Application of Value Analysis Techniques in Developing Unit Rate Budgets for British Columbia Schools

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ABSTRACT

In 1991, the Province of British Columbia established a construction cost budgeting system, based on a unit rate per square metre (10.76 square feet) of building gross floor area. This system is used for establishing construction funding, for all new elementary, middle and secondary schools (Kindergarten to Grade 12) throughout the Province and is updated annually.

The application of value analysis methodology has been the key to developing least-cost unit rate budgets and updating them to take into account changes in educational curriculum, design trends, construction technology, energy conservation and building codes.

The process applies value analysis techniques to the development of prototypical cost models, rather than recycling the as-built construction costs of individually value analyzed facilities. This process allows the Provincial Government to incorporate improvements in educational programming and facility design with full knowledge of their effects on overall capital spending and has reduced school construction costs by approximately 35%, since 1992.

This methodology is currently being extended to establish unit rate budgeting processes for colleges, universities and health care facilities throughout British Columbia.

BACKGROUND

Prior to 1991, construction budgets for Kindergarten to Grade 12 (K-12) schools in British Columbia were established from a statistical analysis of 20 to 30 construction bids received each year throughout the province. This resulted in an acceptable unit cost per square metre of gross floor area; however, the process had some inherent flaws.

The statistical approach, while taking into account the effects of construction cost escalation due to market conditions and increases in the cost of labor and materials, also tends to build in a cumulative increase in construction cost due to design trends. It was found that designers tended to carry forward and improve upon previous designs, thus artificially escalating construction costs.

This was further complicated by the fact that a purely statistical analysis of completed projects makes it difficult to identify the effects of changes to the education curriculum, or changes to regulatory requirements such as building codes. Construction bids, which are typically presented in trade formats, do not readily lend themselves to analysis by design elements, such as structure, building envelope and interior finishes. A new, more manageable approach was required.

ESTABLISHING THE BASE UNIT RATES

In order to provide a baseline on which to establish the initial unit rates, the British Columbia Ministry of Education identified several schools which were generally considered to be "state-of-the-art" school design. The selection criteria were simple - construction was completed, the cost of construction was within budget and the functional program complied with established provincial space programming guidelines.

In British Columbia the functional program for elementary, middle and secondary schools is rigidly prescribed. From a cost point of view this enables a unit cost per square metre of gross floor area to be quite accurately developed, since the functional program is formula driven by the school's capacity and the mix of spaces does not vary significantly from facility to facility.

Having selected the sample facilities, value analysis workshops were convened to review all aspects of each school's planning, design and system engineering. These workshops brought together not only the school board's facility management personnel and the design team for that particular project, but also facility operators and design teams from the other sample schools, acting in effect as shadow design teams, or peer reviewers.

The value analysis workshops reviewed each design in detail to identify and eliminate unnecessary cost features, components or materials. In addition, the workshops identified planning and design features which had not been included in the original design, but which the study group considered would be desirable to add. Throughout this process the effects on operating costs of the facility were considered and changes were identified in order to optimize the life-cycle cost. This process was repeated for elementary, middle and secondary school examples.

A single facility was then selected as a baseline model for each category of school, to which the modifications identified through the value analysis workshops were applied. The as-built construction costs were adjusted to reflect the changes identified by the value analysis workshops. Finally, a comprehensive cost analysis by design element, together with an outline description of the scope of work, was documented.

The final product was not intended to represent any one particular school design, but consisted of prototypical cost models developed from actual completed facilities. The cost models were modified to include desirable planning features and to eliminate undesirable features, while ensuring that capital and operating cost were fully optimized. Single unit costs, per square metre of gross floor area, were developed from the models for each facility type. These became the standard budget allowances for school construction throughout the province.

In order to assist designers to develop concept designs within the construction budget envelope, outline specifications were developed to identify the systems and components upon which the prototypical cost models were based. The intent of the specifications was not to constrain designers in any way, or force them to design to standard technical specifications, but rather to identify for them the basis upon which the baseline unit rate had been established.

To further assist designers in allocating the construction budgets between architecture, engineering and the educational curriculum, the ratios of cost between each of the major design elements, i.e., structure, exterior envelope, interior construction, finishes, mechanical and electrical systems, were tabulated.

