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On Precision in Architecture

Costantino Caciagli discusses the relevance of standards in precision in the surveying of an existing monument and the design process for a new project. In architecture, the term precision, in the sense of “respect for order and exactness”, says everything and nothing.

In architecture, the term “precision”, in the sense of “respect for order and exactness”, says everything and nothing. In fact, “precision in architecture” can be used in reference to diverse aspects such as the carrying out of program functions, to execution, to forms, to distribution of forces, to dimensions, but we could never arrive at a conclusion if the characteristics taken into consideration were not commensurable to a reference sample. If the sample is physical, the procedure of evaluation is possible in practice. If the sample is conceptual (as, for example, a moral standard), it then pertains to the spheres of the individual and the personal. Thus the evaluation becomes less facile and is transposed to a different critical plane, and, lacking a physical point of reference, standards for assessing precision cannot be expeditiously applied. A concrete standard of comparison permits the establishment of three levels of evaluation for dealing with precision: full congruence (1:1); a determined value in excess (>1); a determined value in deficiency (<1). The difference between 1 and the determined value in excess or in deficiency is the tolerance, that is, “the measurable disparity between the actual value and the theoretical value, comprising both errors in construction as well as those in measure”.¹ It is noted that there is not one actual value but an infinity. Studies on the theory of measure have come to define sets of comprised values within a given interval. In architecture, the precision may be established once the measure or module is determined, or once the geometric form is established as a standard. Requisites of quality, function and consequence are all subject to variation in the estimation of correspondences that are larger and more subjective.

The definition “as precise as possible” is at best a potential definition, which can always be applied 1) to an existing edifice, with its history, materials, forms, functions and aesthetic values; 2) to a project to be construction, proceeding from a design in scale to the actual building.

Telematics, a system for the virtual representation of *res extensa* associated with optic instruments connected to a computers running the appropriate software, is a product of the greatest modernity, is a system that spells future trends in surveying in the same manner that the “new economy” spells the future of the economic world. Highly sophisticated instruments are the commercial fallout of technology and of the exploration of the solar system by means of space probes. The precision with which the smallest possible details are obtained, brought back to earth, measured and drawn by means of automatic systems, recalls of the fable of Chinese cartographers who zealously made a map as large as the empire and coincident with it; the problem was how to use it. It also recalls the map of Peutinger in which the Roman Empire was represented in its entirety;² or the city maps that tourists unfold in the summers, as they try to orient themselves in our half-deserted Italian cities. In order to deal with the argument of precision in architecture in a clear manner it is also opportune to recall the concept and the function of drawings: intellectual products that are dependent on visual perception, they are a foundation for the arts of form and for mimetic, symbolical and analogical languages. Historically, drawings would not have had the capacity for representing a synthesis of the

operative, mnemonic and creative realities, had they not been flexible, being at any given time art, technology, message, model, project or all of these together.

If all of this is true, then it is necessary to establish, both in the “reproduction” of the existing and in the creation of a project to be realized, a definition of scale to provide a standard for approximations or the precision required in case dimensions are used instead of graphic representations. When we are dealing with an idea, with an aesthetic message, for example, then precision is not as necessary as clarity for expressing the idea in its fullness. But in this case it is necessary to specify the essential relation that exists between a monument and its survey,³ or between the design of a project and its realization. The fable of the Chinese cartographers excludes preemptively the use of a scale of 1:1. Thus it is necessary to use smaller scales and here the problem is to transfer the building with its proper dimensions to the space available on a sheet of paper for its representation, or, in other words, to determine the degree of detail in which its formal or constructive elements are to be represented. But before making this decision it is necessary to pose some other questions: is the drawing or survey for teaching or scientific purposes? For popular appreciation? For purposes of restoration? For reproduction on a page of a given dimension? Does the architecture belong to a given historic period? Does it mean to comprehend the structural, formal and material aspects?

In the representation of a project, drawings and photographs are antithetical but can be integrated. What doesn't exist cannot be photographed. In the case of a drawing, we have a creative act that from a perceived form extracts and synthesizes the structure behind what is apparent to the senses. In the case of a photograph, the synthesis of form and structure can be achieved by the capacity of the photograph to represent in an undifferentiated way the formal aspects only, with such detail (or distortion) that risks bringing it too close to the complexity of reality, at which point the process of abstracting the structure becomes complicated. Again, I don't want to take a scale of 1:1 as an example, but rather a relationship that may run from a scale of 1:100 to 1:20. Note that in the first ratio, a line thickness of 1mm corresponds to an actual value of 10 cm, and that in the second ratio a line thickness of 2 mm corresponds to an actual value of 2 cm, so that it is useless to pretend either effective or graphic precision. And once the graphic representation is complete, then comes the process of translating the measurements given in scale into actual scale, an operation not lacking in error and adjustment. What is the use of a perfect graphic system when the actual construction and materials have their own tolerances, and when the construction workers in the past have made use of their own personal measurements, such as *pollice*, *braccio*, *piede*, or *canna*?

In the case when a design has been reduced to a representation in plane, without regard for its depth, a computer program can correct optic distortions and give approximations for elements, but these are not sufficient to determine modular, numerical or geometrical relationships, not to mention spatial relationships. A rigorous photogrammetric survey guarantees, if not the essentiality of the data obtained, at least an abundance of surface detail. The excess of precision and detail that want to compete with organic nature, obtainable with the much-sought-after instruments of our times, constitute a waste to which we are inured and which is a product of the consumerist society in which we live. In any case, it is necessary that the whole automated, computerized system, mechanical rather than specifically prepared for the task, be preceded by a rigorous analysis of the means and final objectives of the operation, subject to an adequate scientific and humanistic motivation for the task.

