Trust Yourself: A Doubting Thomas Perspective on Building Research

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Abstract

As physical artefacts, buildings provide material evidence of the process that led to their realization and the effectiveness of the decisions made prior to it: construction details implicitly reflect the knowledge of production factors embedded in the work and the efficacy of the contractual methods employed to structure underlying socio-technical relations; building use patterns validate or reject choices made at program definition and development stages; building maintenance requirements give an indication of the depth of thinking that went into the operational life of the building, or help assess the administrative and labour structure that put it together. Using a major public performance arts complex recently developed in Spain as an example, the paper seeks to validate such statements whilst showing that the empirical analysis required to do it can indeed help evaluate construction work, even in those (many) extreme cases where political sensitivity is likely to stop the disclosure of technical documentation and thwart building analysts' ambitions to examine construction output. In connecting promoters' declared objectives and buildings’ physical results with knowledge of the industry and participating actors’ alleged roles, scholars can be very effective at producing development portraits of specific construction experiences that enable technical and public scrutiny. Understanding the effectiveness of determinate building processes vis-à-vis their end products may assist public agencies, institutional bodies and industry actors in taking full advantage of the intellectual capital generated by specific projects, setting better conditions for the progress of technical knowledge, the introduction of innovation, the economic growth of the industry and, ultimately, the construction of a better built environment.

Keywords: case study organization, empirical analysis, socio-technical framework, public works, knowledge management.
1. Introduction: building scholars as doubting Thomases

To what extent can building artefacts reveal the effectiveness of their development process? If, as Groak and Krimgold (1989) suggest, project-based experiences represent a critical and significant way in which the construction industry brings together its output and tests its procedures, then buildings stand as the physical outcomes of the processes involved, and should be used to verify the validity of the decisions made within them. The ability to establish a connection between as-built products and underlying processes by looking at the evidence ‘concretely’ embodied in the former could help building scholars articulate a position about the works carried out without relying on specific technical documentation that may not be (or be made) available. This paper uses the Palau des Arts Reina Sofia, a major public performance arts complex completed in Valencia (Spain) in 2006, as an opportunity to explore the viability of this position.

In doing so, a ‘Doubting Thomas approach’ is indirectly proposed in relation to building research and information. The expression derives from the Biblical story of Thomas the Apostle, who refused to believe in the resurrection of Jesus without direct or physical evidence of the event. The type of skepticism suggested here is of course less profound and more prosaic than that of the parable in the Gospel but possibly very useful from an academic perspective because, notwithstanding buildings’ physical positions in the public domain, information about their design and construction processes tends to be relatively limited even to the community ostensibly in charge of their analysis.

Indeed, buildings embody many layers of retrievable information, which could each trigger questions and stimulate considerations about their procurement. One layer concerns the building’s interaction with the social, economic and environmental context in which it was produced. Another layer is defined by the connection between the design choices and technologies at the base of its development and the industrial involvement these generated. A third layer involves the public administrative structure of the project in relation to the work apparently required, whereas a fourth layer could coincide with the comparison between stated objectives and objective results. The following pages will show how these layers can find abode in the form and space of the building, its construction details, materials and performance, its use, and its maintenance.

Built form and space connect the appropriateness of design choices to the building’s scope and objectives, which finds ‘Doubting Thomas’ support in the actual use of the building. Occupants’ informed response, in fact, constitutes an ultimate test in building appropriateness, systems’ selection, design efficiency and fitness for purpose. Construction details tell stories about the rights, obligations and liabilities of the parties involved in the building’s realization by providing background material about the contractual system in use, the procurement path selected, and the relations within industry as evident at face value. In fact, the empirical quality of constructed details is likely to inform considerations surrounding not only the project’s detailed engineering but also the appropriateness of the technologies selected, the breakdown patterns of the work, the allocation of responsibilities in procuring and monitoring construction, the ordering of it. Level and the type of post-construction maintenance bring all this together, because the work a building requires after hand-over can reflect four things: the level of pre-construction thinking that went into its life-cycle needs, the circumstances of its construction, the quality of the operations, or the changes in use.
2. The art of building in a building for arts

2.1 The Palau des Arts Reina Sofia in Valencia

The Palau des Arts Reina Sofia is a public building commissioned by the local government of Valencia (Generalitat Valencia and Ayuntamiento de Valencia) to the architect Santiago Calatrava in 1997 to complete the City of Arts and Sciences (Ciudad de las Artes y de la Ciencia), a major urban project relying on the conversion of the Turia river’s old bed outside the old city into a public park and cultural centre. The management of the buildings comprising the ‘City’ is entrusted to C.A.C.s.a., a public authority instituted by the regional government but organised as an autonomous body.

