

IDENTIFICATION OF CONSTRAINTS IN CONSTRUCTION PROJECTS TO IMPROVE PERFORMANCE

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ABSTRACT

Needs and constraints in a multi-party working situation bring complications in project management. Needs are diversified when the client is a large organization such as a public client or a corporate client. However, constraints in construction projects limit their achievement of high performance. The aim and scope of this paper is to identify the constraints in construction project working environment and apply the theory of constraints (TOC), which provides practical steps for making organizational decisions in situations in which constraints exist. If constraints are better understood at the outset, it is believed that better performance can be assured. Presently clients' needs in construction are well discussed, but constraints have yet to be understood in context. We identified the constraints in five categories, they are: (1) economic constraints, (2) legal constraints, (3) environmental constraints, (4) technical constraints, and (5) social constraints. The impacts of these constraints to the construction project were studied. We suggest developing awareness to managing and controlling the constraints in construction working environment for achieving high performance in the construction working environment.

Keywords: constraints, construction, theory of constraints (TOC).

1. INTRODUCTION

There are constraints in every working environment. However, there can be situations that we are unaware of the existence of the constraints, or, we tend to put more emphasis on the project goals. Although constraints have been discussed in much of the management literature, there is little detailed study on constraints in construction working environment. The construction working environment involves multi-party participation. Needs and constraints in a multi-party working situation bring complications in project management. These can further develop into conflicts and disputes, which bring cost consequences, direct and indirect, to clients and contractors (Yates, 2002). The project team members have to meet client's needs on one hand and to overcome constraints on the other hand. With the limited literature for the constraints in the construction working environment, it is important to identify the potential constraints in the construction project, which will help to decrease the unnecessary wastage and loss of both money and time because of inadequate planning. Controlling the constraints is thus a pre-condition for high performance of the project.

Constraint is defined as a constraining condition, agency, or force that limits the systems' performance in a given context/environment (Mayer, Painter and Lingineni 1995, Whelton, Penneanen and Ballard 2004). Every production system will have at

least one constraint (Chua, Shen and Bok, 2003). Constraint describes the relationships between objects and processes (Whelton, Penneanen and Ballard 2004; Tam, 2006). It is whatever impedes progress toward an objective or a goal (Mcmullen 1998). Constraints may cause undesirable consequences or are not supportive of the organizational goals. It is the environment and the limitations of the system which dictates the solutions (Stein 1997). These constraints should be reduced or eliminated in order to minimize waste and make the flow more efficient.

Constraints have to be managed. Practically, in all cases the constraints' limiting impact can be reduced or eliminated. Constraints management contributes to two major project functions, planning and control (Chua et al. 2005). Planning functions emphasize developing optimal schedules using simple or complicated algorithms with the objective of fulfilling project goals such as duration, cost, and quality. Control functions are focused on both plan and implementation such as work assignment and resource allocation, and supply chain management such as material delivery and inventory control. Identifying and removing constraints (Chua et al. 2003) from bottleneck activities help to reduce uncertainties in construction processes and increases the transparency of project management. Yates (2002) suggests that avoidance measures can be taken if they understand the cause of conflicts and disputes. They proposed a framework to identify the caustic factors of the conflict and disputes in the construction industry.

Mcmullen (1998) categorized the constraints into two groups: the constraints with lesser impact and the ones with greater impact. He suggested that every situation contains many relative lower impact constraints but only a single or a few higher impact constraints. The higher impact constraints are called core problems or root causes. He suggested that as time is everyone's prime constraint, maintaining the focus of an individual or management on identifying and acting on the higher impact constraints will help using the scarce time effectively. There are two basic types of constraints according to Goldratt (1990): physical constraints and non-physical constraints. A physical constraint is something like the physical capacity of a machine, in other words, it is something that is rigid and in its current state has a limit on its ability or throughput (e.g. materials, machines, people, demand level). A non-physical constraint might be something like demand for a product, a corporate procedure, or an individual's paradigm for looking at the world.

Constraints are a function of two variables: capacity and demand. A comparison of the two at the system level provides a reliable indicator of progress towards its goal (Dettmer, 1998). The constraints can be categorized into two types: (1) internal constraint and (2) external constraints.

