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ORGANIZING INFORMATION ON CONSTRUCTION DRAWINGS

William Malpas

When a designer walks into his recently completed project, he has a strange sense of dislocation. Everything is there, but shifted slightly from where it was visualized. Perhaps the drawings did not capture the idea, perhaps the builder didn't follow the drawings, or perhaps circumstances intruded on the design. This article will examine the causes of design dislocations and discuss methods for more accurately realizing the designer's intentions.

In order to provide solutions to the problem of dislocation, we must understand that the process of communicating design intentions is essentially a series of translations between mental images and drawings. The designer develops a mental image of the client's function within a finished space. He then adjusts this image to match the conditions; an interior fits within the confines of an existing building, a structure shifts around and finally settles on a piece of land. Once the shape-function relationships have stabilized, the designer can begin work on the spatial and proportional relationships which are the essence of the design. "The facade is parallel to the street", "the building is twice as wide as it is tall", "the windows are centered in the column bays", "the door and window mullions align", "light from the skylight washes down the wall at noon", are statements which describe relationships between parts of the building. It possible to use such simple declarative statements to create a clear image of the project at the conceptual stage and to accurately describe the project after it is built.

Between the original conception and the finished product, several translations take place:

The designer's mental image takes shape as a drawing.
Dimensions are added to the drawing.
The drawing evokes an image in the builder's mind.
The builder disassembles his mental image to put together an estimate and to determine the construction process.
The construction process generates the finished product.

The fundamental change is when the designer's mental image is committed to paper. Specifically, aesthetic relationships are used to generate values. Put another way, construction drawings must attempt to express the declarative ideas about relationships in the procedural language of measurement.

The terms declarative and procedural are borrowed from computer science and can be briefly defined as follows: The statements in a declarative description have no particular order or sequence, all statements are true and all relationships valid simultaneously. Examples of declarative description are paintings, sculpture, and maps.

The statements which make up a procedural description must be evaluated in the same order in which they occur. Measurements are procedural in that they have a starting point, a direction, and a length. Other examples are a story, a recipe, a musical score, or a screenplay.

Designers encounter a fundamental problem when they try to express a declarative design in procedural terms.

In an ideal world, the windows that the designer draws as 8'-6" apart are exactly that. In reality they are either slightly closer together or slightly farther apart, in the same sense that while it may be possible to have three bottles of milk, it is not possible that they will contain exactly three quarts.

Central to the definition of a procedural description and the language of measurement is the idea of sequence. Measurements can be thought of as vectors in which the three parameters are sequential. In other words, each measurement has a starting point, direction and length. The notion of a predictable sequence confronts the inherent randomness of the construction process.

Some phenomena are intrinsically unpredictable. Gregory Bateson (G. Bateson, Mind and Nature -New York: Bantam Books Inc. 1980) gives an example: "If I throw a stone at a glass window, I shall, under appropriate circumstances, break or crack the glass in a star shaped pattern. But within the conditions which produce the star shaped break, it will be impossible to predict or control the pathways and positions of the arms of the stars."

This is a singularly appropriate analogy for the building process in general, and retrofit or rehabilitation work in particular. How can one predict what a hole will contain, which brick will fall first, where the first nail will go, or from which end of a wall the layout will start?


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Other phenomena which may be theoretically predictable, are not in practice. Anything that depends on sequence in construction tends toward the unpredictable. Maintaining construction crews is so expensive that there is every economic incentive to keep the workers busy even if it means doing things out of order. In fact, the key to efficiency is to attack a problem as soon as it becomes apparent; field management therefore rarely has the luxury of doing things in their proper sequence.

In addition to the understandably unpredictable, there are things that given adequate supervision, conscientious workers, and quality materials, ought to be predictable, yet are not due to cumulative statistical error. As an example consider an office remodel with one hundred doors; There are two widths, two heights, two fire ratings, two swings, two wall thicknesses, and two lockset functions, for a total of sixty four different types of door. Intuition indicates that each time the possibilities double, the chances of a mistake increases by some factor. If the factor were one per cent, at least six doors would be wrong.

How does the unpredictability of construction sequence affect the translation of dimensions on drawings to measurements in the field?

Unpredictability affects translation at two levels, the micro and macro. At the micro level, in order for a scaled dimension to have a one to one correspondence with the actual field measurement, the three sequential parameters of the dimension must correspond to the parameters of the measurement. In other words, they must share the same starting point, head off in the same direction, and go the same distance.

Drawings often give the direction and length of a line, but, with rare exceptions, omit the first element, the starting point. More importantly, when one dimension depends on another, the succession must be made clear.