In addition, based on analysis of over forty previously designed and constructed schools, a series of key design ratios was identified. These design ratios, expressed as a ratio of each design element to the building's gross floor area, provide guidance as to the amount of exterior wall, the amount of glazing in relation to the exterior envelope area, the perimeter length and average story height, and the area of the roof relative to the building's footprint area. The ratios are consistent with the prototypical cost models and, if a balance is maintained within the design elements, provide reasonable assurance that the unit rates will be achieved.

Not surprisingly, when the design ratios were first published, they caused considerable controversy amongst the design community. However, once they gained credibility and were accepted into general use, most designers realized that they provide a means to balance the various design elements and could also be used as an effective tool to control the disparate and sometimes disproportionate aspirations of facility users and operators. In addition, they provide much improved control over the mechanical and electrical design disciplines.

MODIFYING FACTORS

The schools selected as a basis for developing the prototypical cost models are located in and around Vancouver, the main population centre of the Province. British Columbia is a large province with an extremely diverse geology and climate. Geologically, the Province has areas which range from an extremely high earthquake risk, similar to San Francisco for example, to areas that have virtually no likelihood of seismic events. Climatically, the Province varies from a wet, temperate climate in the southern coastal region around Vancouver, where temperatures rarely fall much below freezing, to interior areas of the Province which experience significant snowfall and extended periods of temperatures as low as twenty degrees below zero Celsius.

Clearly, if unit rate construction budgets are to be used throughout an area as large and diverse as British Columbia, the modifying factors must take into account engineering issues related to seismic risk, snow and wind load requirements, site specific issues such as the topography and subsurface bearing capacity of a particular school site, exterior envelope and mechanical design issues related to climate. In addition, economic factors must be addressed to take into account regional differences related to labor and material costs.

As part of the value analysis process carried out in developing the prototypical cost models, the costs of addressing the seismic and climatic design issues were isolated by each region. Economic issues - regional material costs, transportation costs, contractor's overheads and profit expectations - were addressed by identifying approximately thirty items which represent the major component costs for school construction and comparing their relative cost for each of seven major population centres in the Province. A price survey is carried out every six months to update this index model. Variations in basic labour costs from region to region are not significant, since all public sector construction in British Columbia is carried out using a standard schedule of wage rates.

Regional geological, climatic and economic cost factors are combined to form a Province-wide location index, relative to the Vancouver benchmark.

In order to modify the base unit rate for facilities which are designed to a different size than the prototypical cost models, a series of size factors were also developed. The size factors address the changing relationship of the quantity (and therefore cost) of the building elements to the enclosed floor area. This manifests itself in such elements as exterior envelope, internal demising, mechanical and electrical distribution. As an example, the secondary school prototypical cost model is based on a 9,000 square metre school, with a size factor of 1.00 (the baseline). The modifying factors for secondary school sizes range from 1.04 for a 5,000 square metre school to 0.92 for a 20,000 square metre school.

NEW ADDITIONS AND RENOVATIONS

New Additions

Unit rate budgets are relatively easy to develop for new schools. Functional space programs for schools in British Columbia are quite rigidly prescribed by Provincial planning guidelines, and the mix of functions remains relatively constant from facility to facility. Since space programs are allocated in direct proportion to student capacity, it is feasible to develop quite accurate unit rates per square metre of the overall gross floor area for a new school.

In the case of additions to existing schools, however, it is not practical to apply unit rates per square metre of building gross floor area. Functionally, an addition may vary from the provision of additional classrooms in one school to the provision of a new gymnasium in another. Clearly a different approach is required.

To address this problem we developed prototypical building shell cost models – structure, exterior envelope, primary mechanical and electrical systems - using similar value analysis techniques to those employed for new construction. We identified the primary cost driver as the height of the building's shell, measured to the underside of the structure. This resulted in three unit rates: one for the low height building shell containing classrooms and administration type functions (in one and two storey versions); one for medium height shells containing multipurpose, industrial education, drama, arts etc.; another for high structures such as a gymnasium.

Once a matrix was established for the shell costs a second, functionally based unit rate, consisting of finishing and fit up costs, was developed for individual space functions such as general-purpose classrooms, business education classrooms, administration, drama, gymnasium, washrooms, corridors, etc. The gross floor area based shell and net floor area based functional unit costs are combined to provide unit rates for budgeting small to medium-sized additions to existing schools.

