. Through the comparison of technological systems and building techniques it is possible to frame the state of construction in an epoch. A possible method to investigate a building has been codified over time in a process that begins with finding sources and represent them as evidence through an architectural survey, in a drawing of the situation present to the researcher (Schuller et al. 2017: 14–15). In the archaeological field, traces of building bodies are detected and studied in order to understand the construction techniques and return the shape of a building, often through hypotheses (De Mattia 2012: 134–138). These are supported by comparisons with the current theoretical knowledge and with similar buildings (chronologically or stylistically) of which certain details are better known (Gruben 2007: 32–37). Similarly, in the case of these industrial architectures, it was necessary to survey the contemporary situation and compare it with the original one through the building plan, in order to understand the evolution of design and the motivation that might have led to a different realization of the work.

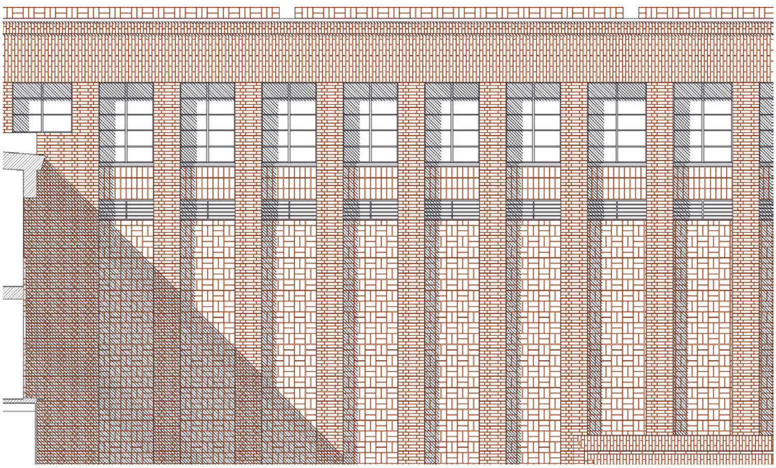
Therefore, in order to understand how a certain building was constructed and with which technologies, it would have been useful to go through the archaeological method. However, what in archaeology is carried out as a reassembly of parts through the study of fragments, in my case has turned into a disassembly of parts and the comparison of fragments that I considered significant. Although the fundamental part of the work was the survey, the aim of the study was still the abstraction of building techniques and their comparative analysis.

A general survey began with a complete cataloging of the state of the knowledge, gathering information mainly on buildings still existing today. The information came from various sources: bibliographical and archival. In the first case, the considerable production of publications, manuals, and material published in the form of books at the beginning of the last century, made it possible to trace many buildings and their descriptions. The archival material, on the other hand, consisting of project reports, drawings, and




2.
*Using a photo editing program, bricks can be counted easily.*
*Photographer: Franco Davide, 2020.*

4.
*Detail of the main elevation of the Kleinturbinenhalle, Heizkraftwerk Klingenberg.*
*Photographer: Franco Davide, 2020.*



3.
*Photo of the north elevation, 1927. Every brick layer is clearly visible.*
*Courtesy: Vattenfall Historical Archive (BEWAG).*

photographs, suffered damage during the two world wars and material was lost due to the relocation of offices.

The collection of this material served as support for the metric and photographic survey of the building. Among the most important material found, there are some technical drawings and high-resolution site photographs. Other technical drawings, used as references, were commonly published in trade journals and, in the case of Hertlein's work for Siemens and the Klingenberg power plant, were published in books introducing the building (Ribbe and Schäche 1985). The AEG buildings (Buddensieg 1978; Rogge 1983) and the Klingenberg power plant, were extensively documented in individual construction phases as one of the largest infrastructure constructions of public interest (Dame 2011: 269).

The metric survey, I carried out on my own in several tranches from September 2019 to January 2022. The difficulty in obtaining permits for access to the various parts of the buildings for measuring it, meant that the resources to be employed would have been great and accurate preliminary planning work would have been fundamental. In addition, the lack of technical support for the survey had proved decisive (Krautheimer/Corbett/Frankl 1937: XV). Therefore, the use of the laser detection and ranging technology (LIDAR) had to be excluded. The only inexpensive tools at my disposal were a flexible and a rigid meter, a 20-meter roll, a laser distance meter, and my camera. In order to always have the buildings close by, I moved my residence to Berlin for the duration of my PhD.

