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Options for applying BPR in the Australian construction industry

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Many industries world-wide have found Business Process Re-engineering (BPR) to be an effective approach in achieving dramatic improvements in production time and cost. Yet little attention has been paid to its potential in the construction industry. This paper identifies the driving forces for the need for BPR in construction, explores its applicability and discusses major issues of current business processes in relation to clients, designers and contractors. BPR is presented as a means rather than a goal in order to facilitate creating wider objectives for all participants in the construction industry. The paper also proposes re-engineered solutions to these selected issues and identifies areas where BPR can be effective. Copyright © 1996 Elsevier Science Ltd and IPMA.

Keywords: Re-engineering, construction, time, cost, client, designer, contractor

Many successful Business Process Re-engineering (BPR) applications have been reported in areas of business management, public administration and service industries. The large majority of these applications have been based upon case studies where the organization executives decide, for one reason or another, to improve the overall performance of the organization. A typical scenario for reported BPR applications usually begins with a decision to improve business processes, in line with the vision and goals of the organization. Soon after, current business processes are evaluated, critical stress factors are determined and a plan of new process implementation is drawn out. Based on this plan, changes start to take place in the organization, leading ultimately to more efficient processes. Such applications, however, limit the definition of BPR to merely introducing changes in the structure of an organization with a view to accomplishing some identified business objectives.

One aspect that seems to be common between reported BPR applications is that reasons behind change and what follows afterwards are largely controlled by the organization. In other words, the BPR application becomes exclusively an 'in-house' operation, in which decisions pertaining to meeting customer requirements, investing in technology and organizing resources are steered and, if necessary, manipulated by the organization, with minimum dependence upon and interference with external factors.

This paper addresses a different perspective of BPR through examining its applicability to an industry as a whole, rather than to an individual organization. An industry, such as the construction industry, represents a major challenge to BPR. This is mainly due to the complex business relationships which dominate the industry plus the key role external factors play in how construction organizations conduct their business.

Throughout this paper, the term BPR refers to re-engineering the entire construction process, i.e. re-designing the pathway by which a conceptual idea is turned into a constructed facility. This definition covers the many phases of the construction process; design, management, procurement, construction, through to the hand-over of the facility to the client or end-user. The aim of this paper is to present the needs for BPR in construction—from an Australian perspective, and explore its applicability through proposing alternatives to main features of current business processes.

The need for BPR application in construction

Due to the growing concern about the performance and competitiveness of the Australian construction industry, several initiatives have been undertaken to investigate, assess and propose recommendations to improve its performance[1–3]. It was found that the industry has become inflexible and unresponsive to the needs of its customers[1]. The complex structure which connects the wide range of industry partners: architects, engineers, project managers, quantity surveyors, contractors, sub-contractors, and material suppliers, has limited the ability of the industry to be innovative. Moreover, the existing adversarial relationships between construction organizations, during a project lifetime, have added more difficulty to achieve inter-organizational cooperation for mutual and maximum benefits.

For decades, the construction industry has resisted changes to the way in which design, tendering, contracting and construction have been carried out. Construction practice has always been dominated by fragmentation of control and conflicting interest. The former is due to the very nature of the industry, where a large number of participants form a temporary group for a particular project then disband after project completion, while the latter arises as a result of having different sets of goals and priorities among those participants.

Another remarkable feature of the construction industry is its lack of performance consistency. Project performance is highly dependent upon circumstances associated with the project. The effectiveness of communication between design and construction teams, for example, can noticeably affect the project performance. A variety of other factors such as construction management effectiveness, client sophistication, procurement system adopted, and many more, have different degrees of impact upon performance[4].