To return to precision in the context of the direct survey or measurement of an existing building. In this case we are dealing with an object constructed in the past. Suppose that I wish to

understand, a posteriori, the design concept and the control of the composition of the parts and of the whole, following, as it were, a sort of design process in reverse. Knowledge of the period in which this particular piece of architecture was constructed, of the techniques of construction used and of the system of measurement that was applied, allow me to choose the scale at which the graphic representation is to be carried out, a scale that brings with it approximations and errors that may be evaluated, but that do not compromise the conclusion of the research project. It is necessary also to bear in mind also that in the case of an edifice built using the local measuring system, such as the medieval fountain of Docciola built in the *braccio* of Volterra,⁴ it is not correct, no matter how expedient, to measure in centimeters.

The master builder or architect had at his disposal instruments of form and of dimension of greater or smaller size for the stone carvers and for himself, in *braccia* or in *canne* and their subdivisions: half-*braccio*, a third, a quarter, an eighth, etc. The material used in the construction, a component that must be kept in mind, was stone worked by hand with chisel and hammer, carved from a shapeless mass; at the end of the finishing process, each stone weighed between 15 and 20 kg. The process for working each block of stone resulted in an actual approximation to within 1/288 of a *braccio* (2.043mm), or .5%. The measuring instrument used at the time was a wooden rod (thus no concrete evidence has come down to us) summarily gradated, certainly not divided into percentages as references, and from which were derived other sticks that were cut for the various stone components to be worked.

I do not hold it correct, from either a conceptual or an operative point of view, to survey an existing piece of architecture from the thirteenth century using an instrumentation that is different from the one that was used in its construction. Indeed, I will go even further. In order to perform a survey that is philologically correct, it is necessary to ban every optic instrument (level, tachimeter, total station, laser measures, optically corrected photographs), to use instead instruments that are similar to those used in the construction: the linear measure (if the unit of measure is known beforehand, then it is possible to construct ad hoc a stick), the cane or rule, the perpendiculum, the water level, the square, the cord, the plumb-line, etc.

Further, the measures must be taken directly. The operation imposes the use of physical contact, if possible, with all the elements of the architecture and a direct knowledge (as much as possible) of the “interior” of the construction.

Applying the expedients outlined above assures that the measurements taken will be of a piece with the characteristics of the edifice that are proper to it and discrete, in the manner that the measures used in the edifice were discrete. In this way I do not introduce into the survey a precision that is useless for the interpretation of meaning (structure, form, measure...) of the work, but rather I am operating according to a procedure that contains a rhythm and a series of actions that are similar to those used to erect the building. Perhaps I am able to understand “something” in this particular architectural situation, as though I had “reconstructed” it.

Consider an example that is closer to us by some centuries: the Villa Rotonda by Andrea Palladio, illustrated by the architect himself in his second book of architecture (1570) and constructed in 1566-67 [Palladio 1997; Gurlitt 1921]. Between the published design and the building as surveyed by Scamozzi differences can be noted, as have been pointed out by Streitz [1973]. During construction, but afterwards as well, various modifications were made that tangibly altered the compositional balance of Palladio’s design.

A precise and rigorous survey, accomplished using all the technology that can produce a precision to within fractions of millimeters and reconstituted automatically, given the useless

precision and the cold mechanicalness, not to mention the complete foreignness to the means adopted for construction of the villa, cannot help to comprehend the compositional and structural criteria that lie at the base of Palladio's project.

In order to understand in a systematic way the precise differences between the design and the villas as built, the degree of precision must be expressed only in whole numbers, obtained through the Vicentine *pie* as the unit of linear measurement, in plan as well as in elevation and by direct measurement taken with an instrument similar to that used originally. In this way a similar relationship is established, through the progression of the acts of survey and of control, based upon the same geometric science that presided over the erection of the masonry structure.

The survey thus accomplished, reinforced by visual and numeric studies, will aid the research and will permit the evaluation of the differences made to the project during the construction of the Villa Rotonda and afterwards. On the other hand, the simple examination of the evidence present in the Palladian design regarding the dimensions of the rooms, placed along the perimeter of the drawing, permit us to compare the survey of the villa as built to Palladio's project.

The internal dimensions are arranged according to numerical relations between 11, 15 and 26 feet, where the first and third numbers are obtained by subtraction or addition of the two preceding or successive numbers, a fact of the utmost importance. The circular space has an internal diameter of 30 feet ($15-11 = 4$; $30-26 = 4$). The number 4 does not appear in writing, but recurs as the base number, on which is based the formal and distributive character of the plan that hinges on the circular central hall. But the distributive character has little to do with the kind of exactness sought by the architect in his design when, to the contrary, he wanted to construct a rule that would standardize, regularize and structure.

If the design of Palladio did not exist, then a survey of the Villa Rotonda obtained in a simple and direct way by means of the Vicentine *pie* as a measure, would permit us to reach the same structural conclusion that has been made evident, in the case that there had been no modifications made over time. In plan it is necessary to complete the dimensions of the connecting vestibules to the porches in order to have a drawing that is completely efficient and such as to permit the masonry members to be reconstructed with the same instrumentalization that was originally used. On this basis the analysis could be carried out in a profitably manner, which I plan to outline in a future occasion in a detailed article.

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Notes

1. Other authors have used the term "uncertainty". See for example [Docci and Maestri : 179].
2. The Peutergerian plan is constituted of eleven connected sheets 34 cm high, for a total length of 689 cm. [Docci and Maestri: 32].
3. The term "survey" comprises a complex of operations, from sketches of the building, to the determination of its dimensions, to its graphic representation.
4. The fountain was commissioned in 1254 by the municipality of Volterra from Maestro Stefano. Between 1260 and 1268 it was enclosed within the medieval city walls [Battistini 1998: 341].

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