## The Process of Redrawing

The operation of »critical redrawing« constituted one of the principles of philological investigation of the building in the 19th century (De Mattia 2012) for researchers called »*Bauforscher*«. These were architects particularly interested in the archaeological field. With their experience as builders, they were able to reconstruct the buildings of antiquity and, at the same time, retrieve from them important information for designing from scratch. Schinkel is generally referred to as the first »*Bauforscher*«, although he never attended an archaeological site (Gruben 2007: 50).[3]

3 »Critical redrawing« is one of the research tools used by the technology department of the Faculty of Architecture at the Politecnico di Bari (Ardito 2014). It is rooted in a

An important design feature of industrial buildings is their vocation for seriality which, in the case of mixed iron and brick structures, is amplified. The brick used in a building can be of a few different sizes; the structures almost always have a regular pitch; the iron elements are designed to be assembled in an elementary way and have a tendency toward the simplification of geometries and thickness which corresponds to an ease of redesign. Considering these elements, the survey activity was divided into two parts. The first one was the analysis and metric survey of the single portions reachable and measurable with a laser disto or a metric roll (fig. 1). A second one consisted of an accurate general, and detailed, photographic campaign which allowed for the reconstruction of entire portions of the building using computer software. Not having the possibility to work in a prolonged manner in the field, the work done later at home became decisive.

The first phase of the survey involved the recognition of homogeneous structures in terms of materials and construction. Of these, portions of approximately one square meter were photographed and the size of individual elements was noted. Iron structures often had replicated dimensions or standardized elements (Büttner 1928; Müller 1928; Herbst 1930; Prokop 2012). The masonry structures, almost always in clinker, presented hand-baked bricks whose dimensions had deviations of +/- 5 millimeters and irregular mortars, but were still traceable to an ideal average size of 10 millimeters. In order to understand the starting size of the element, that is the one chosen by the designer, it was necessary to compare the dimensions detected, and the material, with those present in the catalogs and manuals of the time. The brick-building system also has the advantage of having portions of the structure that are multiples of the size of the bricks themselves: the interaxis of the openings, pillars, and pilasters, etc. The survey of these portions for obtaining the dimensions consisted of counting the bricks that were visible on the facade (fig. 2).

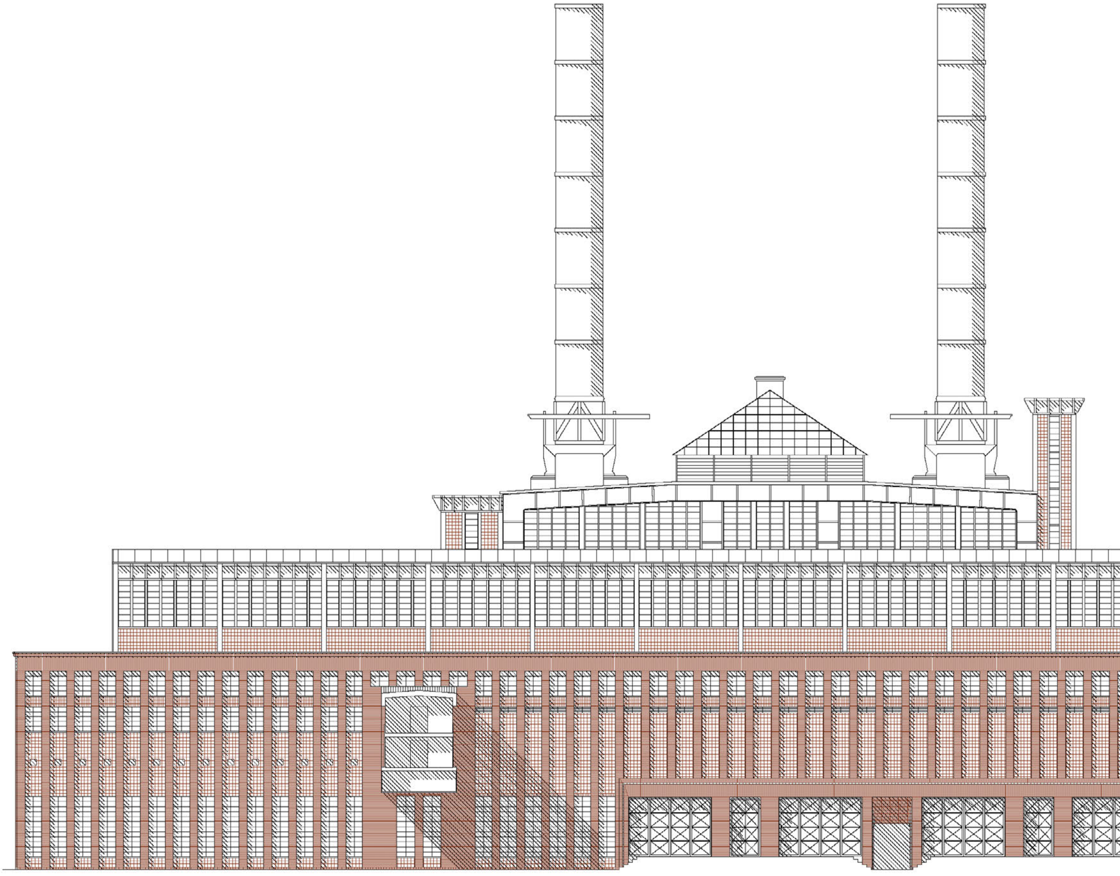
This operation, however, needed to be deepened by analyzing the statics of the masonry construction in the case of the *Prüßwand* (Schumacher 1985: 136–137), whose structure is understood to be an iron lattice simply infilled with two facings, divided by a layer of air. The masonry texture of the nucleus almost constituted a separate investigation: to the same appearance on the facade, corresponded different possible internal dispositions of the ash-