Despite the claim that many projects have been completed on schedule and within budget, it is widely believed by construction professionals that estimated schedule and budget targets do not necessarily reflect the actual or required time and cost. This is due to the inherent inefficiency of current practices and mechanisms of the industry which inevitably leads to time waste. An investigation into time waste revealed that the site workforce spends a considerable amount of time waiting for resources or approval, wanting to work in a particular location, and travelling between places of work to complete a specialist activity[5]. Another investigation showed that 25% time savings is achievable in a typical construction work package without increasing allocated resources[6]. These findings are mainly concerned with time waste on construction sites. However, it is believed that off-site time waste can be of a similar amount. Typical sources of off-site time waste are design corrections and variations, approval of changes, less than optimum planning, and poor communication.

In construction, major production principles such as cost-effectiveness, design for utilization, 'built-in' quality, and certainty of delivery do not always live up to customer expectations. The industry also does not have a reputation of seeking customer's satisfaction. A recent report[7] shows that only 15% of surveyed Australian construction firms have obtained certification for their quality management system. Furthermore, only a minority of these firms routinely involve customers and employees in their improvement activities.

The construction process consists of a large pool of interconnected activities carried out by different participants. This makes every project participant a user and consequently a customer in terms of the participants' next dependent activity in the process. Naturally, a customer, who is either an internal or the ultimate external customer, is interested only in activities which add value to the product. An attempt to measure the amount of non-value-adding activities, from the external customer perspective, revealed that it can be as high as 40% of the overall project time, i.e. from inception to completion[8].

Project management deficiency is another major problem. Ireland[8] states that the construction industry still largely operates in the mode of the industrial revolution with extreme specialization of activities. This practice makes the problem of managing and coordinating 50–100 subcontract and supply organizations to provide a coherent process on a project, a tedious one. Construction activities in general are divided into sequential activities, which are given to different specialists for execution, putting unnecessary constraints on the work flow, increasing the possibility of conflicts and consequently leading to time waste and rework[9].

There have been many efforts to accelerate construction projects by overlapping design and construction activities. Fast-tracking is a typical example where overall construction time is reduced by starting construction before the design is finalized. This approach does not necessarily lead to an optimum design[10] and associated construction costs can be higher and the quality is often lower than in normally paced projects[11]. The lack of success is attributable to focusing on having parallel rather than integrated design and construction activities[12].

All the above findings strongly suggest that there is an urgent need to lift the standards of construction performance. Attempts to lift the performance via concepts adopted from manufacturing, such as quality control, automation, prefabrication, standardization, etc. have been successful in providing some improvement in construction output. However, these concepts, in combination or alone, failed to vigorously address the root causes of the existing problems of the industry. Therefore, it is hard to see any improvement measures that stand a reasonable chance of being effective unless a radical change to current practice is introduced. This radical change simply means construction process re-engineering.

Re-engineering is about introducing radical changes to business processes to achieve dramatic improvements in contemporary measures of performance such as cost, quality, service and speed[13]. Re-engineering is also about creating and adding value in each and every activity within these processes. In the majority of reported re-engineering applications, a re-engineered process evolves around a common principle such as gaining market advantage or reducing processing time and cost. To ensure success for re-engineering the construction process, a similar principle is needed. Delivering the project to the level of customer expectations is undoubtedly a common goal among key project participants. Therefore selecting it as the common principle appears to be an appropriate choice. This paper argues that such a common principle should be used as a means rather than a goal in order to facilitate creating wide objectives for all project participants. Hence, more room for reducing construction time and cost and enhancing quality. The paper also calls for dealing with major issues up-front. Issues believed to be of importance to the success of re-engineering the construction process are discussed below in relation to the client, designer and contractor, respectively.

Issues related to the client

The issues shown in *Figure 1* not only constitute the starting point of the project but they also determine to a considerable degree how the project is to be procured.

Development of a design brief

A successful project, from the client's perspective, is the one which meets or exceeds the stated set of requirements. Whatever these requirements are, a starting point is to develop a brief that explicitly covers and deploys these requirements to the design team which, in turn, transforms

Figure 1 Major re-engineering issues related to client

them into a detailed design. The critical role of a design brief in the design phase cannot be overemphasized[14]. During the brief development, designers tend to focus on developing design concepts rather than on understanding and capturing all of the client's requirements. It is the responsibility of the client to clearly define each requirement to the design team so that the extent of variations ordered by the client is minimized. The current average level of variations was found to be 10% (net by value)[1].

