First International Conference on Construction in the 21st Century (CITC2002)
"Challenges and Opportunities in Management and Technology"
25-26 April, 2002, Miami, Florida, USA

VALUE OPTIMISATION OF BUILDING COMPONENTS IN DESIGN PROCESS

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ABSTRACT

Construction clients have become increasingly dissatisfied with the quality of strategic construction price forecasts provided by the professional advisors. One of the primary functions of cost planning is to optimise the expenditure of client in terms of the price allocation of different components of a building. The paper describes a new approach for building design. The suggested approach contains three activities: (1) Market analysis, (2) Quality function deployment and (3) Cost deployment. The goal of integrating these activities to the building design process is to improve the quality, the functionality, and the innovation aspects of the design of components. This requires the matching of the value of building components with their costs.

KEYWORDS

Market Analysis, Quality Function Deployment (QFD), Cost Deployment

1. INTRODUCTION

The functions of cost advice in design stage includes: (1) To give the client good value for money; (2) To achieve the required balance of expenditure between the various parts of the building; and (3) To keep expenditure within the amount allowed by the client (Flanagan and Tates, 1997). Cost advice is governed by a planning and control system in the traditional approach in United Kingdom and most of the commonwealth countries. Within the system, quantity surveyor produces estimates based on design information and historical cost data. The cost planning process is largely iterative moving back and forwards due to design development and evaluation of design alternatives (Morrison, 1983).

Despite the vast efforts normally required as a result of the iterative process, studies have shown that clients of the construction industry have been generally dissatisfied with the quality of strategic cost advice forecasts provided by their professional advisors (Ellis and Turner, 1986; Proctor et al., 1993). To enhance the quality of cost advice, many alternative approaches have been suggested. One of the established approaches is the use of value analysis. Value analysis is a systematic problem solving approach to achieving the desired quality at the lowest possible cost. The concept assumes that if the functionality of a product design is frozen, there is one theoretical lowest possible cost to meet the functionality (Kermode et al., 2000). Previous development on value analysis focused on (1) the development and refinement of function analysis methods, (i.e., the FAST diagram) and (2) the application of a standard job plan to direct the implementation of the value analysis process. Major concerns to the need and satisfaction of the users/customers are placed on value analysts in assessing the functions of building using FAST diagram. In this regard, there is very limited concern on the relative importance of building functions in the perception of customers / users. This may cause negative impact on the market value of the final building. A revisit of the use of value analysis technique in building design revealed that there could be possible significant improvements should more attention be addressed to the needs and satisfaction of users and customers of buildings.

Dean (1995) distinguished the difference between value engineering and value in design for competitive advantage in that the latter is the measure of customer choice rather than simply, the reduction of cost. Value is a function of quality and cost. The strong emphasis on cost reduction could cause limitation to the application of value analysis techniques in evaluating value in design (Shillito and De Marle, 1992; Dean, 1999). For example, prospective tenants of residential building may want more windows because they realize that those windows make the flat more prestige. Windows is a cost significant item and the customer's need in this example may not be easily identified in the function analysis process where assessment is purely based on the perception of designer. The quality and sophistication of some building design cannot be delivered in a low-cost design. In evaluation of building design, function cost should be in proportion to the function's worth as perceived by the user or customer. To maximize the value in design, major functions of building design shall be evaluated with reference to the users' or customers' need and expectations.

The market research with QFD provides a customer-driven product development methodology. The intent of using the two together (market research data with QFD) is to incorporate "voice of the customers" into all phases of the product development cycle, through concept, engineering and analysis, design, prototyping, production engineering and planning, management and control, manufacturing, and finally into delivery and support. This paper suggests adopting the concept of quality function deployment (QFD) to the design of components in the building process.

2. MARKET ANALYSIS

In the traditional approach, it is very common that the only information given to designer and engineers is the client's brief. In the briefing process, major problems happened in understanding the client needs and translating them into requirements for a building. A report by Barrett and Stanley (1999) revealed that the briefing process was generally weak which made essential requirements not clearly defined. The result of this could seriously erode the performance of buildings.