Trying to layout a complex area with arcs, wings, angles, and door swings without starting points is like trying to read a novel with every third page missing or tuning into a mystery movie half an hour late. Note that this is standard operating procedure: either layout people have strong abilities to infer what the designer intends, or they fall back and scale dimensions off the drawing.

Have we isolated the problem? If starting points and the sequence for dimensions were included on drawings would our troubles be over?

The answer is no, and the reason is at a macro level; the unpredictability of construction sequence means that dimensions may be needed before their logical predecessors are available. An example of this is the floor to floor height to calculate piston travel of a hydraulic elevator is generally needed long before floors exist from which to measure.

Since it is so difficult to translate dimensions on drawings into actual measurements, what alternatives exist? We advocate that the following methods be considered:

1) Explain the Design

Society puts a premium on explanation over description, on distillation over raw data. Each project should begin with a written explanation of the design. Explanation differs from description in the following ways:

> a) Pure descriptions, plans and specifications in the case of construction, have all the facts but no indication of connections between the things described.
>
> b) Explanation contains no information that is not contained in description, in fact, it may have a good deal less.
>
> c) Explanation may approach the problem in a different language. In the case of construction, plans and specifications are labeled drawings and terse lists in word-processor-ese, while explanation is written in English. This two language approach yields insights which are not accessible any other way.

An explanation is an overview of the project. It could be a discussion of the look and function of the finished product; the intention of the design, for example "This project may be submitted for several awards... ", and it may refer to comparable projects to give an idea of the expected level of finish.

When the purpose and goals of the design are clearly stated at the beginning, the builder and his estimating team can more accurately conceptualize the project during the bid phase which will result in a more precise estimate and a better product. During the bid phase, the estimating team has only weeks to digest months or years of design work. A clear explanation enables the estimators to call in appropriate subcontractors and designate appropriate crews to achieve the indicated quality and delivery. There is less chance of misunderstandings, and a greater likelihood that all parties head in the same direction.

In addition, a clear explanation of the design rules eliminates the need for the designer to resolve problems on a case by case basis, allowing decision making to occur at the lowest effective level. This makes it possible for the layout people to infer or extrapolate information not shown on the drawings.

2) Use Words, Not Numbers

Wherever possible, in place of dimensions the drawing should describe the project in declarative terms, “equal”, “flush”, "center”, and "align”, and proportions such as "x" and "2x". The drawings should also indicate where modules begin and end, so that reference lines or planes in the real world can be made to correspond to the logic of the design. In some cases, however, measurements are inescapable. Measurements intrude into the design for a number of reasons: Building codes require minimum dimensions for such things as stairs, handicapped bathrooms, and fire corridors, municipal codes control property line setbacks and easements, and finally, building components come in stock sizes. Note that codes are generally concerned with finished clearances, so required dimensions are generally expressed as '3'-4" Clear', or '5'-6" Finish to Finish'.

Where stock components are to be incorporated, the drawings should note 'Center component here' or 'align edge of component here', and the specifications should include a tear sheet of the component. This leaves the various calculations for thicknesses of materials to be done full size at the time they are needed, rather than the tortuous (and frequently inaccurate) scaled details so common on drawings.

3) Do the Research

Incorporating tear sheets of components in the specifications has several beneficial side effects; the research is done once by the designer rather than by each estimating team bidding the job. The estimators know exactly what to price so there is a better chance that the bids will be comparable. It may even be possible for the designer to check on the availability of various components, and to use this as a criteria for selection.

4) Confine Measurements to the Smallest Logical Module

Measurements should be confined within the smallest appropriate subdivision or module of the design matrix. Modules can be anything from the column bays of a big building to 4' sheets of plywood on a house. When a measurement is needed, and it's logical predecessor is not yet available, the potential error is compensated within that module and doesn't accumulate throughout the building.

Liability

These proposals aid the construction process without increasing the designer's liability. Being held accountable for carefully chosen wording in an explanation is an improvement over being held accountable for words spoken in meetings and in impromptu conversation.

In the sense that errors in addition are inevitable, opting for declarative statements in lieu of dimensions on the drawings may actually reduce liability. Incorporating tear sheets in the specifications makes it less likely that unacceptable alternates or substitutions will be bid. It also shifts the burden of proof that a proposed alternate is compatible back on the person proposing the alternate, because the clearances are worked out full scale in the field in terms of the specific component, to be used, not on the drawings.

Conclusion

Plans and drawings produced with an awareness of the above points look no different than conventional drawings. What is different however, is that methods are incorporated into the contract documents to resolve conflicts between theory and reality and to more accurately realize the designer's intentions.

The Author

William Malpas is a Project Manager for a design build
general contractor in San Francisco.