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ABSTRACT

THE HISTORY, ADVANTAGES, AND DISADVANTAGES OF COMPONENT BUILDING SYSTEMS ARE DISCUSSED. APPLICATION OF THE SCIENTIFIC METHOD TO THE BUILDING INDUSTRY FORECASTS THE USE OF PREFABRICATION AND ON-SITE ERECTION OF FACTORY-MADE SUBSYSTEMS OF BUILDINGS. EDUCATIONAL FACILITIES IN THE UNITED STATES, CANADA, AND ENGLAND HAVE MADE USE OF MANY DIFFERENT SYSTEMS, INCLUDING S.E.F., S.C.S.D., CLASP, AND S.S.P.. THE RELATIVE COST AND EFFECTIVENESS OF EACH SYSTEM IS EXPLAINED. (TC)

R. HALSALL

The Systems Approach to Building.

A brief report on the Canadian Scene in November 1969 with particular reference to School and College Construction

The traditional methods of building construction have relied heavily on labour on the job site. Over the years more and more products have been standardized and factory-produced. Power tools and machines have been introduced to make labour more productive, but in the U.S. 10 years ago 2.7 million construction workers produced construction valued at $66 billion, $24,000 per worker. Last year, in constant dollars, 3.4 million workers produced $85 billion in construction, or $25,000 per worker. This represents a productivity increase of only 0.4% a year per worker, compared with an annual productivity of 2.5% for the economy as a whole. Negotiated wage increases in construction labour in this period have been far higher than increases for other labour, despite this glory lack of justification and clearly we have reached a state where some major breakthrough, either in design techniques, products or management methods, or all three, are desperately needed.

One other statistic here might be of interest.

In 1963 a careful study carried out by the division of Building Research of N.R.C., on a sampling of construction sites in Vancouver and Toronto showed that between 40% and 50% of field labour time was applied to non-productive activities. The report broke down this time into:

- Receiving instructions
- Searching for materials, tools and equipment
- Waiting for materials, tools and equipment
- Held up by other tradesmen
- Personal delays
- Idle for no apparent reason

It also pointed out that there was a significant variation in efficiency between one type of construction and another. Apartment and simple repetitive buildings showed relatively high efficiency, while schools, hospitals and more complex buildings became progressively worse.

Fortunately, there are some hopeful signs to be observed, and they are in fact flashing more clearly in Canada just now than anywhere else in the world.

Three areas of significant improvement are defined with the word "Systems" and they become rather confusing, but here are three definitions:

Definitions

The Systems approach to building is merely the application of the scientists' logic to a problem, rather than acceptance of ad hoc routines that have developed and become accepted over the centuries. The traditional scientific approach to any problem is:

1. Definition of the problem clearly and comprehensibly.
2. Analysis of the problem into its components.
3. Hypothesize responses to the components of the problem.
4. Investigate and reuse until one is able to prove their validity.
5. Synthesize the proven values and relationships into a statement of solution to the problem.
6. Be persuaded to accept recognition and reward.

It has only recently been recognized that this is as equally applicable to constructing an educational building as it is to the study that goes on inside.

The ad hoc approach in many peoples' eyes has been frequently rather different - I say this with tongue in cheek and emphasizing that this is only an unproven hypothesis.

1. Define the recognition and reward that must accrue to a solution.
2. Analyze the defined recognition into component concepts that will photograph effectively for the glossy journals.
3. Hypothesize drawings that might relate to these concepts.
4. Investigate and revise owner's requirements to prove that they conform to the hypothecated drawings.
5. Synthesize the unproven component concepts and relationships into a whole problem on a construction site.
6. Persuade the owner to accept the problem clearly and comprehensively.

Clearly the Systems approach is the better and it is rapidly being implemented by the better architects and engineers.

An example of the Systems approach to building is one of Ottawa's major builders, who retained a firm I am involved with to undertake a comprehensive study of his housing operations. After this was completed, his house design was greatly rationalized but no change was made to the finished product that the house owner would recognize. All the product changes were in fact improvements in quality and performance and reduction in cost. The most newsworthy item that came out was that the builder acquired his own forests and lumber company. That is one result of the Systems approach to the problem of building houses on a large scale.

A Building System is generally meant to be a coordinated and generally prefabricated set of components that can be assembled in different ways to perform one or more functions in a building - such as a structural system, a ceiling system, or a heating and cooling system.

Systems Building is the whole process of construction using an integrated group of building systems, in which generally the planning, design, programming, manufacturing, site operations, scheduling, financing and management are coordinated into a disciplined method of mechanized production of buildings.

First of all we accept the logic of the Systems approach and we apply this to whatever problem we have.

This has been done most remarkably to date in Toronto, in the S.E.F. schools project. It has resulted in the development and acceptance by Metro Toronto School Board of 10 Building Systems that are now being used in a Systems Building Programme of 31 schools and one administrative building, totalling about 2 million square feet of construction.

The S.E.F. project is the most sophisticated product of a sequence of development taking place over the past 20 years. Just after the war a group of school authorities in England faced with an urgent need for new buildings developed a set of parts like a large meccano [erector] set for constructing the skeleton framework of a school. This was the original CLASP system. Floor and wall panels have now been developed, but it is still a very rudimentary system and only provides a building shell. However, this part of the building is installed quite a bit faster than by traditional construction, and the modular discipline it impresses brings advantages also to the other trades.

