ADVANCED BUILDING SKINS

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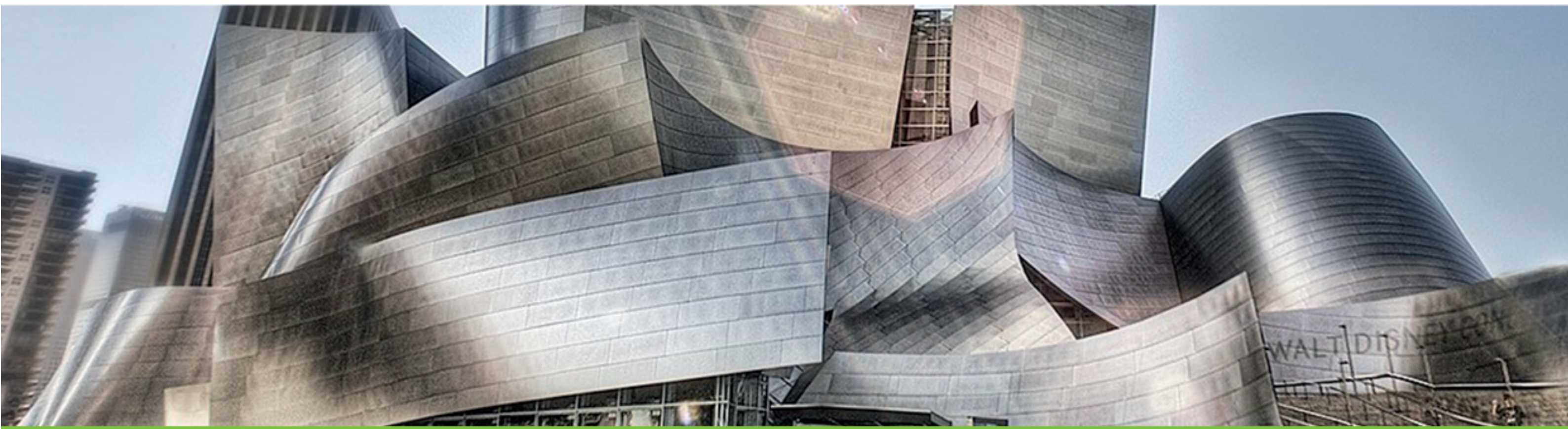

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Advanced building envelopes: design and construction methods

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Abstract

This study examines the theoretical and instrumental contents concerning the executive design of building envelope systems, considered as an operational and cognitive apparatus aimed at planning, managing and guiding the on-site production and construction processes. The executive design is defined as means of knowledge and action aimed at modeling, anticipating and simulating the production and construction reality, and whose objective is to lead, guide and "materialize" the practical implementation, according to the development of the technical devices aimed both at structuring the contents, the rules and the design data, and at the feasibility assessment (Robbins, *et alii*, 1994; Alread, Leslie, 2007; Nastri, 2008a).

The study is defined as a sum of research and didactic activities including the analysis relating both to the references concerning the technological design culture, and the executive design practices carried out in the contemporary scenario. Furthermore, the study aims at developing a fundamental theoretical system concerning the executive design of building envelope systems, whereby to proceed with the configuration of the layout related to the specific subject area and with the in-depth analysis of educational aspects (with respect to the impartation of technical and operational ability and practical and instrumental knowledge), procedural aspects (with respect to the development of organizational and management processes in a production and construction context) and notional and regulatory aspects (with respect to the methods of drawing and use of the executive design).

Keywords: Executive design, Building envelope technical interfaces, Planning and executive models, Construction and production drawings

1. Contents and procedures of the executive design of building envelope systems

The executive design of building envelope systems develops the graphic and descriptive contents with the purpose of:

- Representing an "interaction" and "mediation" tool for operators, professionals, qualified workers, experts, especially in relation to the production phase and the implementation phase (that concerns the manufacturer);
- "Structuring", organizing and managing information (regarding products and materials, systems, components and technical elements, operators and their responsibilities);
- Developing a "decision-making" tool and an instrument that would determine the managing, prediction and rational organization procedures concerning the production and construction phase;
- Creating a communication tool, with the aid and the application of "scientific" representation modes: by using a symbolic and coded language, for viewing and controlling the production and construction phase.

In this regard, the theoretical and operational development of the executive design is expressed as a knowledge and an action tool concerning the productive and constructive reality.

1.1. Executive design as a knowledge tool

Considered from a cognitive standpoint, the executive design of building envelope systems reveals itself as a knowledge tool and in particular as a process of “manipulating” contents, rules and data aimed at the implementation. The executive design requires to analyze and take action in areas that can be empirically verified, by creating and using tools and models necessary to know and intervene within the production and construction reality. Based on this, the project requires the conception of tools for the “artificial reproduction” of the building site reality. The development of (executive) models aimed at providing knowledge of reality becomes a “revealing” practice of phenomenal, objective and experiential reality, that can be observable, assessable and manipulable (Norman, 1993, tr. it. 1995; Lecis, Busacchi, Salis, Ed., 2015).

Furthermore, the executive design intended as a means of knowledge, is defined as a technical process of “rational prediction” both for arranging, organizing and anticipating the constitution and execution of building envelope systems and for “predicting phenomena”.

1.2. Executive design as an action tool

Considered from an operational standpoint, the executive design of building envelope systems is defined as a means of exploration and “systematization” of the reference environment (in order to use what is known to intervene in reality through the “instrumental rationality” that pertains to technical knowledge.