To ensure value for money design, the design team has to know the needs and expectations of their customers. In building projects, the customer is often referred to either the client who uses the building, the tenant who rents the building from the client, the buyer who purchases the building from the client, or the public for government projects. Without considering the needs and expectations of the customers, a prize-winning building can be a poor seller. For instance, fashions and features that sometimes determine a market could override functionality. To accurately predict the needs and expectations of customers, market analysis is one of the good solutions. The aim of doing market analysis is to understand what are required to satisfy the customer's interests. This assists the design process in two dimensions: (1) to establish the key functions needed and (2) to determine the relative importance of these functions.

The voice of customers is formed from a list of the customer want which is revealed from the market analysis. Surveys and interviews could be carried out to understand the needs of the following group of customers: (1) buyer, tenant and user of similar buildings owned by the same client, (2) buyer, tenant and user of similar buildings owned by competitors, and (3) potential buyer, tenant and user. Furthermore, market research should also acquire data about the market value, the performance and technical characteristics of similar buildings developed by competitors (i.e., information for benchmarking)

3. QUALITY FUNCTION DEPLOYMENT

Quality function deployment (QFD) was originally developed by Yoji Akao at Mitsubishi Heavy Industries Kobe Shipyard in 1972. It is defined as "a method for developing a design quality aimed at satisfying the consumer and then translating the consumer's demands into design targets and major quality assurance points to be used throughout the production phase” (Akao, 1990). It is a process by which one can deploy quality into the product; into the system to bring forth, sustain, and retire the product; and into the enterprise as a whole (Dean, 1995). Within QFD, quality is deployed to ensure the customer gets what is desired. QFD allows the designers to analyse the significance of components of building design to improve its functionality and then to add values which are important to both customers and the clients.

In the building design process, professional from different disciplines share the burden of design. This multidisciplinary teamwork usually generate design requirements that are conflicting to each other. For example, the architect may want to enhance the image of the building by increasing the size of lift corridors although this may sacrifice some of the back of house areas. This intent may not agree with the minimum area required for housing the services equipment as designed by the building services engineer. QFD provides a platform for the professional to focus on meeting or exceeding what the market needs. By incorporating the voice of customers into the design development process, QFD becomes a "market-in" approach instead of a traditional "product-out" approach (Prasad 1998). Thus, this customer-driven product development methodology avoids the situation of producing building design that is marketable but technically not sound or vice versa.

3.1 House of Quality

Based on a set of customer requirements and benchmarking data obtained from market research, the "House of Quality (HOQ)" (Hauser and Clausing, 1988) is the most recognised form to carry out the tasks of QFD. The basic concept in behind is the use of relational matrices. The original HOQ proposed by Hauser and Clausing contains four rooms and subsequent works have included “HOW MUCHes” and “WHYs” in the HOQ. An explained HOQ developed by Prasad is shown in Figure 1.