Renovations to Existing Space

Functional change, as opposed to simple upgrading or refinishing of existing spaces, is the most significant component of renovation cost in schools. Although other factors such as life safety and air quality upgrading may influence costs, Provincial policy has been to defer such work until an addition and related functional upgrade of existing space is warranted by increased student capacity. Until recently, the focus of Provincial capital spending has been on providing new and replacement schools. Increasing pressure to reduce or limit capital spending has resulted in a new focus on additions and major renovations to existing facilities.

We completed the initial development of renovation unit rate budgets earlier this year, using similar value analysis techniques to that of new construction and new additions. Application of the functionally based unit rates is still in the early stages and their accuracy will not be fully determined until sometime next year, as projects currently in the design stages are bid and constructed. Given that renovation budgets were previously established at the capital project planning stage on the basis of applying an arbitrary percentage of the budget for construction of a new school, we are confident the system will show considerable improvement in terms of adequacy and accuracy.

APPLICATION OF UNIT RATE BUDGETS TO SPECIFIC PROJECTS

The Capital Budgeting Process

The intent of the unit rates is simply to establish realistic and achievable budgets at the capital planning stage for individual school projects, prior to any form of design work being undertaken.

In British Columbia, as in the most other jurisdictions in the western world, increasing fiscal debt and pressure on capital spending has increased the need for more stringent forms of financial control of public sector construction projects. Whereas previously in the province, budgets have been regarded as entitlements to which a project is to be designed and constructed, the current Provincial fiscal policy views budgets as an immutable upper limit, with the expectation that the final project cost will be less than the target. To achieve this, a stringent value and cost management process has been established for all publicly funded construction projects over $5 million and for all K-12 schools over $3 million.

Once the functional programming process is complete for a particular school, a construction budget is established by the application of unit rates, modified as necessary to the specific geographical location within the province, multiplied by the building's gross floor area. In addition to the building budget, various site specific budget modifiers are applied to address issues such as any premium cost of the building's substructure due to deficient sub-surface bearing capacity, the presence of rock or a steeply sloping site. Correlated or soft costs such as furnishings, equipment and design fees are established as a ratio of the construction cost.

At this point, a preliminary review is carried out to determine the cost benefit of providing replacement new construction versus adding to or renovating an existing facility.

Value Management During Design

On completion of the architectural concept design, a construction cost estimate is prepared by the project quantity surveyor to determine if the estimated cost of the building is within the approved construction budget. At this stage the first of two project specific value analysis reviews takes place to confirm that the proposed scope of work represents the least-cost solution. The objective of the concept design stage value analysis review is to analyze and optimize the capital and operating costs of the proposed building configuration, massing, functional planning and preliminary system selection. Simply put, the value analysis review establishes "what" scope of work is to be constructed.

On completion of design development, prior to the start of engineering drawings, a second construction cost estimate is prepared. Provided the estimated cost of the building is within the approved construction budget, the second value review takes place.

The objective of the design development stage value review is to analyze and optimize the engineering of components and materials. The review at this stage becomes one of value engineering and optimizes "how" the scope of work is to be constructed.

On completion of the contract documents, immediately prior to tender, a final cost estimate is prepared and a value audit is carried out to ensure that the proposals and alternatives accepted as a result of the value analysis/value engineering reviews have been properly incorporated in the final design.

UPDATING THE BASE UNIT RATES

Since the new construction unit rate budgets were first developed in 1991 there has been a process of reviewing and updating the unit rates on an annual basis. At that time, the prototypical cost models are modified to take into account any changes in building codes e.g. fire protection, seismic design, indoor air quality. During the updating process, value analysis techniques are applied to determine the most cost-effective application of these changes to the prototypical cost models. In addition, revisions to educational requirements such as curriculum changes, new class sizes, increased use of multimedia based instruction and changes in data retrieval technology are reviewed and the impacts on design are assessed through the value analysis process, to determine the most cost-effective modification to the unit rates.