The Palau des Arts is the most significant Opera theatre in Spain by size. The building, with a total height of 75 meters, hosts four halls conceived to host different kinds of performances, and covers a surface area of 40,000 square meters articulated on 14 different levels. When compared to the general output of the local building and construction industry, the building presents unconventional design features and structural complexity, which define many of its technological challenges. The volume is defined by two main double curved surfaces and by a cantilevered structure on the roof. The main body has a reinforced concrete structure while the envelope is in steel. Two lateral opening in the surfaces of the curved walls show the aggregation of the internal volumes. The main concrete body hosts the stage tower and has a supporting function for the steel envelope that lean on it through a rib structure system. Beneath the main envelope, the position of the stage tower of the main hall leads the hierarchical aggregation of the other halls and of the secondary and ancillary spaces.

Figure 1: View of the Palau des Arts Reina Sofia, Figure 2: Lateral section

The complexity of overall form and individual building volumes influences the layout of most internal spaces. Plans and sections of the four halls, for example, are arranged within the tridimensional shapes derived from the architect’s original idea. The result is that only the main Opera hall follows a consolidated arena theatre typology; the other three halls do not refer to any traditional layout, rather adapting to the space available beneath the volumes.

The building finishes utilized to cover such volumes are peculiar. The external envelope shows vast surfaces treated with white concrete, glass and trencadis, a traditional Spanish tiling system that uses irregular cuts of ceramic tiles, but normally for interiors. Its extensive application on the curved
surfaces of the roof suggests a new use of the system and its related techniques. Also the glass is employed innovatively, as flooring system of the outdoor bridge from which one enters the theatre, and in the form of long vertical panels used to enclose the foyer. Inside, the main finishing materials are beech timber panels and *trençadís*. Both materials are applied in the concert halls, while corridors and public areas are treated with white concrete.

Changes in government and variations in scope and program characterized the construction process, which was managed by UTE Palacio, the temporary joint venture of two of the largest infrastructure and construction companies in Spain: Dragados s.a. and Necso s.a. Originally, the joint venture had been formed to construct a tower on the same site; yet due to a shift in political fortunes the development of the tower stopped, to be (literally) replaced by the Palau project. UTE Palacio, which by 1997 had already built the foundations for the tower, continued to erect a building on it, only with a different program, under the technical and artistic supervision of the same architects appointed for the tower, Santiago Calatrava Valls. In 2006, the construction cost of the project close to completion reflected a four-fold increase from the initial estimates.

### 2.2 In building truth

On the basis of the information provided above (and publicly available), it is interesting to visit the building or review its official press, to examine the way in which its construction tried to respond to the challenges built into its ‘formal’ design.

Indeed, the relationship between form and functional spaces has been difficult from the very beginning. Inadequate acoustic performance for two of the halls, for example, became apparent during the opening concert, in 2006, and required immediate substantial remedial works to correct their sub-optimal ‘inverted’ layout. Similar issues also exist in the aggregation and the interdependence of other spaces within the building volume - main spaces, service areas and circulation – which seem to suffer from a lack of functionality. The number of toilets serving the main hall, for instance, was found to be limited in relation to their number and location. In 2007, the hall located on the eight level of the building was substantially modified to provide more toilet facilities since, at the time of the opening, patrons had to walk around half the perimeter of the building, along outdoor terraces, to reach the closest blocks. The works also included the creation of a cloakroom and a more sheltered entrance. The only access to this hall was in fact through open terraces that did not offer any protected intermediate or waiting area for the audience.

Figure 3 and 4: View of the concert hall before and after the opening concert, Figure 5: Construction of the new toilets, Figure 6: Construction of shelter entrance and cloakroom for the hall in the eight level
The relationship between building form and the resolution of technical aspects provides equally puzzling elements. The ceiling in the main hall, for example, consists of glass elements that contain fixed fluorescent lights running perpendicular to the stage. Each element is four-metre long and creates issues in relation to lighting maintenance, since it requires the removal of each panel. Moreover, ceiling design does not facilitate the functional installation of stage-related lighting because of its orientation and the lack of supporting structure. In the smaller concert hall, fixed fluorescent lighting system had to be fully replaced by a LED system in 2006 to obtain more appropriate lighting levels.