The operational process takes place as a “modeling” practice, by creating and the using the executive design of building envelope systems as an “interpretation model”, as an organization, simulation and “construction” (not reproduction) tool of reality. The design process, expressed as an “interpretation model”, as a “pattern of action” (or “explanatory pattern”, necessary to set the right correlations among the phenomena), has the purpose of defining the orientation, prediction and direction methods that lead to a concrete action within the production and construction reality (Paronitti, 2008).

2. Executive modeling procedures of building envelope systems

The executive design of building envelope systems, considered as a practice towards knowledge and action is expressed through structuring the instruments aimed at learning contents, rules and data pertaining to reality, with the purpose of formulating the technical devices necessary for planning, managing and directing the production and construction phase. These devices, defined as “executive models” (in the form of “instrumental-logical models”) for knowledge and action, aim at the “artificial reproduction” and at making the production and construction reality become present by means of “schematization” procedures, through “modelling” and “codified formalization”. The “executive models” are herein intended and defined as the supports that can express the instructions, information and procedures in order to configure, anticipate and subsequently guide the production and construction phase façade components.

On these premises, we analyze the constitution and function of “executive models” intended as “structures” and “metaphorical mechanisms” (and therefore not “intermediate” entities between design and reality), that derive from the “metaphorical re-description”. This is considered as a method of “re-elaboration” of production and construction reality of building envelope systems through “transformation” of contents, rules and data whereby models are “interactive”, in relation to the explanatory and communicative aspects concerning their practical application.

The theoretical and instrumental structure of executive design also introduces the “predictive” character of models that allow observation and analytical and operational formulation of façade components, that would be in the form of an “interpretation” and would direct a simulated and experimental configuration of contents and data.

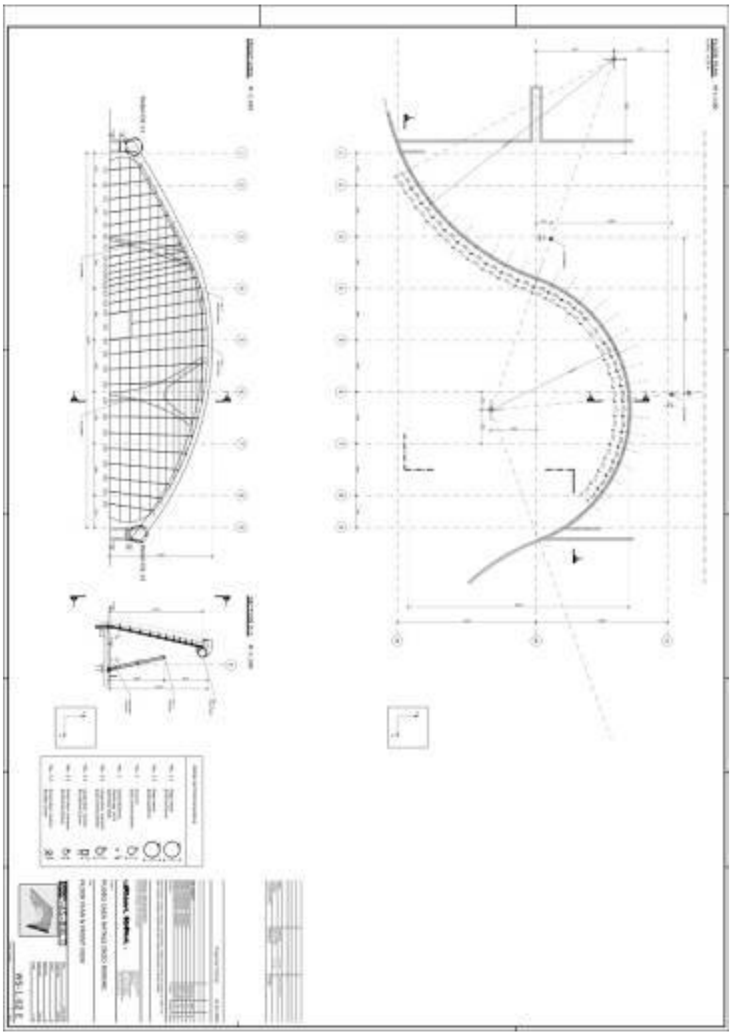

Figure 1. The “coordination procedures” of the “executive models” are determined on the basis of the localization drawings, which are directed to describe the operational planning, the manufacturing phase and the hierarchical organization of technical interfaces (Giancarlo Marzorati, B4H Hotel, Milan; localization drawings).

Therefore, the executive design of building envelopes, also referring to practical knowledge and to technical-operational ability to prepare tools in the form of “executive models” (designed and created as a “pattern of action”), means to define this as a process of “exploratory prediction” aimed at structuring and simulating the production and construction reality (Waddington, 1977, tr. it. 1977). The executive design for the construction of building envelopes, considered as a simulation practice aimed at understanding and action, implies the development of the projects as “executive models”:

- “Analogically”, through the appropriate configuration of the geometric, dimensional, procedural and relational aspects of the building envelopes described and the specific interface conditions between the productive and constructive apparatuses;
- Systemically, through the display, the indication and the explanation of the various phases (for example the connection, installation and assembly procedures), expressed by the time sequence of the action steps (Floridi, 2010).

