

# Methods of Integrated Design and Construction: Design and Building Process Interface

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This paper investigates the interface between design and construction. How much does design determine the construction and how much does construction determine the design? How much is design integrated with construction and how much is it separate? How much does the virtual or design side contribute to the reality of the building and how much does the material or construction side contribute to the reality of the building? The transformation of the art and act of making the built environment will be studied on the level of building methods, and specifically the role of the architect in the building process.

The building method we choose for a particular project has an important impact on the building process as well as the quality of the resulting building — the greater the degree of integration of design and construction, the more opportunity to shape the emerging whole, fine-tune relationships, connect to place, and create a deep human connection with the built environment.<sup>1</sup> Beginning with standard relationships we have to look at the methods of building or building contracts which define the legal, financial, and contractual relationships between architect, owner, contractor, and subcontractors. Building methods are here distinguished from building systems which deal with the structural engineering and construction aspect of a building, and building techniques which deal with particular technical aspects and procedures of construction. Rather than accept the separation of design and construction as a given, such as in the standard General Contractor building Method, we investigate other available methods, or invent and define new methods and types of contractual relationships between the parties involved in building — architect, owner, contractor, subcontractor, and possibly other participants such as manufacturers. More than ten methods have been experienced, partially tested, and partially invented and developed, exploring degrees of integration of virtual design and material construction realities.<sup>2</sup> The form of testing has always been to build particular projects according to one of these methods, so that almost every method has at least one building associated with it. The ten or more building methods are the following:

1. GENERAL CONTRACTOR (GC) METHOD
2. MODIFIED GENERAL CONTRACTOR (MGC) METHOD
3. ARCHITECT GENERAL CONTRACTOR (AGC) METHOD
4. CONSTRUCTION MANAGER AS OWNERS AGENT (CMO) METHOD
5. ARCHITECT CONSTRUCTION MANAGER (ACM) METHOD
6. DESIGN BUILT (DB) METHOD
7. COST AND FEE RENT A NETWORK (RAN) METHOD
8. MEISTER METHOD (MAINLY IN EUROPE) SUBCONTRACTOR (SC) METHOD (IN AMERICA)
9. ARCHITECT SUBCONTRACTOR (ASC) METHOD
10. ARCHITECT BUILDER (AB) METHOD
11. ARCHITECT PRODUCER (AP) METHOD
12. DO-IT-YOURSELF METHOD
13. MIXED METHODS

## FOCUS OF PAPER

The emphasis in this paper is on integrated methods of design and construction in the building process or in architectural process. Which kind of building methods permit a thorough interplay between design and construction during the actual building process? What methods permit the architect direct contact with the actual construction and direct contact with subcontractors, such that design continues during construction and becomes a part of the construction process, possibly to the point that the architect can also build?

The main focus of this paper is to demonstrate to architects that there are a range of possibilities of continuing the design during the construction in varying degrees. The architect does not have to follow solely the standard method of the GC method, which in fact is one of the least integrated methods of building and which rather forces the architect to have everything designed beforehand and leave the building to the general contractor. In a different paper I will develop and apply a critical set of criteria under which these methods can be compared and evaluated, I also will pursue a compari-

son between the different methods according to these criteria. In this paper my main emphasis is simply to show that there is a wide variety of building methods from which to choose for a given project. Secondly, there are a variety of projects which has been built according to these various building methods. And third, that there are particular building methods which have been specifically invented and developed to accommodate a need in a particular project for a process of integrated design and construction. Let us go through some of these methods (with various case studies) which I have begun to research and develop:

## **DESCRIPTION AND SHORT ANALYSIS OF BUILDING METHODS WITH EXAMPLES OF BUILDINGS (CASE STUDIES)**

### **1. General Contractor (GC) Method**

In this standard method (in the United States) an architect hands plans and specifications to a general contractor and observes the work of the GC to varying degrees during the construction — the owner holds separate contracts with the architect (for design) and the general contractor (for construction) respectively. During the construction the architect's involvement is limited to observation of the construction and advisory function to the owner. This method separates design and construction; but, it is also the most common method these days. It is appropriate for architects who only want to do their design, but who do not wish to be deeply involved in the process of building itself. Since most buildings are being built in this method, no particular case study will be presented.

### **2. Modified General Contractor (MGC) Method**

In this method the architect agrees with the GC on certain additional features, such as making mock-ups on the site during construction, which give the architect the right to be more deeply involved and further the design in direct relation to the emerging reality of the building.