well-established method that is the basis of important publications, such as the *Corpus Basilicarum Christianarum Romae* (Krautheimer/Corbett/Frankl 1937).

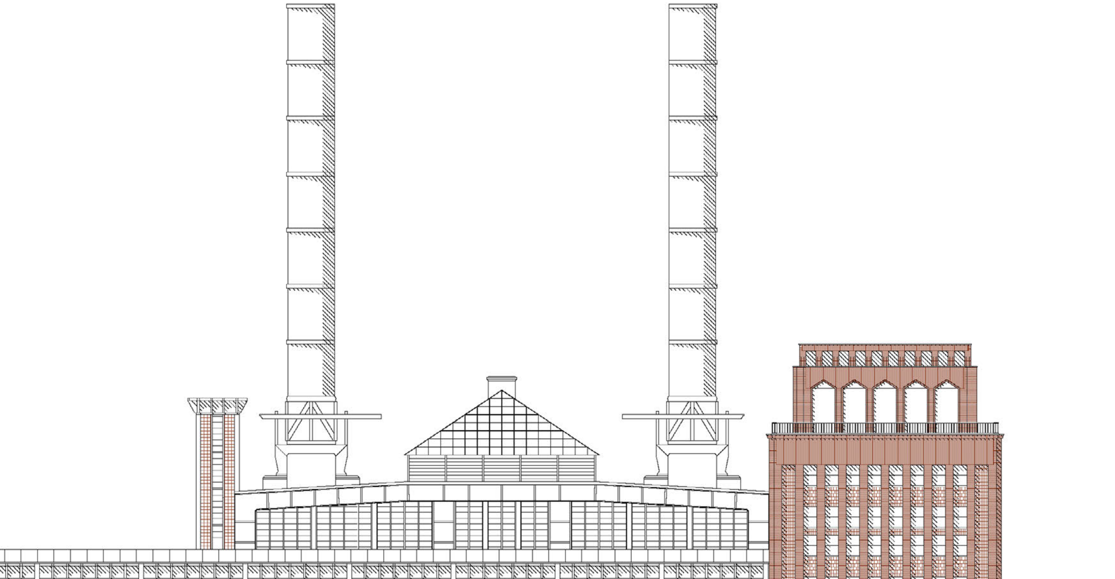
lars. These have been recovered from the manuals of the time. Some dispositions are traditional and well known to masons, others have instead an experimental nature and serve to solve the problem of structural hybridization. The iron parts with riveted box structures have a sheet thickness of 10 millimeters and a rivet diameter of 20 millimeters. The technology, which is consistently repeated, is for example used by the AEG construction department in the buildings they design and construct: the journal *Der Stahlbau* in the 1928 presented many buildings designed by them in which the same patterns of structure are used. Buildings that use profiled iron structural elements instead are easily traceable to the dimensions given in the manual. Some buildings have constantly been compared with design reports and specific drawings, published mainly in the form of demonstration pamphlets or in articles from specialized magazines (Rudolf Laube 1928). The elements embedded in the masonry, undetectable by an external survey, could be redesigned thanks to a comparison and a positioning given by the contingency of the space necessary to the construction of the organism.