The re-engineering approach calls for more attention to be given to client incorporation in the design phase so that the incidence of variations and time extensions are reduced. Clients or their representatives have to have proactive involvement in design as early as possible. One way of achieving this involvement is through partnering between design team and clients, especially those who are frequent users of the industry. This form of partnering can be defined as developing a teamwork approach to fully understand clients' requirements and exhibit commitment towards meeting these requirements. In the context of brief development, the partnering aspect of open communications, for better transfer of information, gives both the client and design team more control over possible design changes and errors.

Clients who are not experienced in the construction process or have no professional representatives employed, may find applying the Value Management (VM) concept useful in enabling them to exercise a level of incorporation in the design. This concept calls for getting the design team to seek less costly or more effective design options which provide best value for the client. The best results of the VM exercise are achieved at the conceptual design phase when the client and design team can see early indications of relative cost performance of design options and their associated quality.

Brief development should not continue to be seen as the responsibility of the architect alone. The input of other engineering disciplines and the project management team regarding this matter can be invaluable to the crystallization of the key elements of the project, both functionally and aesthetically. Also, and in contrast to the traditional prescriptive specifications, the re-engineering approach calls for developing a brief in the form of performance-based specifications, i.e. outlining the basic criteria for the design of building, its services and architecture. This would allow for much greater innovation on the part of the design and construction teams[8].

Appointment of contractors and selection of contractual system

Client requirements can be the highest quality, lowest price, fastest delivery, or a combination of all three. The conventional tendering system, which was originally introduced to ensure that the client gets his/her product for the least cost possible, is regarded as a magnificent system for getting the best price for less than the best product[8]. The current cost of tendering for contracting and design, including unsuccessful bids, has been estimated to be around 7% of the Australian construction industry's turnover[8]. This huge cost is indirectly borne by the whole industry.

No doubt project cost is an important factor for the client when selecting the contractor. Factors such as past performance, quality standards and financial stability should never be overlooked. During the appointment process, the majority of clients, including those who are experienced in the construction process, need impartial advice regarding this appointment and selection of a suitable contractual system.

A range of contractual systems are available on construction projects with the lump-sum still being the most popular. Lump-sum contracts have been criticized for excluding some of the project participants from the planning stage, i.e. the stage where numerous decisions bearing on the ultimate success of the project are taken. Moreover, it establishes adversarial relationships among project team members and does not encourage contractors to implement quality programmes that improve the construction process[15]. Other contractual systems have got their inherent disadvantages too. For example, lack of formal competition, high costs and final cost uncertainty, are typical disadvantages of the design-and-construct, turn-key and design-and-manage contractual systems, respectively.

The re-engineering approach calls for selecting a contractor on the basis of factors such as past performance in terms of time, cost, quality, safety record and financial stability. Clients or their representatives are responsible for negotiating with invited contractors on how to achieve an agreed competitive time and cost performance on adequately developed design as early as possible. It is also suggested to limit the number of invited tenders for each project so that the total cost of tendering is reduced.

Risk sharing

The risks in a construction project arise from different sources, are of different types and are inherent in all construction work no matter what the size of a project[16]. Risk has been an issue which each project participant tries to transfer to others. Designers, for example, pass on the large share of the risk to the contractor who, in turn, passes it on to all sub-contractors in their contracts, creating confusion as to how risk is actually spread. Although risk can never be completely eliminated from the construction process, it can be shared among participants based upon well-defined and allocated areas of responsibility.

In the re-engineering approach, the client's role is crucial in formulating or selecting a suitable strategy for risk identification and allocation in accordance with some principles of equity such that it gives the maximum likelihood of achieving the project's objectives[16]. This can be achieved through establishing a project team where all participants are committed to working towards agreed goals and are taking an appropriate share of risk and reward in relation to allocated control. In doing so, there should be an adequate incentive for participants to act as a coherent team[8].