In this method a contract is arranged with a standard general contractor, and modified such that the architect can make enough changes and modifications on the site to control the emerging whole during construction. This is quite a different process from the execution of a design. In the case of the KOMAGOME BUILDING, CES Japan and I used a modified general contractor construction method. Several major elements that create the quality of the Komagome were designed and tested as part of the construction. For example, a large scale mock-up which I arranged for the exterior facade of the building had a decisive impact on the final choice of materials for the exterior wall — instead of concrete the exterior of the wall became yellow terrazzo. Without the modified construction process the building could not possibly be the same.<sup>3</sup> I also used a modified GC method to design and build the first part of the CHRISTIAN MUSIC VILLAGE in Nagano in Japan. The stake-out of buildings and paths on the site as well as various mock-ups

(including the mock-up for the very important exterior garden house) were architect responsibilities during construction.

For the design and construction of the AGATE MARRIED STUDENTS HOUSING PROJECT in Eugene, we also applied this method, particularly in the form of various stake-outs and large scale simulations of interior apartments. This method seems to be quite flexible, and is, as far as I understand, applied by a wide variety of architects, who need some special arrangement in the construction process.<sup>4</sup>

### **3. Architect General Contractor (AGC) Method**

In this method the architect also works as a General Contractor, in this case complete integration of design and construction can be attained for a project. As architect/contractor, several key aspects of the building process can be clearly transformed to allow wholeness to occur in building. The architect takes direct charge of this process so that the building becomes better, and takes legal responsibility for construction. CES has done this in several house projects, such as the ALBANY HOUSE, the POPPY LANE House, and the LIGHTY HOUSE, and also in other projects such as the MARKET HALL in Fresno and the MEXICALI PROJECT. In the Albany house for example, the experimental and innovative application of a new engineering system mostly in part of an exterior wall, probably could only have been done in this method. For the Mexicali project, incorporating the involvement of users in the layout of the site and the buildings was made easier within this building method.<sup>5</sup>

### **4. Construction Manager as Owner's Agent (CMO) Method**

In this method the owner hires a construction manager (CM) to supervise and coordinate the construction of the project. The responsibilities of the CM may vary, but a typical case is the involvement of the CM in addition to the architect and the General contractor because of the complexity of the project, or because the owner needs an additional supervisor only responsible to the client. This is more of a client's model. It may or may not make the building process more integrated. It seems, however, to result in a further separation of design and construction.<sup>6</sup>

### **5. Architect Construction Manager (ACM) Method**

In this method (different from the standard CM-method), the architect also works as a manager for the construction of the building. What is unusual in this model is that the architect is working as the construction manager for the client who formally takes over the function of the general contractor, but it is the CM who practically carries out this function for the client.

For the design and construction of the EISHIN CAMPUS, CES developed a new method called the Architect Construction Manager (ACM) Method. In this model the architect also manages the construction for the owner. This is quite

different from the standard CM method in which a third entity, apart from the architect and owner, takes on construction management responsibilities. The main difference is that in our case it is the architect himself who takes on this work for the owner.<sup>7</sup> It means that control of "construction means and methods" and "contract administration" is in one hand. This constitutes a major transformation, since means and methods are emphatically excluded in normal current practice (see for example distribution of responsibility in typical architect contract B 141 in the US.). With the Architect CM construction method in place, the following major areas of design and construction were in one hand for the purpose of achieving profound quality in this project: planning, design, landscape, structural engineering, material testing and development, construction, and cost control. While the first four of these areas are typical architect/engineer responsibilities and the last two contractor responsibilities, it is the combination of all into one unit which opens up new possibilities for the integration of design and construction.<sup>8</sup>

One such opportunity is the design and construction of the site plan directly on the site in order to achieve an unusual degree of integration and connection of the buildings to the site. In the case of the Eishin campus the rather large site plan was developed directly on the site using bamboo sticks, flags and strings for demarcation of building positions, these positions were carefully recorded and became the actual site plan. "It was a great moment, after months of hard work, when the final site plan was in front of our eyes with white, yellow, red and blue flags. It was amazing to see, suddenly it was real. The bowl-shaped site was filled with flags, which were climbing up the homebase street, and then continued along the tanoji center. Everybody who saw it was inspired."<sup>9</sup>

### 6. Design Build (DB) Method

In this mostly American standard method the attempt is to place design and construction in one hand, so that the architect also works as a builder or general contractor with the main purpose of getting the cost down and to do efficient construction in a design-bid fashion, mostly connected to a guaranteed maximum price (GMP). The American design build is often done in cooperation between an architect and a construction company.<sup>10</sup> The advantages are mostly for the owner in terms of this GMP and also with regard to possible dispute problems between architect and contractor. Integration of design and construction is possible, but not necessarily with the goal of improving the human quality of the building.

