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ABSTRACT

BUILDING DESIGN, PLANNING, AND CONSTRUCTION PROGRAMING FOR MODULAR DECENTRALIZED MECHANICAL BUILDING SYSTEMS ARE OUTLINED IN TERMS OF COSTS, PERFORMANCE, EXPANSION AND FLEXIBILITY. DESIGN STRATEGY, APPROACH, AND GUIDELINES FOR IMPLEMENTING SUCH SYSTEMS FOR BUILDINGS ARE SUGGESTED, WITH EMPHASIS ON MECHANICAL EQUIPMENT AND BUILDING ELEMENT REPETITION. THE TECHNOLOGICAL GAPS ARE OVERVIEWED BETWEEN BUILDING DESIGN AND THE CONSTRUCTION AND BUILDING INDUSTRIES. (TG)

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"DECENTRALIZED MODULAR SYSTEMS VERSUS CENTRALIZED SYSTEMS"

The assigned title of "Decentralized Modular Systems versus Centralized Systems" suggests a paper which would involve a detailed collection and synthesis of innumerable cost items. These items would then be displayed in complicated graph and tabular form. I do not intend to develop this type of study. "Modular Decentralized Systems" is a term that designates the development of mechanical systems that solve relatively small portions of a building complex by the installation of standardized equipment and distribution routes. This solution is then repeated throughout the building design.

Mechanical engineers have continued to implement design methods which have been developed through a continuous evolution of centralized systems. This practice was reinforced by successful experience with this equipment as opposed to relatively sad exposures to the early unitary equipment installations. We have all been plagued with numerous incidents of poor quality construction, as well as a relatively continuous barrage of misleading published information. However, this past history should not automatically condemn the present trend towards unitized or modular design which is occurring throughout this Continent. At the present time there are many reputable manufacturers who publish data on their equipment which is as reliable or more so, than anything received in the past on centralized equipment. The manufacturing techniques and reliability of the equipment itself has improved tremendously to the point where the manufacturers themselves are willing to accept the maintenance contracts for the complete system involving their equipment. We no longer can afford the luxury of dismissing this type of system to the so called lower quality category of residences, apartment buildings and supermarkets. It might also be worthwhile to investigate our attitudes towards these areas of design as they constitute a larger and more important portion of the economy than the specialized fields of educational buildings.

Recent cost studies of educational buildings indicate large differences in heating, ventilation and air conditioning costs that may vary between $2.00 and $8.00 per square foot. This spread in cost figures can be somewhat justified by the variation in the loads imposed on the spaces and their specific performance criteria. However, there have been many incidents where equal performance has been achieved at prices that vary from $3.00 to $5.50 per square foot. The lower cost figures are being obtained by systems which have been designed to handle relatively small portions of the building as a mechanical module or system area.

The concept of modular design often uses the existing pieces of unitary equipment,but in many cases it is still necessary to blend the items of built-up equipment with unitary items. In the future I expect these two generally recognized classes of machinery to thoroughly blend so that they are no longer recognizable.

The building industry is now belatedly entering the era of technological manufacturing methods which relate all component items to cost control, performance and flexibility. The engineer can no longer work in a vacuum and exercise his arts to achieve known results with known methods and materials. He must recognize the greater world in which he performs which includes all the functions of political science, sociology, psychology and economics.

The client must be identified and accepted before proceeding into design decisions and commitments. In the educational field he can best be thought of as the representative of the general public with all the hopes and fears for the future of their children and their willingness to bear taxation and assign priorities for expenditure of public funds. The present growth of educational capital and operating budgets has in effect stated the constraints which must be followed in the selection of all components of the building including the heating, air conditioning and ventilation systems. These are as follows:

1. <u>Interest Rates</u>

   Interest rates have risen to such a degree that it is obvious that all capital expenditure must be arranged so that the maximum use and benefit can be achieved in the shortest possible period of time. We cannot afford the luxury of building large, oversized facilities which will not be fully used to capacity until some vague date in the future which may be ten or fifteen years away.

2. Cash Flow

Due to the large number of institutions which are simultaneously being built, the expenditure of funds must be related to the budgetary methods of obtaining funds and therefore would be ideal if it could be restricted so that it follows the curve of annual enrollment.