Internal constraints are inside the system and are usually more under control. This means that when the system cannot keep up with the demand, action needs to be taken to eliminate the constraint. But continuing such an action will in turn bring to a point where capacity exceeds demand and constraint exists in another form. Middle managers frequently encounter situations when a task is assigned by the top management with constraints. The middle managers then have to go over these constraints in order to complete the task. The consequence is that they may have to take more time or resources than what has been planned. If they face constraints that cannot be overcome, there is a possibility that they may have to do things outweighing

their capability in order to accomplish the task. Some managers will have to take irregular actions such as illegal action, deceiving action, or force the others to comply without any redress. External constraints are outside the system and are less under control. This means that the system has slack capacity to handle external constraints and action taken can merely minimize the effect of undesirable consequence rather than breaking the constraints. However, constraints can never be permanently broken. They merely migrate from one place to another and TOC has to re-apply.

The theory of constraints (TOC) developed by Goldratt (1990) is a process aimed at identifying and removing constraints in organizational processes that are standing in the way of organizational goals. A constraint is defined as *anything that limits an organization or entity from moving toward or achieving its goal*. TOC logic forms major portions of the organization's philosophy of continuous improvement. It is applied to identify what factors limit an organization from achieving its goals, developing a solution to the problem, and getting the individuals in the process to invent the requisite changes for themselves. The five steps in applying TOC (Goldratt, 1990) are shown in Figure 1.

Removing constraints (Goldratt 1990, Chua et al., 2003) from bottleneck(s) are the most effective means of improving overall system performance. Once the existing constraints are removed, however, new ones emerge. Identifying and removing constraints represents an iterative procedure that pushes system capacity closer and closer to its limit. Therefore, the process should be reapplied (Goldratt 1990) as illustrated in Figure 1. It emphasizes balancing throughput across the entire production line and making the best use of available resources via continuous improvement.

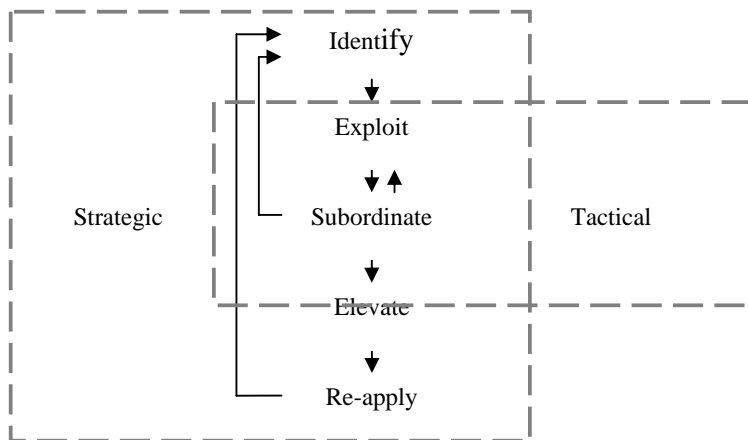


Figure 1 Five Steps of Theory of Constraints (TOC) (Goldratt 1990)

It has been suggested that TOC can be applied to project management (NewBold, 1998; Stein, 1997; Patrick, 1998; Masterman, 2002). Construction projects (Clough, Sears and Sears, 2000) are intricate, time-consuming undertakings. The construction project needs a good management to achieve the satisfied result including (Walker 1989) functional satisfaction, aesthetic satisfaction, completion on time, completion within budget, value for money, and health and safety. Walker (1989) defines the construction management as: “The planning, control and co-ordination of a project from conception to completion (including commissioning) on behalf of a client. It is concerned with the identification of the clients’ objectives in term of utility, function,

quality, time and cost, and the establishment of relationships between resources. The integration, monitoring and control of the contributors to the project and their output, and the evaluation and selection of alternatives in pursuit of the clients' satisfaction are the fundamental aspects of construction project management. Whelton, Penneanen and Ballard (2004) stressed that the project definition process is significant if it offers opportunity for the clients and the team to identify constraints, and project constraints have to be considered when formulating the project strategy (Masterman, 2002). Masterman (2002) suggested quantifying the assessment of the actual constraining effect on project objectives and the procurement process. Chua, Shen and Bok (2003) suggested that the theory of constraints could be adopted in the construction context because project development in this respect resembles a production process in which productivity is affected by various constraints.