Issues related to the designer

Designers have the responsibility of designing the facility according to engineering codes, standards and other relevant regulations. Since more than two-thirds of a project cost is locked in during this phase, an early assessment of the design features is undoubtedly of great interest to all parties. Three major issues have been identified for re-engineering the design process. These issues are discussed below and are illustrated in *Figure 2*.

Design evaluation

Clients select a design firm based upon its past experience in completing similar work. Agreed common goals have to exist between the design team and client; both need to state what they want from the design process and limitations to satisfying the goals of the other. Assuming that client requirements are the core of the design process, evaluating design options can be a difficult task, especially in large projects where a number of design options exist. In current construction practice, there is no formal approach for design evaluation. It is carried out informally and is mainly based upon two parameters, i.e. construction time and cost.

The re-engineering approach is to make design evaluation and consequently selection based upon more parameters that the traditional time and cost. Quality, for example, is an important parameter that should be taken into account during design evaluation. Kim and Atkin[17] developed a framework aimed at conceptualizing the quality dimension of building projects for early design decision-making. Quality Function Deployment (QFD) is another technique which has the potential to facilitate the evaluation of proposed design alternatives against a number of different parameters as specified by the client[18].

Constructability analysis

Contractors have no complaints about the design concept, but rather the details that it incorporates[19]. Design details for construction projects depend largely on skilled judgement that accounts for all likely variables. Construction difficulties associated with these details are prevalent and do exist on every project. An effective design process requires incorporating construction knowledge and experience through the early involvement of personnel with appropriate expertise.

The re-engineering approach is to allow a review of the proposed design by the contractor to avoid constructability problems or conflicts that may arise during construction. Carrying out constructability analysis during the design phase leads to many benefits such as ease of construction, adaptation of design features to site conditions and enhancement of contractor productivity—all of which reduce construction time significantly without compromising quality[19]. It also gives the design team the opportunity to consider possible substitution of materials, components and systems from the contractor's perspective.

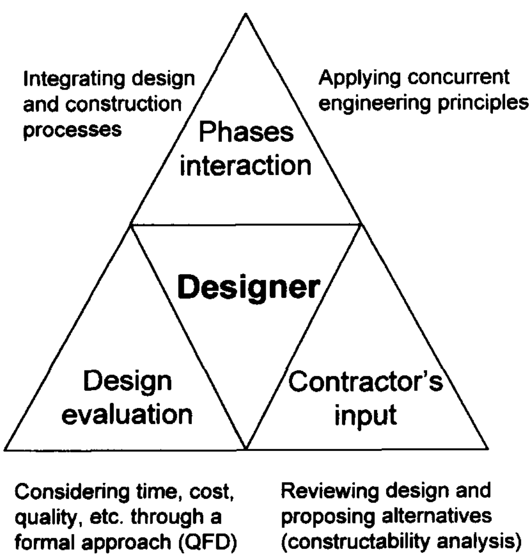

Figure 2 Major re-engineering issues related to designer

Project phases interaction

Traditionally, the interaction between the many phases of a construction project is minimal. This lack of interaction, in many cases, gives rise to several generic problems such as having few or no iterations in the design process and ignoring the effects that constraints of subsequent phases may have on the quality and serviceability of design[9].

The re-engineering approach calls for applying the concept of concurrent engineering. This concept refers to a design process where all aspects and requirements of downstream project phases (construction, operation, maintenance, etc.) are considered simultaneously at the conceptual design phase. The major objectives of this concept are adding value to the design, compressing design time and reducing the number of design changes. The input of both the client and contractor, for example, at the conceptual design phase is crucial for assessing the numerous parameters that affect the life cycle costing process of the constructed facility. Important aspects of concurrent design/construction processes are client satisfaction, team approach, strategic relations with suppliers and continuous improvement[12]. These aspects are fully relevant to ensuring better and faster design output.