3. Flexibility

This very much misused word has become major requirement in the design of these colleges. Flexibility relates to change and time. In the case of the colleges, time can be day to day during the design and construction period, and month to month following construction. The change portion of flexibility can only be handled by permitting the change of an individual component in the selected system or providing space for the addition of a special solution for the individual case.

4. Programmed Coherence

A continually expanding building program required a general solution which can be applied during the initial and following stages of construction. This general solution should be selected so that it can easily follow changes in size, use, shape and orientation. It must permit the inclusion of future technicological development without the penalty of changing or having to accept a rigid system of distribution of energy and operating methods.

5. Cost.

Cost control of the design is perhaps the prime restraint. The cost of mechanical systems in the recent past has demonstrated that there is a tremendous variation in the contract cost involved in education buildings. One of the prime elements that is contributing to the cost of building is the extremely high cost of field labour rates in the construction industry which is still increasing at an accelerating pace. When this high labour cost is combined with low efficiency in the field, it is obvious that all our efforts must be directed at increasing the work performed at the manufacturer's factory while reducing the work load at the job site.

Our office is presently developing one approach to this problem and trying it out in a series of designs. This solution is not being offered as the panacea of all problems but may be usefully described as an illustration of what can be presently achieved. This system utilizes gas or all electric multi-zone roof top units. The equipment being used is a direct development from the California system which led to the S.E.F. program in Metropolitan Toronto and the systems developed for the Catholic School Board in Montreal. The Ontario Fire Marshall's office restricts the use of fuel burning equipment to one installation per 4,000 square feet of roof area. Self contained packaged heating, cooling, ventilation and humidification units are available in sizes up to 14,000 cubic feet of air per minute. The combination of these two items restricts the design of a roof mounted fuel burning system to buildings of three storeys or less, as 14,000 cubic feet of air will handle a maximum of 12,000 square feet of gross space. When this is related to the Fire Marshall's regulation of 4,000 square feet of roof area, a building configuration of three storeys or less is determined. However, this limitation is not absolute as electric energy is not restricted by the Fire Marshall. Therefore it is still possible to design modular mechanical systems for higher buildings that operate on the all electric principle or are combined with a central fuel burning boiler plant that is either in existence or may be selected for the specific project. It is to be hoped that future development will give us more numerous tools to work with and somewhat ease up on these present limitations. If a system can be designed so that the air handling units are repetitive and either mounted externally on the roof or internally on a continuous series of penthouses, then all heating and cooling can be accomplished by air. Where specific requirements arise such as entrance ways, stairwells, receiving areas, etc. these can be solved economically by the use of local electric heat. The air handling, heating and cooling of all units may be energized with gas, oil or electricity. Ceiling systems are available that incorporate lighting, supply air diffusers and return air plenums. The ductwork can be selected to use a restricted number of sizes, and all pumps, pipe insulation and piping can be removed from the installation with the resulting benefits of simplicity, construction time and field labour cost reductions. Control sequences for the air handling equipment are standardized and installed in the manufacturer's plant, thereby reducing the heartaches involved in the field installation of highly sophisticated individual control systems which are difficult to install and operate.

The evolution of this concept can be illustrated by looking at the design of a series of buildings. The first slides show the new Life Sciences Complex at Dalhousie University. The large concrete shafts on the perimeter of the building enclose a series of air handling units which feed the adjacent areas of the building. These units are stacked vertically up to three units high and are fed from a central heating and cooling plant.

The second series of slides show the Manpower Building of Sir Sandford Fleming Campus in Peterborough which is very simple and is serviced by roof top units.

The final series of slides show the campus of Cambrian College in North Bay and the new campus of Sir Sandford Fleming in Peterborough. In this design the roof top units have become part of the total building concept and are repeated on definite intervals.

The concept of repetitive units at regular spacing is now being applied to penthouse and duct distribution systems for the new addition to Scarborough College and is being proposed for the Prototype Terminal Unit for airport design being developed for the Department of Transport.

When the modular system is used a large portion of the design effort is concentrated on the early development of the mechanical, electrical, structural and architectural elements. This demands a complete acceptance of this approach by all members of the design team and a continuing discipline of all members during the later development stages. The repetition of these elements has a pronounced effect on the configuration of all building elements and imparts a cohesive theme to the complex. If the selection has been well made it will result in a building which is continuously expandable and is capable of handling all of the forecastable requirements. Future alterations and conversions will be simplified and maintenance operations will be repetitive and capable of organized scheduling.