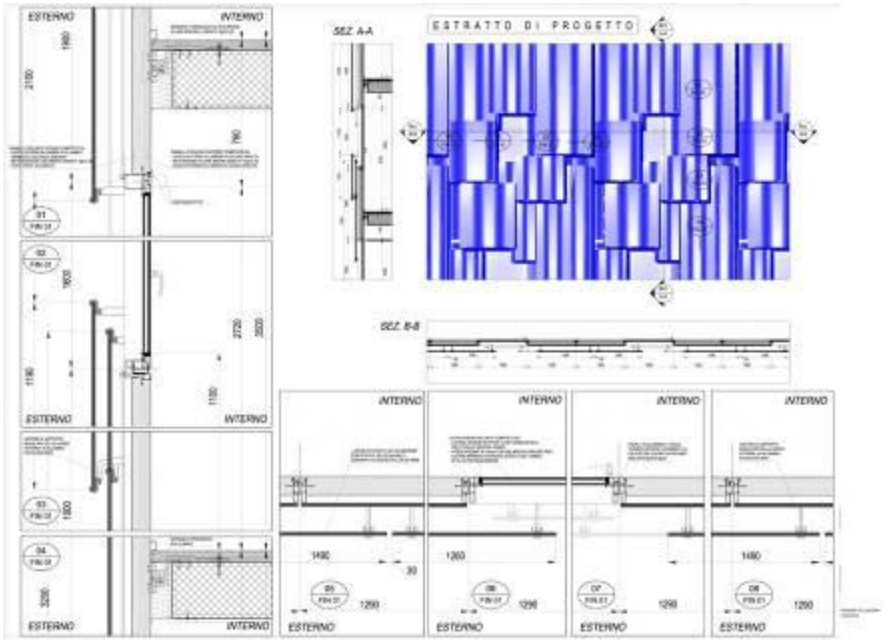

Figure 2. The "coordination procedures" of the "executive models" regard the guidelines relating to the geometric representation, to the (general and specific) dimensions, to the positioning of technical and organizational interfaces (Future Systems, Andrea Morgante, "Enzo Ferrari" Museum, Modena; localization drawings).

The technological culture in question refers to the acquisition and the expression of principles that pertain to *architectural engineering*, applied to executive design and to the construction of window and doors frames. It is considered as a process aimed at developing and controlling the interaction criteria between the parties, by analyzing their synergies and correspondence. This is meant to be an application and a demonstration of both the "art of connection" and of the "aggregating" logics aimed at explaining and controlling the assembly system, the connections and the executive sequences (Frampton, 1999).

The practical operation of the executive design is implemented through the conception, the drafting and the construction of technical interfaces, defined as the connective context (of dimensional, technical, constructive and operational type) between the façade components and the building sections. Therefore, the executive design of technical interfaces is expressed at a spatial level (as a place of contact, integration and connection) and at a physical level (as a joining place of elements, materials and devices required for the connection to the structural sections and walls). The study and drafting of technical interfaces of façade components are developed through the assembling of the parts that need to be connected, the installation methods and the tools, the sequential criteria for construction.

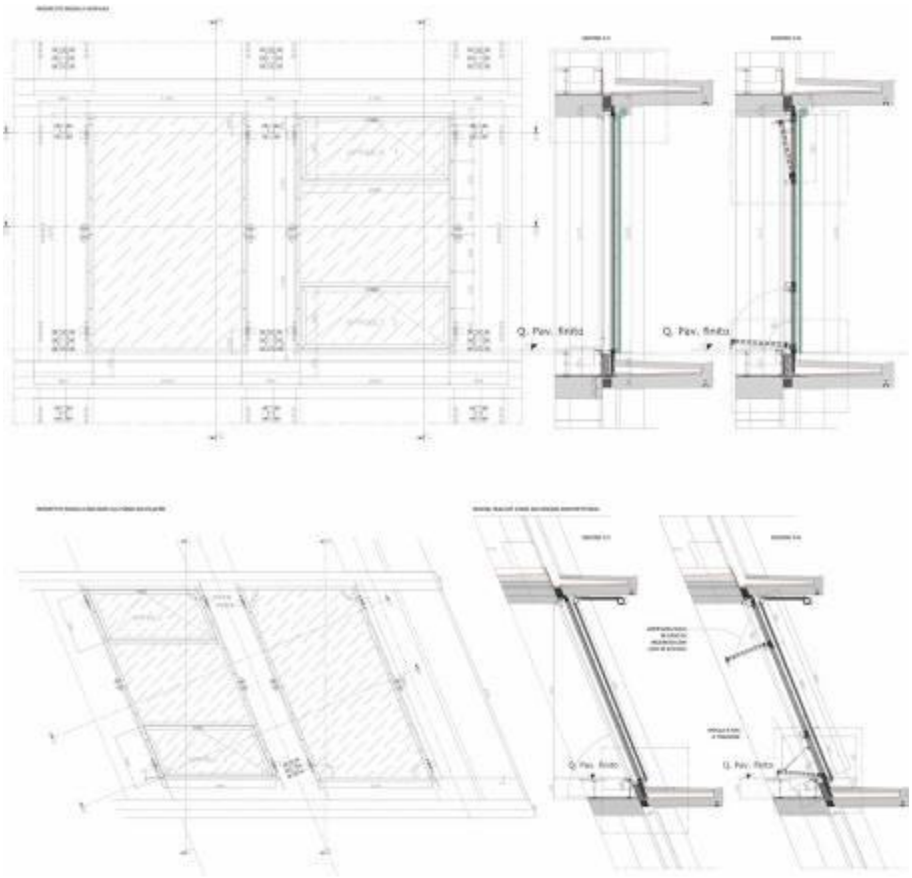

Figure 3. Construction procedures of the building envelope in accordance with the structural and functional characteristics of the model (Herzog & De Meuron, Feltrinelli Foundation, Milan; specific localization drawings).

The technical interfaces, considered as a context of rational analysis to study the production and implementation processes of the building envelope systems, define the procedures of typological identification, localization and coordination (these are meant to be as a set of “combinatory rules”) which lead to:

- Respect of the morphological, physical, structural and executive “hierarchy” and the “aggregating logics”;
- The formulation of a building plan, both general and specific (considering the joining procedures).