2. RESEARCH METHOD

Unpleasant problems or “undesirable effects” are the result of relatively few core problems (Newbold 1998), or, in other word, the constraints. Once these core problems are identified and dealt with, the majority of the undesirable effects will go away. We recognize that the identification of the constraints is the first step to apply TOC in project management to help project managers to make better decision and achieve higher performance in construction project management. In our study, we firstly classified the constraints into five categories based on literature review (Manning 1995, Peter and Rod 2003, Lambropoulos 2006; Schultmann and Rentz 2002). They are: (1) economic constraints, (2) legal constraints, (3) environmental constraints, (4) technical constraints, and (5) social constraints.

Among the 120 questionnaires sent out to the government and contractor companies in Hong Kong. 30 questionnaires were returned. The respondents were asked to fill in an open-ended questionnaire to indicate any of the constraints that they encountered in the project in construction working environment. We conducted follow-up telephone interviews to elaborate the content of the data collected. The respondents were asked to explain the cause, effect and level of impact, using a rating scale of 1-10, of the constraints on project performance and procedure.

3. RESULTS AND DISCUSSIONS

The interviews are recorded and the content of the communications were analyzed. The nature of the constraints is elaborated and their impact to the project is analyzed.

1. Economic constraints

The economic constraints mainly happened with budget limit and allocation of the money. Due to the budget limit, the adopted construction system may not be the best option for achieving the project goal and quality. It will affect the proceeding of the project. As for the allocation of money to be used in the project, if the money is not effectively allocated, it will affect the progress of the project. The effect on the project is the product quality and performance of the project. In summary, if economic constraints for the project could not be managed well, the product/performance/function/quality of the project will be affected.

2. Legal constraints

The legal constraints exist because there are many regulations that are ruling the construction project. The legal constraints are mainly related to work law, safety regulations, and supervision plan. For example, as prohibited by law, certain types of construction work could not be carried out during Sunday and public holidays. From the other perspective, when there are new regulations published in Hong Kong, which is not infrequent due to the recent construction industry reform bill, the project have to update the project schedule now and again to comply with the new regulations. As for the impact of the legal constraints, from one side, it may affect the schedule and lead to project delay. For example, when traffic diversion demands immediate decision, the team has to wait to get procedure approval before proceeding on site. From the other side, it may affect the planning and progress of the project, such as traffic ordinance and excavation permit, where approval is required before the work starts.

3. Environmental constraints

The public concern and regulations require the environment to be protected such as air protection, tree preservation, traffic limit, noise control and so on. In the planning and design stage of the project, the responsible people need to go to the “Environmental Department” to apply for the approval/justification for the project. This takes time and will affect the project progress. If the approval is not obtained on time, the whole project will be delayed, or could not be carried out. There are also other technical constraints arising from air protection, tree preservation, traffic limit, limit due to excavation permit for works, etc.

4. Technical constraints

There are quite a few technical constraints arising from restrictive site area and congested surroundings which are particularly applied to the site environment in Hong Kong. On one hand, building projects in Hong Kong are usually constrained with restrictive site area where storage space, transportation and temporary works require input of careful planning by design engineers, while the design and construction of the building works itself can be fairly certain at the outset. On the other hand, coordination of services works also poses technical constraints in construction. While having electrical wiring, ventilation ductwork, fire services and plumber works with further complication of broadband alignment, telephoning system and security system give rise to technical constraints that demand coordination and collaboration of multi-parties in terms of design and construction. Technical constraints are more readily recognized at the outset and at the stage of design, but this does not mean that all constraints can be overcome.

5. Social constraints

No construction work could proceed in rural area without people’s involvement. The social factors constitute constraints in the construction working environment. It is not surprised to learn that undesirable effects come from a relative small number of key persons and the constraints are human constraints. These social constraints may appear minor and insignificant, but is very complicated to deal with. Sometimes it may arouse big problems for the project and will at the same time affect the progress of the project. Chinese “Feng shui” is a good example of social constraints. in New Territory of Hong Kong, the original residence believe the “Feng shui”, some of the construction companies need to spend a lot of money to avoid the bad “Feng shui” and also hold some ceremony for the belief of Chinese “Feng shui”. Furthermore, public

concern and media pressure also constitute constraints to the construction project. Public concern and internal audit on “proper” use of public money, in fact impose restraint on new initiatives and engagement of better contractor on expense of higher contract sum. Sometimes, when a new technology or design is proposed to carry out in a project, the public, such as the media and the audit department, will restrict the endorsement of the usage of the money. The checking system prefers using every dollar effectively. This constraint will affect the adoption of new technology usage in construction project. It also affects the design and contracting of the project.