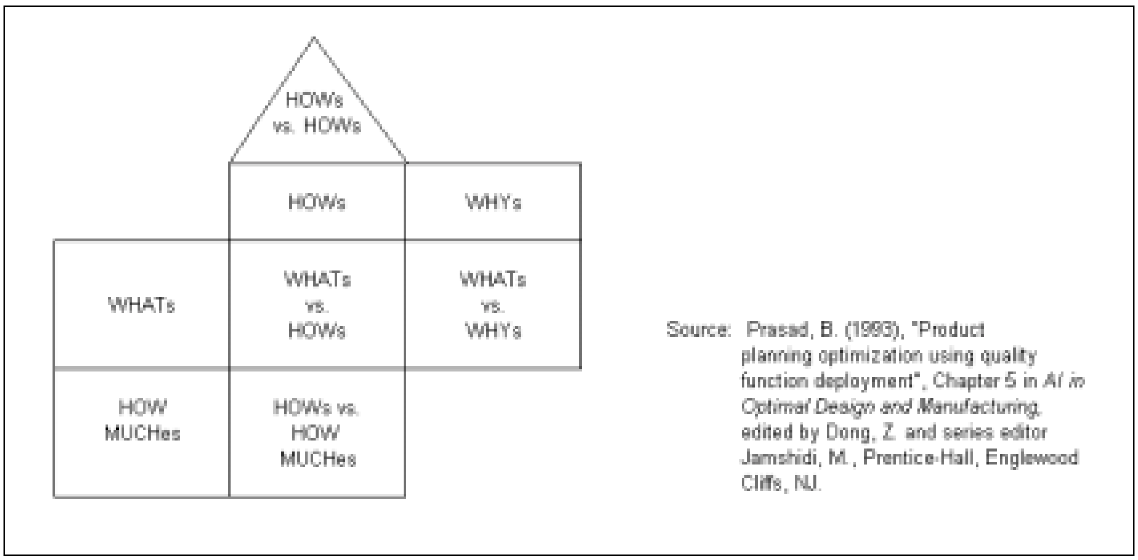

Figure 1: A Schematic View of an "Expanded House of Quality" (HOQ)

3.2 WHATs: Customer Requirements

The “WHATs” room contains a list of customer requirements in a structured format which is considered as the voice of customer. It could be developed by direct interview with user or potential users of the building. The interview group shall be encouraged to describe their wants, needs and desires. Techniques of affinity and tree diagrams could be applied to sort out the logical relationship between various customer requirements.

3.3 HOWs: Design / Technical Requirements

The “HOWs” room contains a list of measurable design / technical requirements developed by the design team that are relevant to the listed customer requirements. Because HOWs determines the set of alternate quality features to satisfy the identified customer requirements. Again, techniques of affinity and tree diagrams could be applied to derive the relationship between requirements.

3.4 WHATs versus HOWs: Interrelationship Matrix

In the HOQ, an interrelationship matrix is created by putting the WHATs list along a column against the HOWs list along a row (See also Figure 3). Team efforts would be spent on defining the relationships between the WHATs and HOWs as strong, medium, weak or none in the rectangular area between the rows and the columns. It is possible that some of the quality solutions may affect more than one market requirement. The more densely populated and spread in ranks the correlation matrix is, the more valuable the information is likely to be (Prasad, 1998).

3.5 HOWs versus HOWs: Technical Correlation Matrix

Identified design / technical requirements may support or impede each other. A technical correlation matrix (also named as roof matrix) is constructed to evaluate this by the effort of a multidisciplinary design team. Relationships are defined as strong positive, medium positive, weak positive, strong negative, medium negative, weak negative and none. Special attention should be drawn on those requirements with negative relationships to each other. Attempts are encouraged to develop innovative solutions that avoid unnecessary compromises between them.

3.6 WHATs versus WHYs: Relative Importance of Current Products to Competitors Products

The "WHYs" are represented by the relative importance factor of customer requirements corresponding to the WHATs. They also illustrate the relative importance of current products or components under assessment with competitors' products or components. The customers would be asked to rate the relative importance of the customer requirements identified. In developing the relative importance, it is possible to apply more mathematical approaches such as the application of the Analytic Hierarchy Process (Satty, 2000).

3.7 HOWs versus HOW MUCHes: Technical Importance Rating

Within the matrix of HOWs and HOW MUCHes, it contains the technical importance rating for every design / technical requirement. This is calculated by summing up all the product of the assigned value of the interrelationship matrix and their corresponding customer importance rating. The rating represents the relative importance of each technical requirement. Another information contained in this matrix room is the competitive benchmarks. Technical information of similar products from competitor is compiled and is used to compare with the product under studies by HOQ. HOW MUCHes are the target values for the identified design / technical requirements. They are a set of engineering values to be achieved after evaluation of the product by technical importance rating. The suggested target values would become the criterion for assessing success. It is a measure of the importance of HOWs. The process of constructing the matrix enables these targets to be set and prioritized based on an understanding of the customer needs, the competitors' performance and the organization's current performance.

4. COST DEPLOYMENT

The primary coordinates of value appear to be quality and cost (Dean, 1995). QFD is a process to deploy quality into products by obtaining the relative importance of components. This would have to combine with the control in cost before the full benefit of value for money design could be appreciated. Cost deployment is a means of designing for cost (Dean and Unal, 1991, Dean and Unal, 1992). It allows allocation of cost targets to specific components. The determined relative importance of components in QFD shall form the basis for the allocation. To optimise the value of buildings, it is suggested that the value of components shall be matched with their cost. Theoretically, the value of component design is optimised when the component having its relative importance equal to its relative cost. The relative cost of each component is derived from dividing the cost of each component by the total cost. Figure 2 is the value graph used to illustrate the correlation of importance and cost. The line with slope equal to 1 indicates that all points on the line have relative cost equal to relative value.