A young American architect who had been working in Britain on the CLASP programme then returned home and in 1961, with help from Educational Facilities Laboratories and financed by the Ford Foundation, he persuaded a group of school boards in Florida to coordinate into one programme the needs for 13 schools, about $30 million. This programme was analyzed and it was decided that building systems could be developed to provide for main components of the school buildings, structure, ceiling-lighting, heating-ventilating, and interior partitions, covering about one half the total cost of each school.

Performance specifications were written defining clearly the properties, performance and target prices for these systems and proposals were received from industry. It was claimed that the cost of the products involved in the programme was 20% less than the price that would have been obtained using existing standard items, and the programme was satisfactorily completed.

One very interesting item regarding the prices for the products developed for this program, S.C.S.D., is that the successful and the unsuccessful bidders have been busy marketing their system across the States ever since and the cost of the structural frames built to these specifications has been falling steadily, even in terms of contemporary dollars. The State of Florida has accepted the S.C.S.D. specifications for $40 million school building programme. In 1963, the initial

S.C.S.D. structures were low-bid at $_____ per square foot. In the most recent Florida tender call, structures using the same specifications were priced at $____ per square foot. This is the fact of progress we need.

In 1967 the Metro Toronto School Board launched its S.E.F. programme aimed at 2 million square feet of school construction, and in 1968 Montreal started work on the R.A.S. programme with an objective of 3 million square feet of construction. The Montreal programme involved 5 systems. The tenders received early this year were below budget and an ingenious precast concrete structure was the result. I have no illustrations as there is nothing yet built, but the political and administrative problems appear now to have been resolved and construction of a prototype building has recently been authorized.

The Toronto programme is getting into full swing and I can give some illustrations. My firm was retained firstly by the Canadian Steel Industry Construction Council to advise them on industry participation in the venture, and then we were retained by a consortium to prepare a design and manage the whole project of testing, interfacing and bid preparation. This was the successful structural proposal and here are some slides of the end product.

Firstly, a small school addition was built as a test bid to demonstrate that all the low-bid systems did in fact perform as they were supposed to do. This was successfully completed and the first year's batch of schools, representing about one half of the programme, are now underway. The largest is Roden public school in the City of Toronto, a 3-story building containing 83,000 sq. ft. The bare frame of this structure was erected in 8 days and the whole school is scheduled for completion within ______ weeks of the contractor getting access to the site.

The schools in this programme have much more elaborate capabilities than conventional buildings. They are fully air conditioned and carpeted. All electric electronic power and communication circuits are freely available by connection on a five foot grid throughout the ceiling. Partitions permanently demountable and operable may be located anywhere on the 5 foot grid and a complete range of surfaces are availabe. The only non system items are stairs, foundations, slabs on grade, field painting where necessary and exterior site work. Virtually all possible problems have been tackled and either eliminated or solved, in the design of the standard components and the design of the buildings, and their construction in the field becomes a quick and accurate process of assembly. The structure is designed to allow up to 4 stories, with clear spans of up to 35 x 65 ft. and live load throughout of 100 pounds a square foot, with partitions locatable anywhere on the 5 foot module as I mentioned earlier. The cost with all these facilities is below the target set as the Metro ceiling cost formula at the beginning of the programme and it is estimated that these schools, which cost about $11 a square foot, would cost $4 a square foot more if built by conventional construction.

These performance capabilities are in response to the S.E.F. specification, produced after a profound study of the present and foreseeable academic preferences in school buildings for the Metro Toronto area.

They are not necessarily appropriate to the particular needs of other education systems, but many authorities want to take advantage of this new hardware. Vancouver School Board has commissioned an architect to use 5 of the major S.E.F. components. Boston is accepting virtually the whole S.E.F. spec. on two large schools immediately and enquiries are being received from across the continent by the participating manuafacturers.

A sales organization has been established to offer a group of systems that were developed for S.E.F. in an integrated fashion and with some modification to the products to lower the cost somewhat by removing the most expensive of the sophisticated refinements requested by Metro Toronto. I expect that the systems developed for the Montreal programme will also soon be actively marketed. The two cities had significantly different requirements, but the basic modular dimensions are the same and some interchangeability between components is likely to develop.

So much for the hardware of systems developed for educational buildings. Many of these are probably directly applicable to large areas of community college buildings, providing high performance, flexibility of function at controllable and modest cost (S.E.F. price lists).

There are not really very many areas of a community college where one can honestly guarantee that the components will be the right things in the right size in the right place for the 50 years or whatever that the building shell might be acceptable for. Probably only auditoria, stairwells, dormitories, swimming pools, main mechanical and electrical rooms and washrooms are genuinely fixed. Other elements that may have a permanent type of occupation may very widely in desired size and service - such as libraries, cafeterias, lecture rooms, laboratories, shops. Who say what future courses or teaching methods will require?

For a building to be suitable for organic growth or rearrangement it is really neccessary for the various elements to have a dimensional precision that can only reasonably be achieved by factory manufacture. However, the systems now available on a large scale do not by any means meet all the requirements of a community college building project and we return to the Systems approach.
Define the problem.
Analyze it into its components - see how far existing Systems can most efficiently meet some of the needs.
Investigate remaining needs and see if other systems should be developed or other rationalization carried out.
Synthesize the systems into the efficient whole.

Here are some slides indicating in a diagrammatic way the Systems approach applied to fundamental planning developed by one firm of architects with whom we collaborate, and directed specifically at community college buildings.

To close, I should mention other areas where systems building is coming into prominence. These include hospitals, apartment buildings and residences, service stations and motels, houses and parking structures - to name only the fields in which I personally have become involved, and to show that systems building in the hands of good architects can produce most pleasing as well as efficient buildings, here are some final slides.