We observe that the social constraints usually come from the people. Inadequate assumptions or bad judgment arising from human constraints can bring disaster. Frustration, lack of motivation and mistrust will destroy morale and commitments to work (Newbold, 1998). Constraints related to people can appear in three different forms: (1) human resistance, (2) emotional constraints, and (3) ownership of the problem. In implementing changes, there will be human resistance. So constraints have to be thought of during the planning stage before actual implementation so as to minimize the effect of human resistance. As for the emotional constraints, there is a tendency for people to take defensive action rather than ‘toleration’ even the rational minds tell them not to. In this stance, people are emotional disturbed. In situations when constraints are concerning job security, the impact of the emotional constraints can be even greater and can cause devastating effects. As for the ownership of the problem, people may at times facing problems caused by others or by Act of God. It is easy to say that they do not cause the problem and thus are not responsible for it. Someone have to be held responsible for whatever causes there are. Moreover, providing an answer to a problem even if you are aware of it sometimes may not bring in the expected results. By the action of supplying a person with the answer you block them from the opportunity of inventing answers for themselves (Goldratt, 1995) as people like to have autonomy within their capacity. Therefore, to induce people to invent solution would charge the person with ownership of the problem and hence commitments in solving it.

The average score of the rating scores on the level of impact on the construction project is shown in Table 1. The legal constraint has the strongest impact on the construction project, economic and environmental constraints both ranked second among the constraints. The social constraint has a modest impact comparing with other constraints. Technical constraint has the lowest impact on the construction project. The results show that the legal, environmental and the economic constraints have the strongest impacts on the project. It is suggested that time and enough resources be allotted to these constraints in the planning stage of the project. The social constraint has special local and traditional features. Although not as important as the other constraints, it could not be ignored. If the social constraints could not be handled well, the project could not be proceeding well, and at project evolving stage, this may even lead to discontinuation of the project.

Table 1 Level impact of the constraints on the construction project

Constraints	Level of Impact on the construction project
1. Legal constraint	7.20
2. Economic constraint	7.00
3. Environmental constraint	7.00
4. Technical constraint	4.75
5. Social constraint	5.40

Although the technical constraints have the lowest score, it is also important for good quality of the product. These constraints are intended to be resolved by engineering design and close coordination of design and construction activity. If technical constraints can be resolved at the design stage, these constraints will no longer be constraints at the construction stage, but this kind of technical constraints can take up much of design engineers' time prior to start of construction and yet there may be new technical constraints arising from actual working environment. An example of this can be seen with the Deep Bay Link (Tam, 2006) where the design and construction team faced a range of ground constraints and time constraints. The solution was to have a technical team assigned to offer design and time-saving solutions together with careful logistic planning.

The results confirm that if one constraint could not be overcome, another constraint may be triggered. For example, if the method of disposing wastage threatens the environment, which breaks the regulations, the company may need to spend money to deal with the wastage in a legal way. The project budget may not be enough as a result, thus economic constraint is encountered.

The identification of the constraints helps project managers not only understand the characteristics of the constraints, but also predict the time and stage that the constraints may be encountered. The economic constraints, legal constraints and the environmental constraints are mainly appeared in the planning and definition stage. It affects the proposal and design of the project. The technical constraints and social constraints are expected to be encountered during the project implementation and maintenance period. A good prediction of the constraints helps make good project planning and resources allocation. Project managers can judge whether the constraint is maintained through the whole progress of the project, which we name them as "permanent constraints"; or where the constraint could be removed, which we name them as "temporary constraints".

4. CONCLUSION

To have a good understanding of the identified constraints at the planning stages, we suggest the management to have the constraints documented and to consider these constraints in the relevant project planning agenda and schedule as well as the designing of the organizational structure. At the implementation stage, the management should keep track of the progress and be aware of the constraints they encounter. The management should ensure that enough resources, which include money, facilities, staffing and effort, are allocated to decrease the limitations from the constraints encountered. In view of the nature of the different types of constraints, we suggest that the middle managers are empowered to take up adaptive management in response to the prevailing conditions. Although we are still in the process of collecting data, we regard the results sufficiently indicative of how constraints in construction would be like. We consider further study in other areas of TOC necessary to understand the complex nature of construction.

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