Issues related to the contractor

Contractors are responsible for the physical construction of the facility, i.e. site operations. Motivated by financial gains, a contractor joins the project team, after selection, with a view to accomplish the allocated tasks according to detailed drawings, on the required time and within budget. Selected issues believed to have a crucial role in re-engineering construction operations are presented below and shown in *Figure 3*.

Re-organizing work packages

In the last few years, there has been a strong move towards sub-contracting the major bulk of site operations in the form of specialized work packages. This practice has transformed the traditional role of a contractor to managing and coordinating sub-contractors on site[20]. The existence of a large number of small work packages carried out by different sub-contractors leads to inefficiencies in the form of sub-contractors re-visiting the same work area or poor coordination between them[9]. In many cases, these tasks are similar in execution steps and/or required performing skill[6,8].

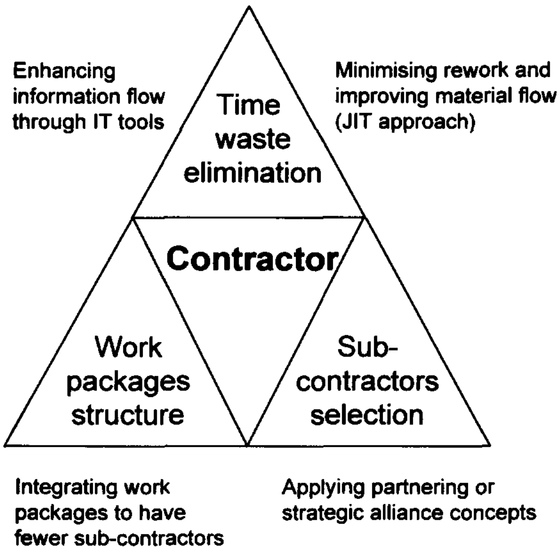

Figure 3 Major re-engineering issues related to contractor

The re-engineering approach is to re-organize these work packages into larger work modules, performed by fewer sub-contractors to minimize inefficiencies that occur through the requirements of sequencing of work. This can be achieved through integrating site activities (combining small activities into new ones), extending current responsibilities of sub-contractors to cover wider areas of the process and encouraging the use of a multi-skill workforce, wherever practical, to allow for more flexibility in re-designing these activities.

Partnering with sub-contractors

Due to the current economic climate, contractors bidding for contracts tend to keep their tender prices as low as possible, by either quoting the lowest price given by sub-contractors or negotiating with sub-contractors to lower their price down at the tendering stage. After the award of a contract, contractors endeavour to meet their initial estimations and profit targets. In doing so, and due to the different goals between the main contractor and sub-contractors, their working relationship may get hindered as a result of any problem that arises during the course of the project. This undoubtedly has a negative influence on project performance and productivity.

To avoid the above problem and ensure better project performance, the re-engineering approach suggests the use of the partnering concept between both parties. Partnering, in the context of a contractor/sub-contractors relationship, is not a legal partnership. It is simply a procedure in which cooperation, team building and mutual trust between both parties exist and sustain to meet project objectives. The partnering process empowers project participants with the authority to accept responsibility to do their jobs[5]. Partnering, however, is not prevalent in the construction industry. This is mainly due to the lack of commitment, by some parties, to the non-adversarial win–win attitude which is an essential element for the partnering process[21]. Also, the majority of current partnering implementation is not based upon proper principles to ensure success. Partnering would not be effective if sub-contractors were not involved in setting the partnering goals at the early stages of a project[15].

Time waste elimination

The amount of inherent time waste in current construction practice is substantial. Time waste can be either hidden within some construction operation or explicit in the form of delays and rework. Root causes of this waste are many and constitute a challenge to construction efficiency. In the context of site operations, three major causes are selected and addressed below. These are: rework, poor material flow and inefficient information flow.