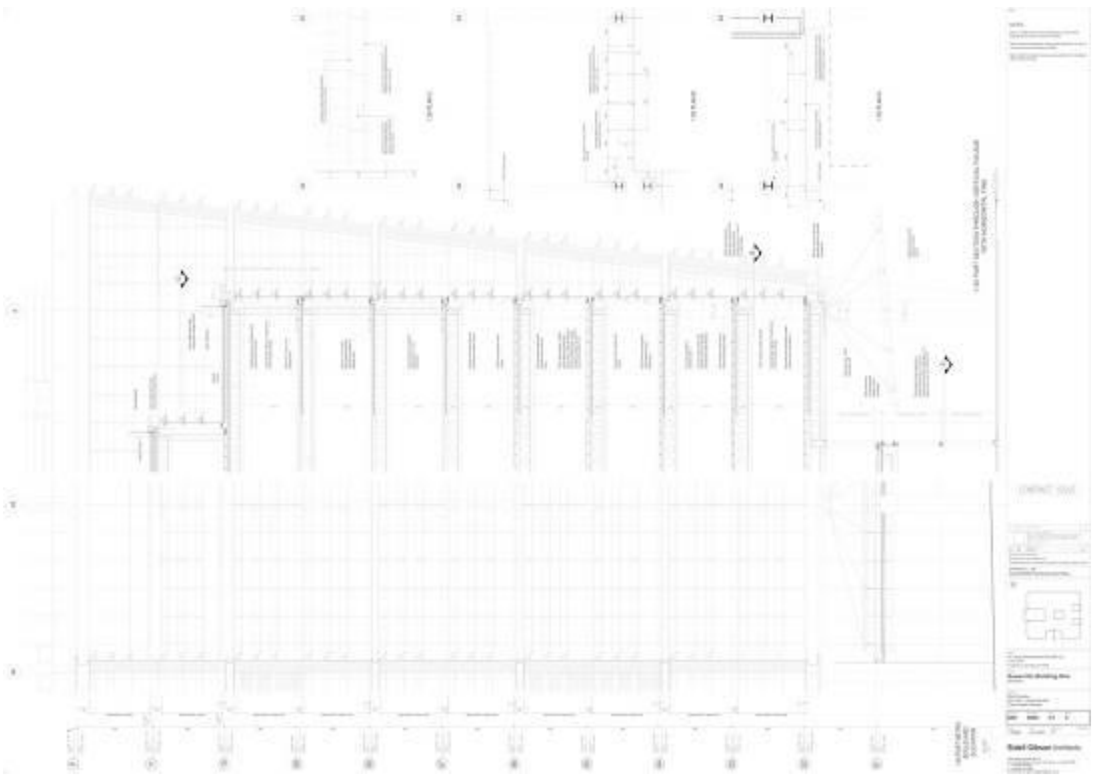

Figure 4. The "coordination procedures" of the "executive models" explain the identification code of the spatial elements, the dimensional or modular plans of coordination and/or the reference plans (Sidell Gibson Architects, edificio One Snow Hill, Birmingham; localization drawing).

The executive design, both on a practical and a conceptual level, contains the understanding and management procedures of technical interfaces between the connective sections, with respect to:

- The conditions of "generic interdependence", referred to the "standardization coordination", which consists in developing a set of rules aimed at constraining the morpho-typological, mechanical and physical behavior of the façade components with regard to the joining devices and the connecting parts (defining through the repetition and/or progression of both the solutions and the processes that the situations that need to be addressed are relatively stable, repetitive and limited in number and variety, so that the rules that tackle them may be appropriate);
- The conditions of "sequential interdependence", referring to the composition and operation of joining devices related to the façade components with respect to the interface as a whole, according to a specified order (temporal, connective and executive);
- The conditions of "mutual interdependence", referring to the performance and execution influence of a section relating to the façade components towards another section with respect to the interface (resulting in the adoption of a strategy of "coordination for mutual adaptation" of the doors and windows frames parts during the production and implementation processes).