The process of reconstructing the nucleus started therefore from a plan design of several overlapping rows (fig. 3). Subsequently, this drawing was implemented through the design of a »by handbook« configuration. Finally, the »critical redrawing« obtained was again compared with the actual state to understand if it was a plausible and functional solution in all parts of the building. Thanks to the available site photographs it was possible to draw the construction of the structural cores with more accuracy and to establish the relationships between the different techniques and technologies (fig. 4).

Since the survey and redesign were carried out at a scale that tended from the detailed to general, the final drawing also absorbed this characteristic. The portions of the building were redrawn at a scale of 1:20, preferring the restitution of the parts that constituted »constructive modules«. Subsequently, with the help of photographs, the missing parts of the buildings were saturated, obtaining the overall drawings of the fronts in scale 1:50 (fig. 5). The peculiarity of this process lies in the fact that the drawings could be performed away from the building without necessarily being able to reach all parts of it. Thanks to the use of photographic and historical documentation, it was possible to count the rows of bricks, obtain the apparent textures, and establish with sufficient approximation the dimensions of the structures. For example, the north face of the *AEG Großmaschinenhalle* has 251 rows of bricks measuring 65 x 115 x 240 millimeters with a »*Kreuzverband*« texture. The pilasters of the tower of the Klingenberg power station are built with 425



*5.*
*Main elevation of the Kleinturbinenhalle, Großkraftwerk Klingenberg.*
*Drawing: Davide Franco, 2020.*

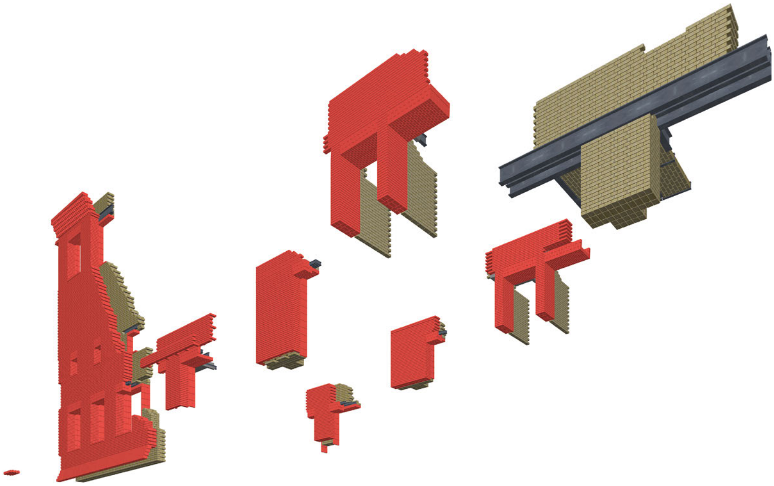


rows of bricks measuring 65 x 120 x 250 millimeters. In this way I could also reconstruct the height of the buildings.