Rework, which is mainly associated with customer dissatisfaction at the end of a process, adds considerably to the total construction time and cost[22]. The main two causes of rework are variations and errors. The former are caused by inadequate capturing and meeting of customer requirements while the latter are caused by improper application of quality measures. Current quality measures are neither specifically tailored to the needs of the construction industry nor adequately implemented on construction sites[9]. Construction and project managers, for example, who use inspection to achieve desirable project outcomes, aim at detecting and correcting deficient results. This practice of inspection followed by correction not only consumes resources and time but also does not improve working procedures.

The re-engineering approach views inspection as a non-value-adding activity which ideally should be eliminated from the construction flow process[9]. It calls for a shift in the inspection paradigm, i.e. from inspecting products to designing quality into the products[18]. Whenever visual inspection is a necessity, the re-engineering approach proposes having common inspectors with greater control and extended areas of responsibility. This is to reduce the number of site supervisors and provide more consistent site control.

Material flow is primarily concerned with the physical movement of resources to and within construction sites (unloading, storage, queuing and multiple-handling). Elimination of time waste, associated with these activities, has been identified as a prerequisite for improving the construction process[9].

To achieve this, the re-engineering approach calls for the implementation of the Just-In-Time (JIT) system which has its roots in manufacturing[6,9]. It employs a 'demand-pull' technique, in which resources are delivered only when needed by the process, thus eliminating unnecessary activities[23]. Such implementation requires an effective resource flow system based upon a high level of planning and co-ordination between resource suppliers, sub-contractors and site managers. Another area of opportunity is the use of prefabricated components/materials which reduces the material flow on site and eliminates much of the material waste to be transported away from site.

Information communicated from and to construction sites is diverse in terms of source and subject. Time is typically wasted on locating the appropriate information, duplicating or re-wording documents, providing redundant or too much information for individuals to consume, and providing insufficient information for critical decisions. In many cases, information is not updated on time or is transferred informally, undermining the value of the content, and impacting on both construction time and cost[24].

The re-engineering approach is intrinsically linked to the application of information technology (IT)[25]. Rapid advances in IT capabilities can be a key enabler in re-engineering site managerial operations due to its huge potential in enhancing communication among project participants[26]. An information management system, for example, that provides every project team member with an immediate access to required information, such as project progress, would have a positive impact upon project performance. As project information becomes available on a shared project database, non-value-adding operations such as checks and unnecessary controls would be reduced to minimum, thus enhancing the project outcome.

The ability of construction managers, for example, to electronically exchange site information, installation procedures and design details with the office has the potential to bring fundamental changes in the traditional practice of face-to-face site meetings. Another example is the use of Electronic Data Interchange (EDI) for integrating work processes between suppliers and sub-contractors. This will inevitably lead their collaboration to the next step of re-defining the traditional roles and responsibility split between the two in such a way to eliminate non-value-adding processes[27].

Priorities for introducing BPR

The majority of the above-listed issues and proposed measures can be considered to be BPR initiatives rather than incremental improvements as they do not focus on current practice but rather challenge it by having a broad and cross-functional scope that involves:

- Introducing major changes to key business activities. For example, incorporating a contractor's input into the design process would improve constructability and introduce practical knowledge into a process which has always been thought of as a highly technical operation exclusive only to designers.
- Adopting the concept of an input–output view of business, not a responsibility-centred and structural view. A typical example is allowing for more interaction between project phases to ensure that participants, i.e. internal customers, have their share in enhancing the value and quality of the final product, i.e. the built facility.
- Challenging the traditional or *status quo* structure of business operations which has dominated and continue to dominate the construction industry. A typical example is abolishing the tendering system, as we know it today, and replacing it with a new system which allows for a combination of elements that concern the client to be considered, e.g. performance, quality and environmental issues as well as the price. Another example is the re-organization of work packages with a view to integrate them, thus having fewer sub-contractors and consequently better coordination and control.
- Exploiting available technologies to achieve outstanding results in terms of time and cost savings. Implementing information technology tools is just one example of how current construction business operations can be transformed to reduce coordination costs and increase the scope of coordination.