### 7. Cost and Fee Rent a Network (RAN) Method

This method, which I first got to know in Japan, is used quite often between various large construction companies, where one construction company rents the sub-contractors network from another large company for a fee. For the construction

of the Eishin Campus in Japan, we tried to reinterpret this method in such a way that the architect works as a construction manager for the client and uses the sub-contractor infrastructure from another company. In fact, in negotiations with large Japanese construction companies, one of the larger companies offered us this method as a possible contract and construction procedure.

### 8. Meister (MM) Method (Mainly in Europe) — Sub-Contractor (SC) Method (in America)

In this (mostly European) method all major works in the building are done by Meister (masters)—the architect works as a Baumeister. In the United States this method probably would have to be called the Sub-Contractor Method because there is no general contractor, there is only the owner, the architect, and the various major sub-contractors. This method is not very popular in the US., but it is the method I grew up with and which I learned first. This method puts the architect in a much more responsible position since he has to coordinate the various sub-contract works much more than in a general contractor method. The potential for the integration of design and construction is much stronger than in a GC situation. In fact, I have participated to work on various projects in my father's office in this method as my first experience of a professional building method. For the construction of the PARK CITY HOUSING PROJECT in Frankfurt by CES and my own company HNA, we are considering to apply this German traditional standard method in a modernized version.

### 9. Architect Sub-Contractor (ASC) Method

In this method, the architect works as a subcontractor and craftsman to achieve quality in a particular important part or feature in a larger project which is run by a General Contractor. In fact, this method belongs to the Mixed Methods (see mixed methods), but because of the great possibilities for the architect to be involved in the process of integrated design and construction, I list it here, as a method in its own right.

In CES's SHELTER FOR THE HOMELESS in San Jose, the architects took on several of the construction projects as subcontractors, such as a rather innovative concrete truss for the dining room, special concrete columns for the arcades, the tiled exterior wall on the second floor, as well as a beautiful tiled fountain in the entrance garden. In this case, if the architect cannot do the complete construction, he/she can take direct control of sub-projects which will most increase the life of the whole. The main idea here is that the architect takes on a few key subcontracts, let's say for about ten percent of the construction to make sure that key elements have such a high and particular quality that they determine the feeling of the overall project, even though some other parts of the project may be much less in quality<sup>11</sup>

### 10. Architect Builder (AB) Method

In this method the architect also works as a builder, with the

main purpose of creating a beautiful building (similar to how cathedrals were built). The difference to the Architect General Contractor method is that in this case the architect does almost all of the construction in-house. There are no or very few outside sub-contractors. The method is highly suitable for the process of integrated design and construction and fits in particular for experimental buildings. For the design and construction of the MARTINEZ FIELD STATION, CES applied such a procedure. This building was developed in an innovative gunnite procedure — all walls, and even floors and ceilings are mostly shot in gunnite, a form of rather dry concrete.<sup>12</sup>

### 11. Architect Producer (AP) Method

In this method, an architect and a building product manufacturer together form a construction company to build a project. In the SAKURA TSUTSUMI example, I invented a new method called the “Architect and Producer” (AP) construction method. In this project PermaStone Nihon Co., which manufactures a prefabricated unit facing material (PUF), and my own company in Japan formed a construction unit. With the AP construction method the following major elements of the building process were under our control: design, structural engineering, material testing and development, manufacturing, construction, and cost control. Thus, we could integrate design and construction to a high degree. Not only could the emerging whole be fine-tuned and adapted throughout construction by experimentation with various building details, but there was also the opportunity to work with the manufacturer to experiment with and modify the unit facing system in direct relation to the emerging whole. In particular, the development of the exterior wall with the double diamond shaped stone unit, and its technical connection to the wall was a rather innovative development and good cooperation between architect and the manufacturer.

### 12. Do-It-Yourself Method

The Do-it-yourself method has in essence all the important ingredients of a process oriented and integrated architecture within it. First, you have a vision, you feel a need of something which needs to be improved in your house. You think about it, make some sketches on the back of an envelope and later some better paper. Then you think of how to do it, what it will cost, how much time it will take. etc. But mostly you think about how this little action will improve the world around you.

My wife, for example, has by now built various versions of a Japanese BAMBOO FENCE in front of our house, right next to the street in a public zone. This place which before was used by dogs, is now a real pleasant place, with flowers, making our life just a little more happy. Another example is the terrazzo floor in front of an entrance of a friend's house. This method is actually quite relevant when one thinks just about the amount of construction which is done through this method.

### 13. Mixed Methods

We also have to consider the case, where mixed building methods are being applied. This means that some of the previously explained methods are either being used together such as the architect sub-contractor method which was used within the General Contractor method for the construction of the San Jose Shelter for the Homeless. Or different methods may be applied in sequence such as the Architect Construction Manager method for the first part of the project and the Modified general Contractor method for the second part of the Eishin Campus project. Mixed methods need to be understood and analyzed and developed more extensively.