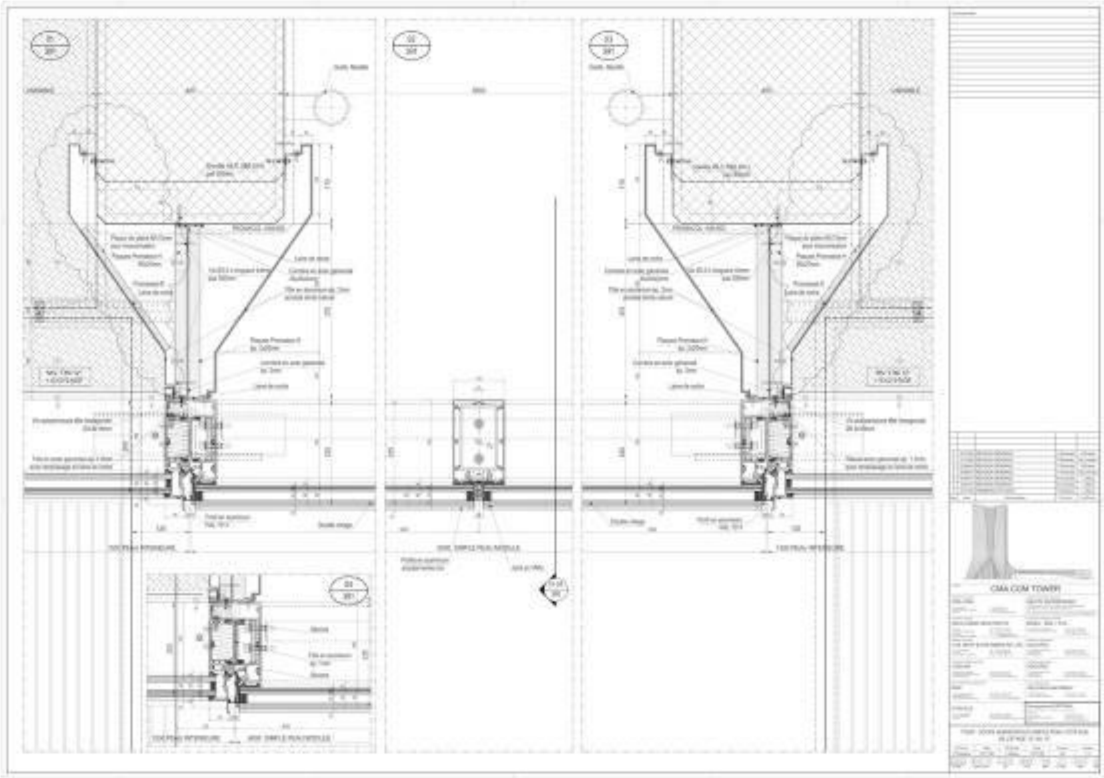

Figure 5. The "presencing" of the production and construction reality of the building envelope by means of "schematization" procedures, through "modelling" and "codified formalization" (Zaha Hadid Architects, CMA-CGM Tower, Marseilles; construction drawing).

The executive design of technical interfaces also incorporates the prediction and temporal aspects concerning the actual implementation criteria of façade components, considering the technical drawing as an anticipation and simulation procedure of the real construction conditions of the building site. In this regard, the executive design of technical interfaces implies and defines both the contents and the constructive tasks aimed at representing the real conditions of installation and assembly, according to the rules that determine:

- The systemic subdivision of the joining and connecting criteria into "subsystems", where every constructive sequence may constitute a coherent and independent section with respect to its application, both in terms of a temporal and spatial level;
- The development of "assembly plans", considering the manufacturing and implementation phases of components, technical elements and materials (according to their morphological, physical, dimensional, functional and structural aspects);
- The information and guidelines relating to the productive resources and tools, the required means and equipment, the chronological correlations of the construction details of the technical project with respect to the building site reality.

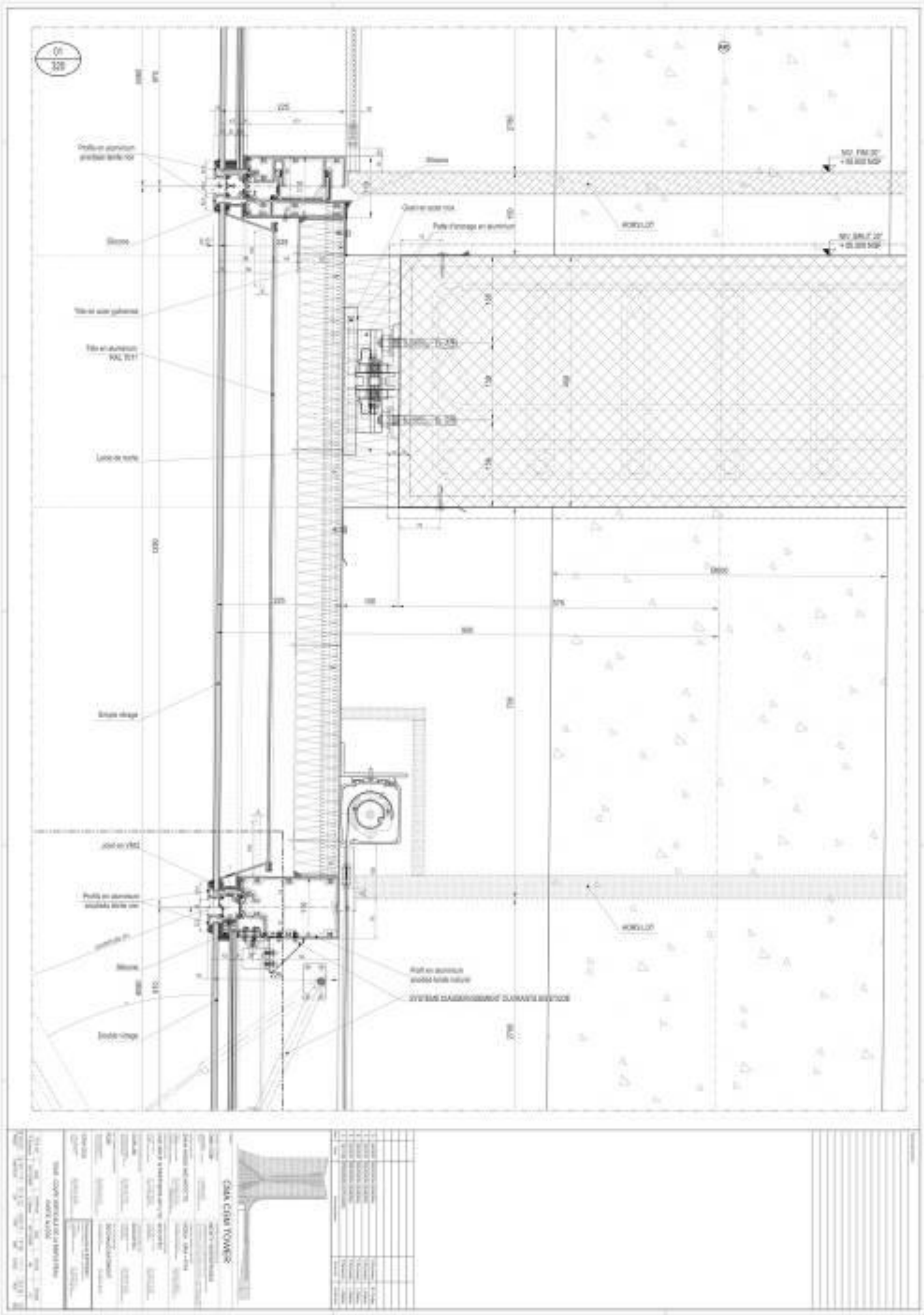

Figure 6. The design process of the building envelope expressed as an "interpretation model", according to the purpose of defining the orientation, prediction and direction methods that lead to action (Zaha Hadid Architects, CMA-CGM Tower, Marseilles; construction drawing).