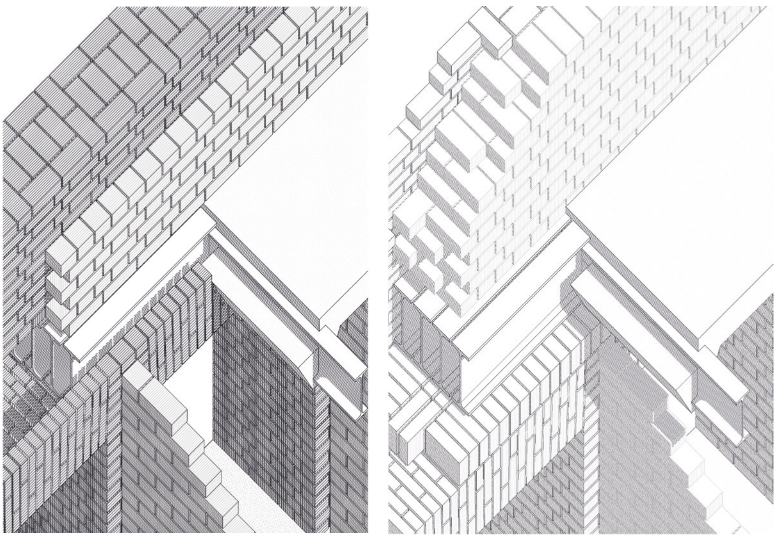
However, the replicability of the construction remained at the stage of appearance. The redesign of the *Umspannwerk* Kottbusser Ufer building is a case in point. The structure expresses the use of large masses and a distinct boxiness. However, bibliographical sources indicated the presence of predominantly iron-frame buildings with a secondary masonry system concealing the load-bearing part in the work of the architects Felix Thümen and Hans Heinrich Müller (1879–1951), all designed for the *Berliner Städtische Elektrizitätswerke Aktien Gesellschaft* (BEWAG) between 1922 and 1930. No historical photographs were found. The initial survey was therefore performed assuming a frame system concealed by the two-face masonry thickness. The external face is composed of violet clinker measuring 52 x 105 x 220 millimeters and the internal one of yellow clinker 65 x 120 x 250 millimeters.

My photographs showed some incongruities between the rules of frame construction — which is presumed to be made of discrete and punctual elements generally aligned up to the foundations — and the actual construction of the building. The most obvious detail was the thin thickness of the *Schalthaus's* mezzanine floor facings which prevented the placement of the steel mullions. A three-dimensional model of the portions of the building was created on computer-aided design (CAD) software. The model replicated the masonry construction on a 1:1 scale, modeling each dimension of the ashlar, and rebuilding the masonry portion digitally but with a handcrafted process (fig. 6). Only the accurate replication of the masons' work could somehow suggest the structural syntax of the masonry. Despite the possibility of reading the dimensions of the steel parts — reported on an original plan kept in the Vattenfall archives[4] — five different models were made, one after the other, each with small variations: the arrangement of the lintels, the arrangement of the ashlars, the relation between the iron parts, and the masonry ones. A further question was raised by the thickness of the masonry, which in the drawing's reported dimensions of 510 x 640 millimeters, actually found in the dimensional survey of the building. Only the last model definitively agreed that the thing detected corresponded with the thing guessed, and coherently explained the different parts of the building: these are load-bearing wall boxes resting on linear steel elements. The floors are

4 Part of the BEWAG Archive has been absorbed by the Vattenfall and is currently stored in a building next to the Klingenberg power plant.



*6.*
*Constructive fragments seen on CAD 3D modeling.*
*Drawing: Davide Franco, 2020.*



*7. – 8.*
*Schalthaus Kottbusser Ufer. First (left) and last (right) hypothesis.*
*Drawings: Davide Franco, 2020.*

made with a steel structure embedded in concrete resting on the wall box: in this way, there is no need for the beam to correspond to a solid, to a pillar in the facade. The holes are obtained by means of flat bands that hide steel girders (figs. 7 and 8).

## Aesthetics of Redrawing

The critical redrawing carried out at such a detailed scale allowed for an understanding of the experimental techniques that were avant-garde elements of industrial design in the 1920s. Moreover, the disassembly of each part of the buildings returned a picture of the overall situation of the construction that allowed the introduction of the concept of »technical style«.