In addition to annual updates, changes can be easily and effectively made at any time to reflect changes in political strategy or new priorities in public spending that affect the educational curriculum and, thus, have a direct impact on the design and construction of school facilities. Similarly, from time to time, trade associations propose systems and assemblies that they believe are more cost-effective than competing products. As an example, two or three years ago, we carried out an in-depth study of the capital and operating cost implications of flat vs. pitched roofs. It seems obvious that, from a product point of view, a flat membrane roof finish is less expensive than a sheet metal sloped roof finish. The holistic capital and life-cycle cost analysis, taking into account the cost of the roof structure, the need to provide a roof overhangs to protect the exterior wall assembly from inclement weather and to provide shading to exterior glazing, as well as the cost benefit of housing mechanical equipment in attic spaces, demonstrated that a sloped roof presents a more cost-effective alternative.

Using such value analysis techniques to modify the prototypical cost models allows the Province to make changes to their education capital program with full knowledge of the effect on planning, design and the educational environment of the finished product.

APPLYING THE RESULTS OF PROJECT SPECIFIC VALUE ANALYSIS

Since the introduction of the unit rate budgeting methodology, project specific value analysis/value engineering reviews have also been carried out, during the design phase, on over 150 elementary, middle and secondary schools throughout the province. While this process has been very successful in eliminating over $40 million of unnecessary cost, beyond the established budget envelopes, it has been speculated that the value analysis process on individual projects would eventually be self eliminating. This has not proved to be the case.

While similar value issues arise on most school projects, the particular design solutions to an individual school board's teaching requirements are often quite different. The long-term operating cost side of the funding equation may also be unique to that particular project, such that a cost benefit analysis often produces different results even when considering the same capital cost issue.

Notwithstanding this, however, analysis of the results of the reviews carried out during the last five years has indicated that there are a significant number of value issues common to most school projects, where similar least-cost alternatives have been identified and accepted. The Province has now published a library of 50 to 60 "standard" value analysis issues. School boards and their design teams are expected to incorporate them in their design as a matter of course, since the base unit rates have already been adjusted to eliminate these items. Under the Provincial value analysis policy, design or engineering solutions which deviate from the standard list are required to be supported by a least-cost business case analysis in order to be accepted. This has eliminated a considerable amount of time and cost in "reinventing the wheel".

OTHER APPLICATIONS OF UNIT RATE BUDGETING TECHNIQUES

Currently the Province is in the process of implementing unit rate budgeting for post secondary educational facilities - technical colleges and universities - and health care facilities. These types of facilities present different challenges. The functional programs for technical colleges are not as rigidly defined as they are for K-12 schools. The curriculum varies considerably from location to location, depending on the makeup of local industry and the particular focus of training. In many cases, the focus of capital expenditure is on expansion of existing facilities. Similarly, many health care facilities involve highly customized functional programs. In both cases, the budget unit rates need to be established on a functional space program basis in order to be effective. Functional unit rate budgeting tends to be less reliable due to the variance in net space grossing factors, such as horizontal and vertical circulation, service and support areas.

Multilevel care facilities are an exception since, as with K-12 facilities, the gross floor area is directly related to the number of users, in this case residents instead of students. The calculation of the gross floor area for multilevel care facilities is largely formula driven and thus lends itself to the application of a single unit rate per square metre of gross floor area. Earlier this year we completed the development of a series of prototypical cost models for multilevel care facilities, using the same application of value analysis techniques as described in this paper. Application of the unit rates to the multi-level care budgeting process is now underway, but is still in the early stages. However, a similar level of success to that experienced in the K-12 education field is anticipated.

CONCLUSION

The development and application of unit rate budgeting techniques to school construction in British Columbia has proven to be extremely successful. During the period from 1992 to 1999 the unit cost per square metre of gross floor area of an elementary school has been reduced from $1,150 to $900 ($107 to $84 per square foot) - a reduction of 22 percent. The unit cost per square metre of gross floor area of secondary schools has been reduced from $1,300 to $940 ($121 to $87 per square foot) - a reduction of 28 percent. In addition, during this period, construction costs have escalated approximately 15 percent.

A total of 144 new schools have been completed during the period, representing a capital construction cost of approximately $1.15 billion. As a result of the unit rate budgeting process, capital spending (adjusted for cost escalation) has been reduced by over $200 million, excluding direct savings from project specific value analysis reviews.