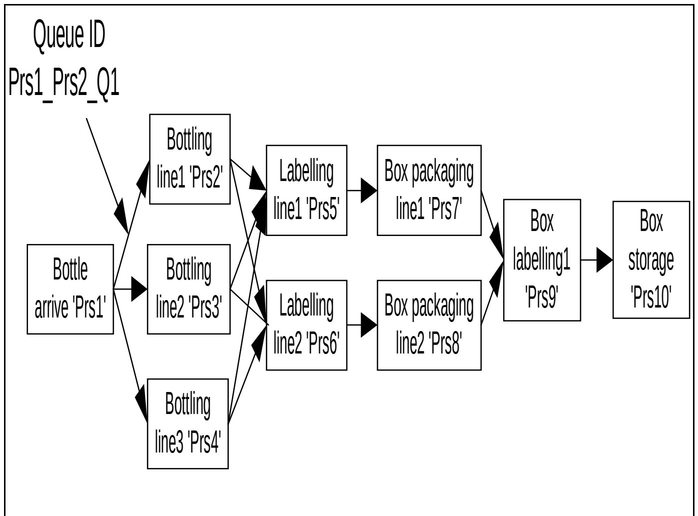

Figure 3: Network model for a Bottling and packaging line

Figure 2: The Value Graph

5. A CUSTOMER-DRIVEN DESIGN APPROACH

This section describes a suggested customer-driven design approach that incorporates the market analysis, the concepts of quality function deployment and cost deployment. Figure 4 shows a framework of critical information flow under this approach. Since it is driven by customers, the earliest information needed is the information from market research. Information required includes customer / user functional requirements (WHATs) as well as their corresponding degree of importance (WHYs). On the other hand, the design team shall also know the market value of the building. The market value will be used to calculate the total target construction cost by deducting the assumed profit and the other cost of deve1opment such as the land premium and professional fee, etc. Since about 80% of building costs are come from 20% of the total items with reference to the Pareto’s rule (Munns and Al, 2000), only cost significant building components would be identified for further evaluation. A set of HOQs is constructed and each of them represents one component only.

A simplified example of the HOQ for kitchen cabinet is shown in Figure 3. The WHATs and WHYs extracted from market analysis together with the design / technical requirements (HOWs) proposed by the design team shall form the basic elements of HOQ. The design team then have to assess the relationship between customer requirements and the technical requirements (WHATs vs. HOWs). In the matrix between WHATs and HOWs, the design team shall facilitate their judgement on their relationships. Relationships can either be weak, moderate, or strong and they carry a numeric value of 1, 3 or 9 respectively. After assessing all the interrelationships, the assigned ratings shall be multiplied with the relative importance (WHYs) rated by customers earlier. The customer importance ratings are on a scale from 1 (least important) to 5 (most important). By combining the two ratings, i.e., the WHATs vs. HOWs given by the design team and the WHYs given by the customers, an absolute importance value can be obtained for each technical requirements. For example, the absolute importance of the technical requirement – Fire Resistance is calculated by multiplying the interrelationship rating by the corresponding customer importance ratings such as “allow strong fire cooking (3 x 1)”, “easily-maintained environment (1 x 4)”, and “durable and wearable cabinet (3 x 5)”. Therefore, it is equal to 22. This value can be used to determine the relative importance subsequently. The relative importance in the example as shown in Figure 3 is a simplified calculation for a single component. In practice, it requires the application of the analytical hierarchy process to determine the relative importance among the components. The developed relative importance shall assist the design team to establish the target values (HOW MUCHes) for every technical requirement.