3. Procedures for representing the executive design of building envelope systems

The modeling and simulation procedures are characterized by the executive design of building envelope systems through an "indicative" and "metaphorical" language. The language of the executive design of building envelopes is defined according to:

- The application of a "scientific" code by using a conventional and instrumental system of signs;

- The development of executive tools focuses on drawings that can contain and convey the guidelines for building the façade components. This is accomplished through the procedures for the constitution of “executive models” able to “analogically” and systemically “build” the pragmatic conditions of the project with the aid of codified representation techniques and of “linguistic symbolization” necessary to visualize and communicate the production and construction information.

Figure 7. Construction phases of the “unit system” building envelope (Zaha Hadid Architects, CMA-CGM Tower, Marseilles; construction drawing).

The executive design contains criteria) expressed through the operating language aimed at “decoding” and “structuring” the contents, which requires the use of “concrete” representation techniques and the work of “codifying” the productive and constructive “meaning”, explained and expressed in detail according to the peculiar rules, conventions and requirements that pertain to graphic description.

The working drawing concerns the operational instrumentality of the “executive models” for the building envelope through the descriptive and graphic representation of devices capable of displaying, simulating and communicating the contents and information for the implementation, by focusing the analysis on the interface and connection possibilities of building systems, components, technical elements and materials. In particular, the working drawing concerns the implementation criteria of the logical and operational coordination tools necessary to display and simulate the “constructive situation” of the building envelopes and their technical interfaces, by the graphic representation of “executive models” able to “analogically” and systemically build the pragmatic and implementing conditions of the project. The working drawing is expressed through:

- The development of “experiential observation” and “discretization” of reality, which is simulated and “objectified” through the graphic and descriptive expression of systems, components, technical elements, materials and their physical, dimensional and connective relationships;
- The “technological and constructive” explanation according to “aggregating logics” relating to technical interfaces as a methodological guidance of “tectonic” type aimed at explaining the “connection artifices”.