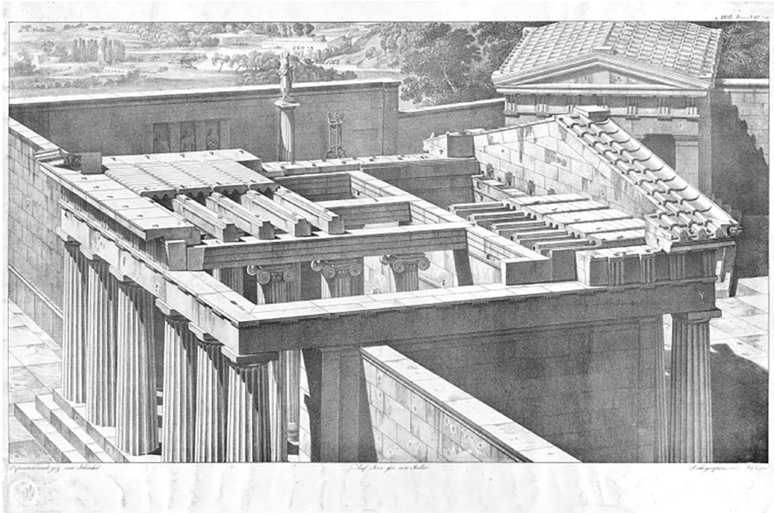
In the choice of the graphic expression to be used, two drawings fascinated me: the first is the ideal construction site of a Greek propylaea (fig. 9), made by Karl Friedrich Schinkel (Schinkel 1821: 63), the second is the collection of detailed axonometries (fig. 10) made by August Choisy (Choisy 1873). In both cases the organic idea of the building passed through the ideal representation of one of its constructive fragments. Schinkel's drawing represents the elements of the propylaea construction (elevation and roof) in a way that suggests the process of building the individual elements, as »unfinished« that aims to describe how the building is made and the logical sequence that unites the various technological elements. Choisy's axonometries, on the other hand, have the aspect of a fragment, that is, a portion of the organism considered by the author to be significant enough to constitute a drawing. In contrast to Schinkel, this type of representation does not aim to describe the construction phases, but is rather a, so to speak, anatomical dissection: the single parts of the construction are clear, but they are always traced back to the unitary and whole idea of the building.

My intuition that guided the initial categorization of the case studies was then confirmed by the empirical activity of survey and redesign. Those architectures that at the beginning were interesting from a historical-critical point of view proved to be milestones in the process of consolidation and diffusion of a constructive thought concerning technical buildings in the Berlin context. The two-dimensional redrawing carried out with an initial 1:50 scale detailed and then deepened or simplified, that means brought between the scales 1:200 and 1:10, showed the material continuity and allowed me to understand the design and construction phases of each building and to compare them, obtaining an overall picture of the construction technique. For example, the clinker wall construction of the *Umspannwerk* Kottbusser Ufer reveals the dualism between structure and tectonics (Frampton 2005). The drawing in the masonry core would show that the building was conceived with a single clinker dimension like the other pre-1924 buildings designed by Felix Thümen. A hypothesis for the difference in the treatment of the facings can be then explained with the chronological coincidence of the construction of the building and the architect Hans Heinrich Müller joining the BEWAG's technical office, whom might have suggested the introduction of purple clinker out of a need for the appropriateness of language in the urban context (Hoffmann-Axthelm 1986; Potgeter 2021).

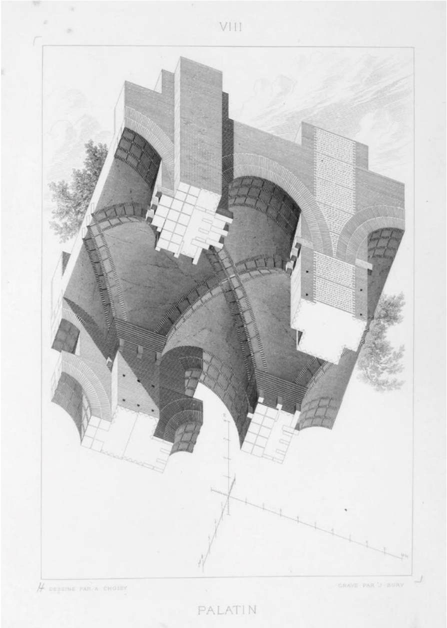
The analysis and hypotheses concerning the building cores made it possible to make explicit the relationships between different architectures. The tower structure of the Klingenberg power station is directly comparable to that of the *Schaltwerk Hochhaus* in Siemensstadt. The system of two profiles joined by a steel sheet is described by Hertlein (1928) and can be seen in the site photos (Hertlein 1928, 23; Vattenfall Archives). The *Kleinturbinenhalle* of the Klingenberg power plant, apparently consisting of only six-headed pillars, conceals an iron structural system. In this case, the discretized masonry becomes an unprecedented element of mediation between the language of the discrete and the continuous system. Again, the critical redrawing provided the basis for reading the building and revealed the complexity of the designers' thinking.