As one might expect, the nine issues presented earlier in this paper do not share the same level of priority for introducing BPR in the construction industry. Depending on whether the proposed measure is a BPR initiative or an incremental improvement, the ease and implication of implementation vary considerably. *Table 1* shows the significance and breadth of opportunities resulting from a concerted effort of introducing BPR into the construction industry.

Concluding remarks

BPR is a proven method of achieving dramatic improvements in production time and cost. Having seen its reported successful implementation in many industries, the construction industry can also benefit from its adoption. Interest in BPR will continue to grow as the Australian construction industry focuses on process improvement to bring about higher levels of performance. This paper has argued that reducing construction cost and time and increasing output quality is achievable by re-engineering how major construction business processes are conducted.

Success of BPR is highly dependent upon many factors such as culture change, strategy, human and technical resources, information technology and communication. The paper has introduced a total of nine issues believed to have a crucial role in the success of re-engineering the construction process. These issues have been presented with a view of how to re-think business processes as currently performed by key project participants, i.e. the client, designer and contractor. In doing so, main project processes such as conceptual design, design, procurement and construction have been dealt with in terms of their structure (the sequence of tasks or activities that generates an outcome), and/or cross-functionality (characteristics that define the boundaries among key project participants). The paper has also demonstrated the potential of performance improvement in applying concepts such as partnering, value management, quality function deployment, concurrent engineering and Just-In-Time in construction.

The pursuit of re-engineering the construction process requires the development of a cooperative culture between industry professionals, in which the aim is to meet the project objectives by cooperation and team building as opposed to the present confrontational approach. To achieve this, an awareness is required by all team members of the benefits of win–win professional relationships. All team members, including the client, would benefit by establishing such a relationship.

Clients have a crucial role in determining how projects

Table 1 Summary of possibilities for BPR advancing the construction industry

	Type of change		Role in successful BPR		Ease of implementation	
Issue	**BPR initiative**	**Incremental improvement**	**Critical**	**Useful**	**Easy**	**Difficult**
Brief development	Yes		Yes		Yes	
Risk allocation	Yes		Yes			Yes
Contractor selection	Yes		Yes			Yes
Design evaluation		Yes		Yes	Yes	
Constructability	Yes		Yes			Yes
Phases interaction	Yes		Yes			Yes
Work reorganization	Yes		Yes			Yes
Partnering		Yes		Yes	Yes	
Time waste elimination		Yes		Yes		Yes

are to be procured. Their positive involvement in the conceptual design phase henceforth would have a positive impact upon project performance. They also have to realize that selection of design, management and construction teams should not be based solely on price. The potential gain in value and quality of project performance can outweigh any small financial gains that seem to be achievable at the early stages of the project.

Designers are urged to encourage design input from clients, other engineering disciplines and contractors during the conceptual design phase. They should not see the exercise of allowing for project downstream phases as interference by others in their business process. Benefits of long-term relationships with sub-contractors and material suppliers must be sought by contractors who should work towards integrating small work packages into new ones, designed around their outcome rather than their old structure. Such new work packages would promote higher productivity through better coordination and site control.

Contractors should also increase their investment in information technology and material management capabilities to enhance re-engineered operations based upon optimum project communication and information flows.

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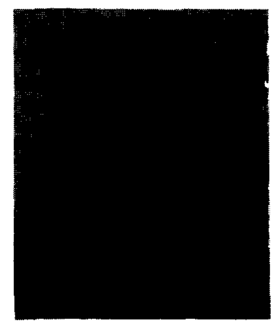

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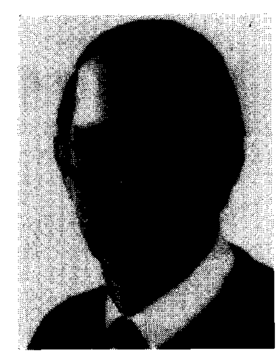

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