Acoustic quality issues have also appeared throughout the building, and not only in relation to layouts. In the stage area of the large concert hall, vertical wooden panelling had to be removed and replaced with boards laid at a different orientation in order to provide adequate levels of sound absorption. In the main hall, the use of *trencadís* as finish material produced unacceptable degrees of acoustic distortion, with the result that a special coating had to be applied to all the surfaces covered with it. In 2007, a year after the opening, a new acoustic ceiling and proscenium not defined in the original project were added to the stage, while 16% of the seats had to be moved because of visibility problems. The new seats are now located on a raised platform that improves view of the stage but also raises accessibility issues because of the steps required to reach them.

The coordination of building form and construction planning can be somewhat gauged by the way in which different components have been selected and put together, junctions between different materials are dealt with, and services and internal finishes relate to each other.

In the foyer, the details of the façade invert conventional construction thinking. Glass panes, metal frame and concrete structure on the external facade are visually connected by applied plaster elements disguised as concrete. Inside the space, glass panels don’t follow the modular distribution in the frame as defined by their structural mullions.

A lack of expansion joints between different materials may cause maintenance issues such as the deterioration of materials or structural cracks. Discolouration and cracking of white concrete is occurring around the perimeter of the building, where the material is adjacent to steel components. Coastal air salinity also facilitates its deterioration, as well as that of *trencadís*-covered surfaces, which were not subject to protective treatments. The broken or damaged ordinary float glass used as flooring surface on the bridge and in the foyer raises additional questions on the appropriateness of selected materials and on material detailing.

In general, an apparent lack of concern for the integration of trades transpires from the relationship between finishes and services. In one of the halls, for example, the bio box pierces the large back wall, interrupting the main pattern of the wall’s mosaic finish. Similarly, the power points located throughout the building show little consideration for the finishes they interrupt.

Issues with users’ requirements emerge not only in relation to patrons. The orchestra pit of the Opera hall is located on the axis between the two main entrances, and therefore in line with the only possible wind direction. Since the entrances do not have wind locks they allow breezes in, particularly during
intervals, when the doors are open. Consequent changes in temperature can be wide enough to effect the tuning of the musical instruments. Backstage changing room and rehearsal spaces are similarly affected, and, since long straight corridors separate them from the stage, singers’ voices also become susceptible and exposed to temperature variations. Service corridors in the Palau, however, also serve as workshops because of problems in the use of certain stage areas. The storage rooms and the set workshops are not adequate for their programmed function, neither are the number or for the dimension of their doors. In some cases in fact the workshop space would be adequate to build sets but the dimension of the doors would not allow bringing them out.

At building level, the need for extra-ordinary maintenance has been massive. Since the opening of the theatre, in 2006, roof windows have had to be replaced or fixed nearly twenty times due to water infiltration problems. The trees located in the external terraces also need to be periodically replaced because of the dimensions of their planter boxes, too small to accommodate the growth of the roots. Moreover, in the absence of dedicated gantries, catwalks or access points, teams of professional climbers with specialised equipment must be contracted for daily, cleaning and light replacing building maintenance. Finally, in October 2007 the Palau des Arts was damaged by major flooding after three days of rain. The flood affected all basement areas, including offices, workshops, stage machinery and storerooms; it forced the closure of the complex, and required major reconstruction work. Multiple causes seem to have contributed to this incident: the location of the building in a sub-optimal site, its inability to cope with difficult but predictable weather conditions, and the difficulty of its fabric to manage unforeseen events or emergency circumstances.

Figure 7: Seat relocation in the main hall, Figure 8: Connection by plaster element, Figure 9: White concrete degradation

Figure 10: Planting box maintenance, Figure 11: Roof window replacement, Figure 11: Daily maintenance
2.3 The communicative power of building

Many of the concerns raised by a visit to the actual building and reflection on how it operates are surely triggered by decisions taken within the architectural realm of the development process. Here one could comment on the level of open debate that exists on the viability (or straight-out appropriateness) of particular ideas. None of the official architectural literature on the Palau des Arts considers any of the issues described above. The Valencian performance arts complex is known to the public (and to the expert public) metaphorically from afar or in the abstract, and mostly through its forms rather than its technologies and functioning life. Most of the publications that refer to the Palau des Arts (Jodido 2007, Tzonis 2004) only analyse its formal importance rather than trying to understand the way in which the building answers specific technical challenges.