There is one mixed method which I always try to implement. And that is the Architect builder method within any other of these methods. This means that the architect builds at least one little thing himself. For the Agate Housing Project, for example, we build the brackets for the entrance gate and gave it as a gift to the owner; for the Emoto Apartment Building we made some tiles and gave it as a present to the owner, and for the Eishin Campus we built a little storage shed just for fun.

### CONCLUDING REMARKS: FOR THE FUTURE

We have started with the assumption that the building method has an important impact on the building process and the quality of the building. The greater the degree of integration the more opportunity to shape the emerging whole, fine-tune relationships, connect to place and connect the human feeling with the environment. We have looked at various building methods with varying degrees of integration of design and construction, including standard methods such as the general contractor method, which is one of the least integrated methods. We have also looked at other more integrated methods, and we have looked at various new methods which we have invented. Rather than accepting the separation of design and construction as a given, we have shown that the architect can invent and define new methods and types of contractual relationships between the parties involved in building. Several methods have been developed and applied successfully many times over in many projects. We have seen a variety of projects associated with these methods so that at this point we have a variety of case studies in which these methods were applied.

The focus of the paper was to demonstrate that design and construction do not have to be separate processes but can very well be integrated, so that we can achieve other kinds of qualities in our buildings than provided by the more standard kind of methods. These other kinds of qualities have been made concrete in the various building examples which have been built in these various methods. The main purpose of the paper, therefore, was to show and explain these methods in order to inform and inspire, and overcome the separation of design and construction, so that one can choose from them for a particular project.

There are of course many related issues to this topic which

are beyond the scope of this paper, such as the question of comparison between the different methods according to a list of critical categories. In a future paper I will develop and apply a list of categories which can be used for comparing these various methods in terms of performance, such as: a) level of integration of design and construction, and b) possibility of innovation, etc. Next, I will prepare an organized comparison between these different building methods. Also, since we have a lot of built projects at this point, it also may be possible to prepare a comparison of success of projects and then relate the project to the building method.

There is also the question of the appropriateness of a method. Each method may be appropriate for particular kind of project, for instance a large steel bridge may be more appropriately built in a General Contractor method. The key question, however, is always which method helps best to improve the quality of the built environment for a particular project.

## NOTES

<sup>1</sup> see Artemis Anninou, "The Unified Building Process: Variables Which Produce a Coherent Structure of Space," (Ph.D. Diss., UC-Berkeley, 1986).

<sup>2</sup> For a first analysis of various building methods from the point of view of an architect, see Hajo Neis, "City Building: Models for the Formation of Larger Wholes," (Ph.D. Diss., UC-Berkeley, 1989) pp. 186-90.

<sup>3</sup> Maison de Louran, "Good Reaction to the Landscape and Urban Scape: It Succeeds to Interweave with Delicate Shape," *Nikkei Architecture* (6-13, 1988), special issue on small urban buildings in Tokyo, title page and pp 65-9.

<sup>4</sup> Dominique Bonnamour-Lloyd, "Significant Details: Three Stories," *Critical Practice* (Proceedings for the 1994 East Regional Conference) pp. 450-61.

<sup>5</sup> The Mexicali project is reported at length in: Christopher Alexander with Howard Davis, Julio Martinez and Don Cover, *The Production of Houses*, (New York: Oxford University Press, 1985).

<sup>6</sup> For an understanding of the conventional CM method, see for example: Kavanagh, Muller, and O'Brien, *Construction Management*, (New York: McGraw-Hill, 1978).

<sup>7</sup> Christopher Alexander, Hajo Neis, *Battle: A Crucial Clash Between World System A and World System B*, (Book ms, Berkeley, 1994). Section on construction method.

<sup>8</sup> "Big Difference of Japanese Reality and Exposure of Difficulties of CM-Method," *Nikkei Architecture* (5-20, 1985), title page and pp. 60-8.

<sup>9</sup> Hajo Neis, "City Building: Models for the Formation of Larger Wholes," (Ph.D. Diss., UC-Berkeley, 1989). p. 225.

<sup>10</sup> In Japan the large construction companies usually have their own design sections, they therefore also have the capacity to deliver design build projects as one entity and quite often function as such. This form of the design build (DB) method differs from the American version, and may therefore constitute an additional method in its own right.

<sup>11</sup> see, Thomas Fisher and Ziva Freiman, "The Real Meaning of Architecture," *Progressive Architecture* (July, 1991), pp. 100-07.

<sup>12</sup> see for example, Pilar Viladas, "Harmony and Wholeness," *Progressive Architecture* (June, 1986),