Since my research had initially assumed traits of continuity within the study of historical architectures, I decided to rely completely on a graphic restitution as close as possible to that of my references. This feature was extremely efficient since the same »skeletal« drawing, which I had used for the study of the building, presented itself in the printing phase with a bare and technical aesthetic. The presentation of general elements was enriched with information and contingencies in the drawing of the details. The substantial difference between the drawing elaborated on CAD and the drawing executed in an »analogical way« is found in the infinitesimal precision of the vectorial drawing and in the possibility of multiplying the elements with a single command. The construction of the drawing itself is more mechanical, but the restitution is obviously more precise. The digital instrument also allows an immediate interscalarity.

The line drawing has meant for me the instrument of study and presentation at the same time. An immediate passage from the photograph and the hand-drawn eidotype to the publication. The final drawings are divided for



*9.*
*Karl Friedrich Schinkel, Vorbilder für Fabrikanten und Handwerker. Steinkonstruktion des Gesims- und Deckenwerks bei den Propyläen zu Eleusis, 1821- 1830, 63.*




*10.*
*Auguste Choisy, L'art de batir chez les Romains (1873, 237). Public Domain Mark 1.0, https://digi.ub.uni-heidelberg.de/diglit/choisy1873 (accessed: July 2021).*

the different chromatic treatments: the sections and the axonometries are simple, in gray tones and the elevations are in color, following the constructive chromaticism. Each chromatic difference owes its reason to a communicative necessity. The plan and the sections show the relationship between the elements and the space they build and sometimes describe. The gray tones give back a difference necessary for the legibility of the various parts of the building, making the representation homogeneous at the same time. Similarly, axonometries tend to describe the portion of the building element in its unity, although composed of different parts and studied in an analytical way. Elevations, on the other hand, use lines in color. Red or yellow represent the clinker parts, those in dark gray the metal parts. The choice of color representation comes from a desire to suggest materiality. The burgundy-colored rectangle drawn on the screen, if composed with other rectangles, becomes immediately intelligible as a brick in the reader's mind.

The three-dimensional digital model assumes peculiar characteristics in the work of investigating the construction of these industrial buildings. The original file can be explored and rotated in space for further analysis, but the entire portion is consistent and detailed in all its parts. This means that the constructive details represented in axonometry are the result of a reasoning also applied to the parts hidden in the drawing, i.e., those that are behind the shown object. In this case, the use of the exploded view as a mode of representation has the will to return the complexity, not only of the original element, but also of the work done for the digital reconstruction. The planimetric axonometry returns an overall view of the object by altering the perceptual relationships between the parts and giving a more descriptive view. As it is composed of a plan that shows the elevated in a 1:1:1 ratio, it is possible to measure the parts on the printed drawing and immediately understand their mutual relationship.

The method of modeling »brick by brick« was not only useful to understand similarities and differences, and to identify the structural essence but also as a simulation of the craftsmanship: stacking, joining, and juxtaposition had to be done in an elementary way, based in each case on principles of practicality and economy: of construction site, of finances, of time. The model, though detailed, was voluntarily left as a »snapshot« of the construction process in the making to contribute to the understanding of the architecture represented as derived from a physically constructed architecture. And, as with Schinkel's drawing, to restore constructive relationships and subordination between the various parts of the architectural structure.

The redrawing method described above has shown its validity but also its weaknesses. Critical redrawing, used as a graphic synthesis of theoretical and practical study assumes the contours of an essential and decisive tool in my training as a researcher, but above all as an architect. The redrawing of all the parts that can be seen and the drawing of the hidden parts force me to think in terms of the re-design of the building. The activity of restitution of the single parts of the building is supported by an accurate bibliographical and archival investigation in order to decipher the signs of the construction and endorse possible hypotheses. The nature of the instrument is not simply inventive but advances and is refuted in a scientific way (De Mattia 2012: 28). It is possible that the hypotheses described and represented are re-discussed, but the very construction of the drawing provides a logical reading of the parts that make up the building. The redrawing has helped frame the language of these architectures and to suggest their ways of being constructed. More in-depth studies may reveal more precise solutions, but these are alternatives to already valid hypotheses.

The investigation of an existing building carried out by means of an inverse archaeological method and through redrawing, reveals the validity of a traditional method that, thanks to the recent technologies of vector drawing and digital modeling, offers an easily employable working tool without the need to resort to extraordinary resources.

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