At a project and building procurement level, the investigation of the results needs to consider the responsibilities of the technical parties and the socio-technical definition of their interaction because, in a complex project such as the Palau, the guarantees for its correct development are provided through the scrutiny reciprocally exercised by all the agencies engaged. If this does not happen, as it seems to have been the case here, then the problem is not only with the architecture but also with the structure of work-plan in place.

The structure of the Palau des Arts’ project administration was organized according to a traditional scheme in which architect, client and main contractor manage all of the building development process. This organization appears to be limited in dealing with the realization of a building characterized by innovative features. Difficulties in managing the coordination between different phases of the project and the construction led to a final product that faces problems in its fitness for purpose (for example in the design plan of the halls, inadequate services and ancillary spaces), in the design and definition of its engineering of components (acoustic and lighting issues) and in the coordination between form and technologies (materials and joints). These issues bring into questions responsibilities for the quality of the product in the different project stages. The artistic direction of the architect may cover only part of the issues encountered in the construction of the building, which was primarily managed by the main contractor. First question that can be put forward is therefore related to the appropriateness of the project administration structure put in place, and understand why a non-traditional building has been built while relying on a traditional scheme of building procurement? Were any alternatives methods available that may have led to more effective outcomes?

Moreover, it would be interesting to understand to what extent the contractual methods utilized influenced the relations between the parties involved and the responsibilities allocation. This aspect may influence the ability of the industry in answering the building’s specific technological requirements in terms of time, quality and performance.

The construction management of the Palau des Arts on face value appears to have made project timeline the most important imperative at the expense of construction, quality and project budget. Observations of the building suggest that fast-track and on-site solutions to construction challenges have been taken ad hoc in their implementation rather than following a determined project or program
process. If this is the case, considering the scale of the project and technical complexity of the building, it would be interesting to understand if setting up a project control structure may have helped the construction process pursue more adequate and qualitatively advanced technological solutions rather than relying on the contractors and consultants’ ability of determining on site solutions.

Analysing the building maintenance issues encountered (for example the repeated replacement of roof windows due to waterproofing problems), raises questions in relation to testing procedures and the level and degree of industrial and building standards. What were the forms of testing procedures applied to the components? Were any of the industrial and building standards applied to achieve minimum requirements for the building construction? What was the extent and degree of consideration and application? Were these standards adequate for the building formal and technical complexity? Can such building be used as testing ground to advance regulatory regimes or make them responsive to changing industrial conditions? These questions lead one to considerations of the long-term and cost-benefit balance of the construction choices, such as the use and treatment of materials or the form and quality of the construction details. Issues related to maintenance can be traced back to the program in terms of how the building performs over time, as well as to a deficiency in the architectural and engineering services in considering the technical behaviour of the building during its lifetime. Therefore, it would be interesting to understand what value was assigned in the early stage of the project to detail definition, engineering of components, and materials treatment, in order to understand the rationale and output generated in the construction process.

This discussion serves to highlight that, if a strong linkage between design and construction exists at every level of the building development process, this linkage can be examined and interrogated by identifying and using clues coming directly from the artefact produced or assembled on site. Doing so increases not only our knowledge of the products of the industry but also our capacity to tailor research questions, so as to investigate production and professional experiences that are, by definition, idiosyncratic.

3. The tell-the-tale detail

In 1984, the Italian academic Marco Frascari wrote a famous article in VIA, the journal of the University of Pennsylvania, titled “The tell-the-tale detail”, in which he celebrated the communicative power of building details for architects. By the same token, we could say that building details are equally important for those interested in the organizational processes underlying construction activity, particularly from a scholarly perspective. By looking at details it is possible to tease out considerations about the development process that may help understand the impact of choices taken during the process on the final product to the benefit of the many actors involved.

Looking at details and the building as an artefact can trigger a connection with the design process and may provide information (or raise questions) that would not be available otherwise. Despite the importance of assigning a value to a built artefact and its performance, the information about technical outcomes of buildings is rare. Of the many reasons why this happens, we could suggest that the private nature of building projects downplays the importance of formally recording their experience.
for future use, and makes the external appropriation of their lessons difficult. Moreover it seems to be
difficult to determine which actors are better positioned in the process to register or analyse the
building outcomes. Yet the information embedded in a building experience can be significant to the
industry or to scholars.

The ability to read information embedded in a building and formulate links with its realization process
can be significant for a building researcher to overcome difficulties in finding technical information or
documents or in defining unbiased framework about the building process. By looking at the outcomes
of a building it is possible to define a framework of information that can help understand the features
of a built artefact, providing guidance toward the formulation of specific questions and analysis that
can support building research.

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