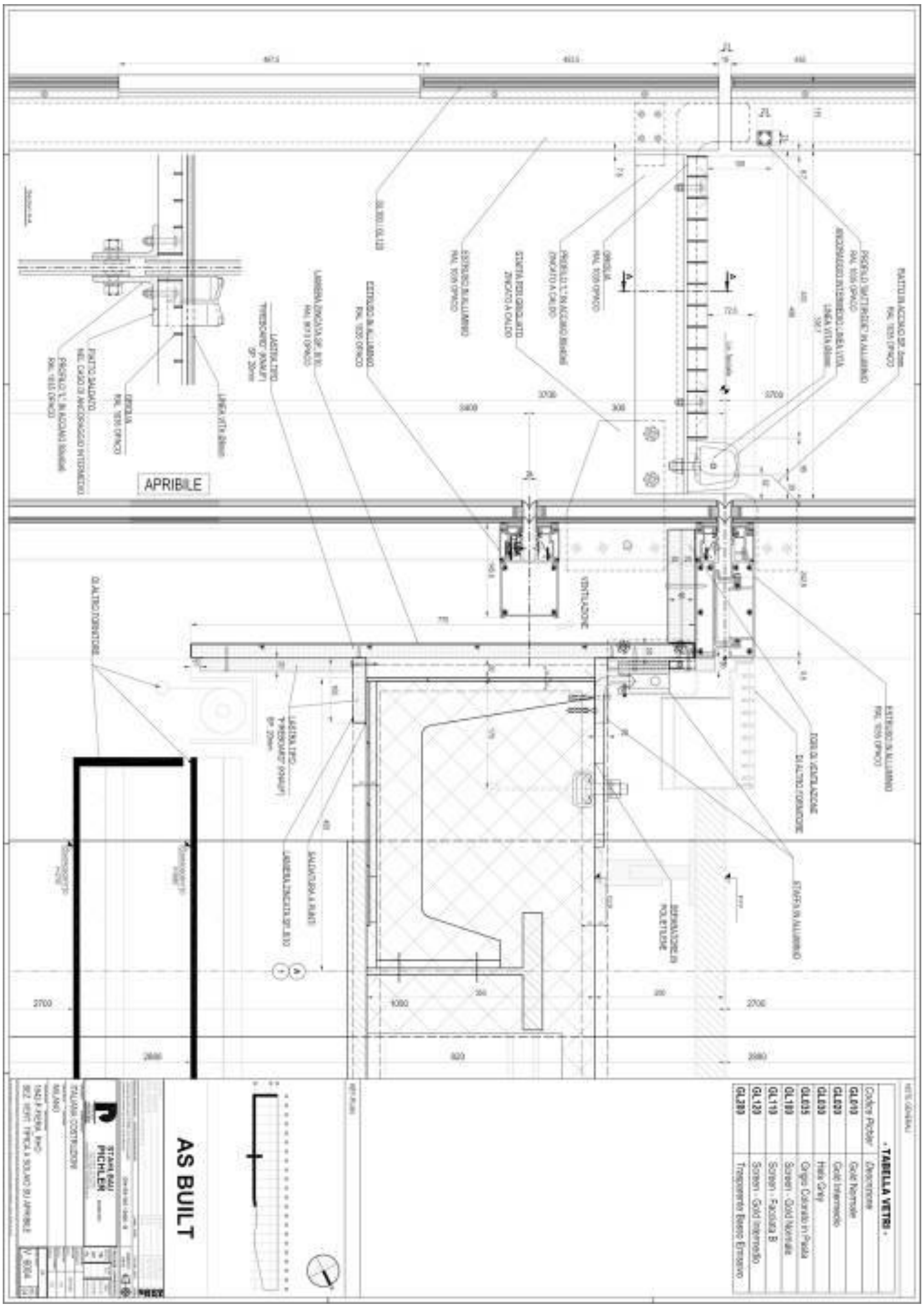

Figure 8. Executive representation as a process of "formalization", into the reality of the building site, of the double skin façade (5+1AA and Jean-Baptiste Pietri Architectes, Office Building, Rho, Milan; construction drawing).

In this regard, the working drawing is determined as a representation method through the drafting of the supports that will lead to the real building, based on "information" aspects and "scientific" ways of expression through:

- An "indicative" type of language for "acting within reality", as well as "objective" and "metaphorical" type: the working drawings are therefore represented as "explanation and prediction tools", aimed at knowledge of the physical reality and at the subsequent information and communication of operations;

- A "symbolic" type of language aimed at concentrated information and practical application, characterized by procedures that provide guidance and instruction about the real action to take in construction.

Figure 9. Production of the "double skin façade" mock up (5+1AA and Jean-Baptiste Pietri Architectes, Office Building, Rho, Milan; construction drawing).

In general, the operational work of the executive design aimed at the application of façade components takes place through:

- The "coordination procedures", aimed at the prioritisation of production and construction contents, i.e. directed to systemic structuring on the basis of the geometrical and dimensional framing, both general and specific (defined as a "structural matrix", through the application of "general" and "specific" *localization drawings*);
- The "interface procedures" established by:

- The drafting of guidelines aimed at explaining and displaying the executive techniques, the technical elements, the materials and the connection modes, according to the objective of conveying precise information to the workers in the different stages of production and construction;
- The analysis relating to the sequential steps of installation and/or assembly (through the application of the *construction drawings*, *assembly drawings*, *interface details* and *production drawings*; Nastri, 2009).

Figure 10. Construction phases of the "double skin façade" components (5+1AA and Jean-Baptiste Pietri Architectes, Office Building, Rho, Milan; construction drawing).

The "coordination procedures" of the "executive models" are determined on the basis of the *localization drawings*, considered as instruments that define the constructive framing of building envelopes (through the multi-modular reference network): in this respect, the drawing is directed to describe the operational planning, the manufacturing phase and the hierarchical organization of technical interfaces (Wiggins, 1989; Wakita, Linde, 1999). The *localization drawings* (either in the form of a "general" or "specific" representation of portions of building envelopes) express:

- The guidelines relating to the geometric representation, to the (general and specific) dimensions, to the positioning of technical and organizational interfaces (with comprehensive information on construction systems, components, technical elements and materials);
- The identification code of the spatial elements, the dimensional or modular plans of coordination and/or the reference plans;
- The executive framework of the building envelope and of its specific parts during the transition phase of practical implementation (through the drawing of a *setting out plan*), coordinating the physical arrangement of the technological systems on the building site.

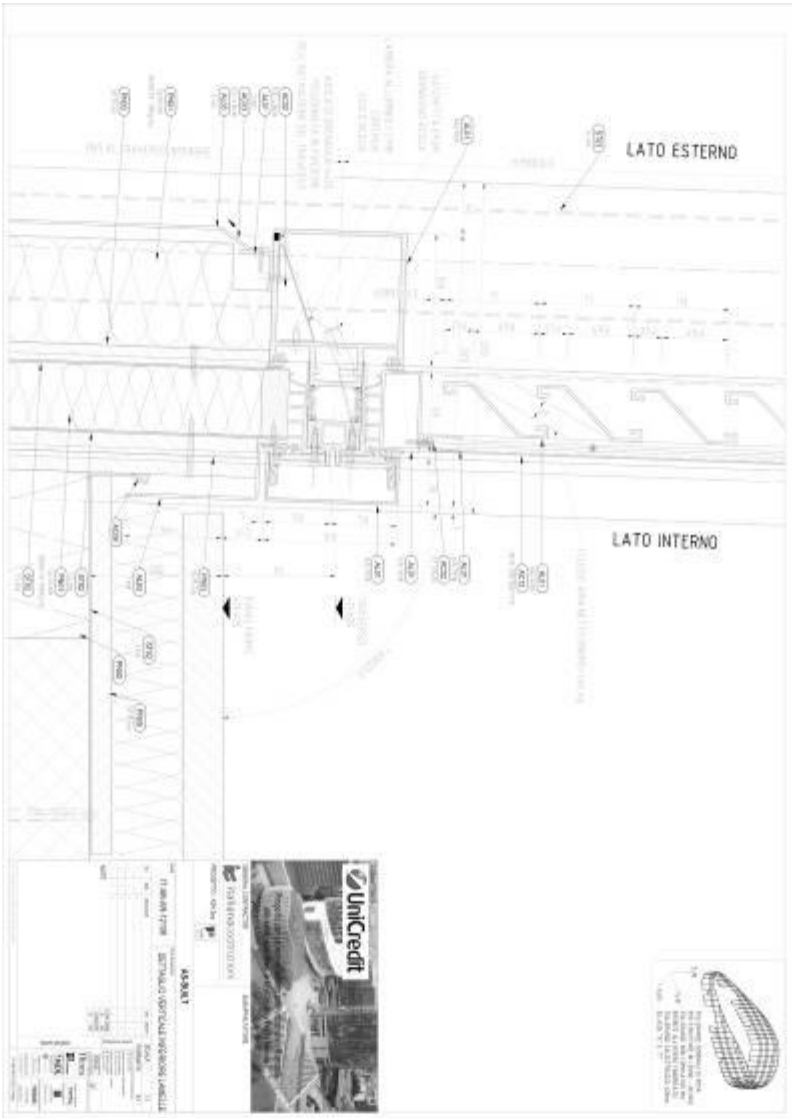

Figure 11. Modelling, anticipating and simulation criteria of the intervention towards the building envelope (by means of "executive model") aimed at leading and directing the production and construction activity (aMDL, Michele De Lucchi Architetto, UniCredit Pavilion, Milan; construction drawing).