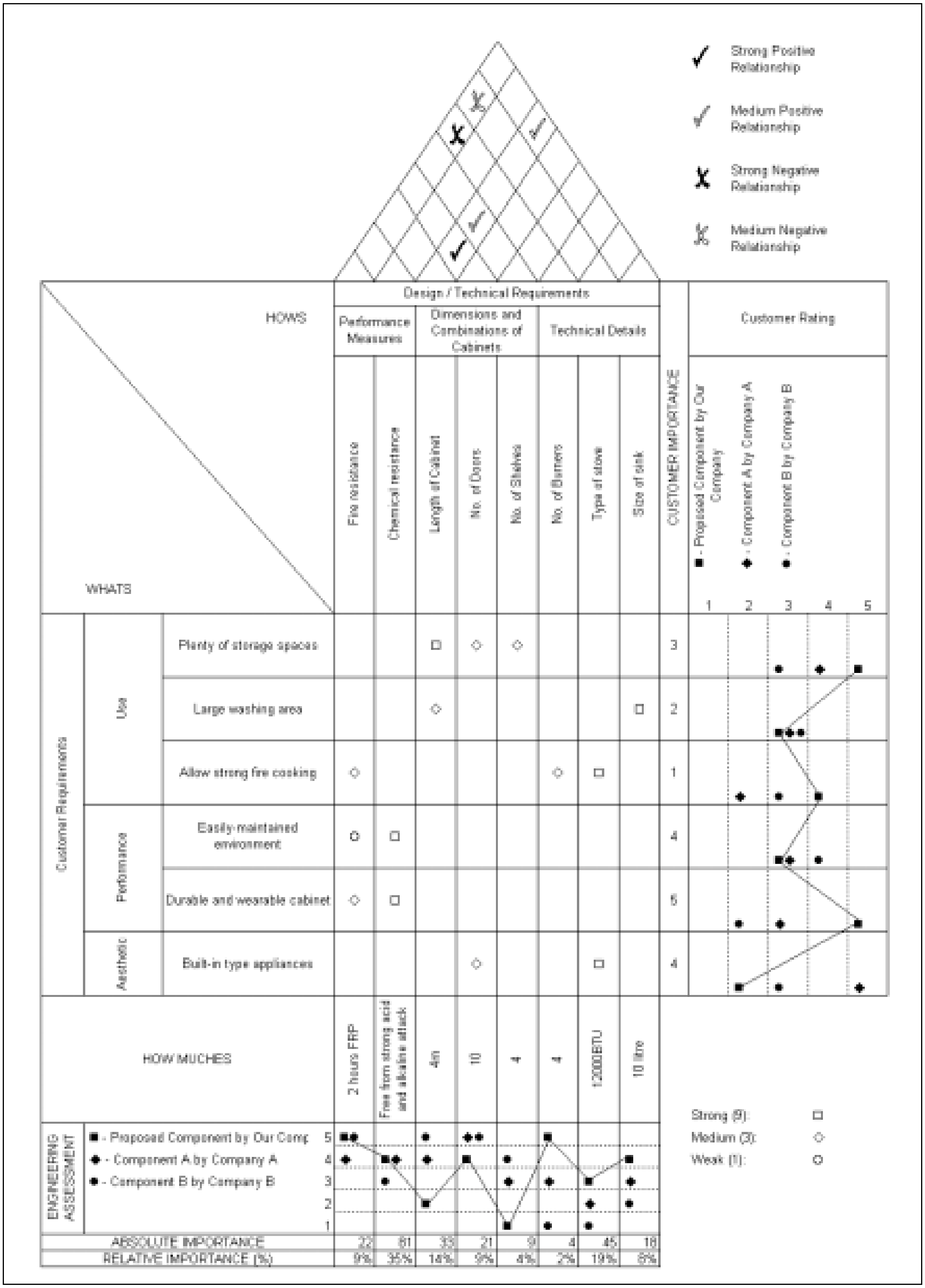

Figure 3: A Simplified Example of the House of Quality for Kitchen Cabinet

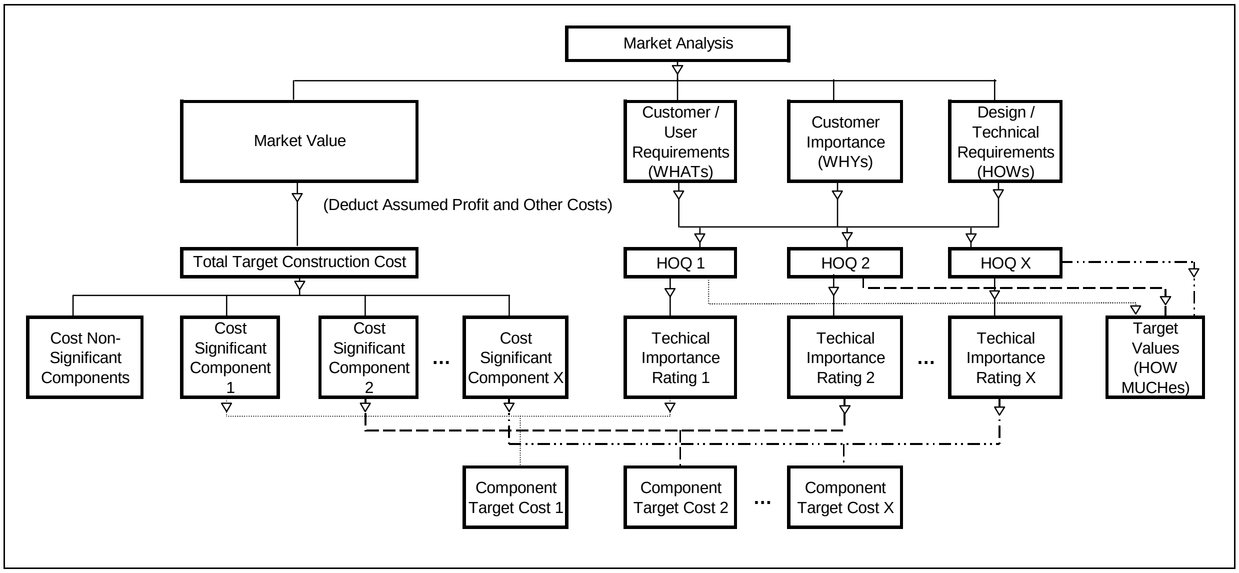

Figure 4: The Framework of Critical Information Flow under the Customer-Driven Design Approach

Apart from the core matrix, the design team has to evaluate the relationship among various technical requirements (HOWs vs, HOWs). In the example of kitchen cabinet, fire resistance is found to have negative relationship with the type of stove and no. of burner. This will leave rooms for the design team to generate innovative ideas to deal with the design / technical conflicts.

To better understand the competition in the market, it is worthwhile to include the technical analysis and customer rating of competitor's building component. Designer will have to judge the technical performance of competitor product on a scale of 1 – 5 and customers will be requested to rate their satisfaction of the requirements. In practice, difficulties may be faced by customers in visualizing the building components which have not been constructed. An alternative way of producing comparison is to use the same component from a previous similar project constructed by the same company as a reference instead.

The final step of the proposed approach is to deploy cost according to their relative importance. The total target costs are broken down to target cost for components according to the proportion of cost significant items to overall cost (derived from historical cost data) and the relative importance of a component.

6. CONCLUSION

This paper has described the concept of adopting quality function deployment and cost deployment in the design process. Focusing on the customer needs is the essence of the whole approach. The innovative elements suggested includes the use of market analysis to determine the voice of customers / users, the evaluation of market information and technicality by HOQ matrices and the establishment of target costs for components based on technical importance rating derived from the HOQ. The HOQ evaluation method assist the design team to assess components based on their functionality and encourage them to innovate possible alternative solutions that reduce cost or increase functionality. The evaluation process in the HOQ is well documented which allows efficient backtracking of the rationale of design decision made. In the light of accurate information about the needs and expectations of customer / user, quality of design could be improved because of (a) reduction in mismatch situations, i.e., discrepancies between functions of design and the requirements of customers; (b) increase in satisfaction of customers; (c) reduction of subsequent design changes; and (d) increase in the awareness of likely market changes. The deployment of cost ensures the building cost being effectively allocated to various components. The integration of cost deployment with QFD encourages the matching of value with the cost and the attainment of value optimisation in building design.

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