The "interface procedures" are defined by:

- The *construction drawings* and the *assembly drawings*, as representations that help visualize and simulate the composition and the executive sequentiality of the constructive section (distinct and located within a technological system organized through a *localization drawing*), pointing out the construction phases (on-site laying, assembly or installation phases) concerning the identification (morphological, technological, productive and connective) and the constitution (physical, dimensional and material) of components, technical elements and joining devices. The *construction drawings* and the *assembly drawings* are defined as documents aimed at providing specific technical information concerning the implementation methods of the construction and/or assembly operations of the technical elements. These drawings, that relate to each construction situation technically distinct inside the technological and operational subsystem of the building envelope, must contain the information relating to:

- The dimensional or modular coordination plans of and/or the reference plans;
- The shape of the technical elements that constitute the building and the subject of the document, in conjunction with:

a) Their nominal size;

b) Their position with respect to the dimensional or modular coordination plans of and/or the reference plans;

c) Their identification code;

- The shape of the technical elements already built and technically and dimensionally connected with those mentioned in the document;
- The position and identification code of the section planes of other construction and/or installation details;

- The *production drawings*, as drawings that provide the specific information about products that can be manufactured separately or prior to the construction site, and provide the size and shape of components, joints, treatments, and type of work performed (Mecca, 1993).

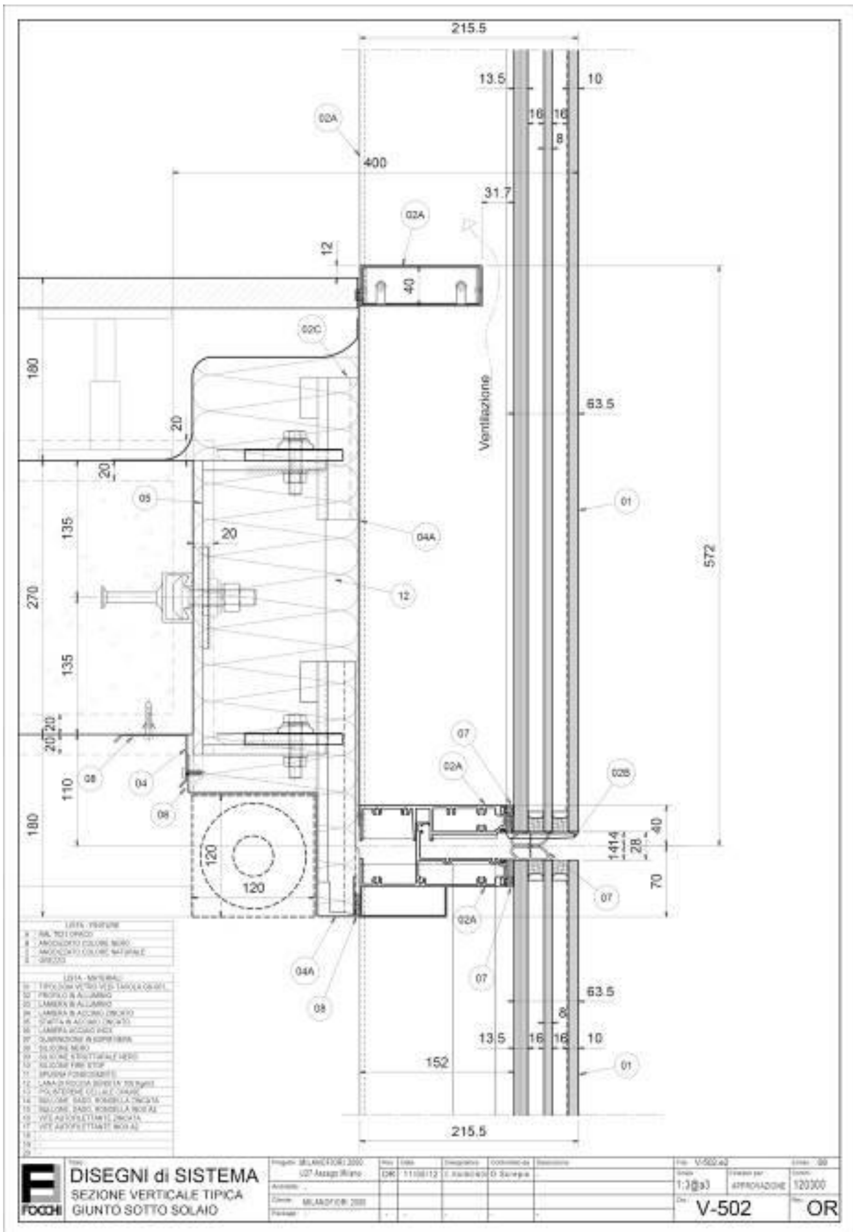

Figure 12. The executive design defined by "predictive" modeling and simulation of the building envelope, as a practice of "exploratory prediction" (Park Associati, U 27 Building, Assago, Milan; construction drawing).

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