11-1997

TQM in the construction industry in Hong Kong : a supply chain management perspective

Shiu Ho, Alfred WONG
wongsh@ln.edu.hk

HKIBS/WPS/014-978
November 1997

TQM in the Construction Industry in Hong Kong A Supply Chain Management Perspective

Alfred WONG
Department of Management
Lingnan College

and

Patrick FUNG
Department of Management
Hong Kong Polytechnic University

Hong Kong Institute of Business Studies
Lingnan College
Tuen Mun
New Territories
Hong Kong
Tel: (852) 2616 8373
Fax: (852) 2572 4171

TQM in the Construction Industry in Hong Kong
A Supply Chain Management Perspective

Alfred WONG
Department of Management
Lingnan College

Tuen Mun, Hong Kong
Telephone: (852) 2616 8306
Fax: (852) 2467 0982

and

Patrick FUNG
Department of Management
Hong Kong Polytechnic University

Hunghom, Hong Kong
Telephone: (852) 2766 7392
Fax: (852) 2774 3679

TQM IN THE CONSTRUCTION INDUSTRY IN HONG KONG - A SUPPLY CHAIN MANAGEMENT PERSPECTIVE

ABSTRACT

TQM is increasingly being adopted by construction companies as initiatives to solve quality problems in the construction industry and to meet the needs of the final customer. However, TQM should incorporate the integrated quality management activities of members in the supply chain. This supply chain context is especially salient in the quality assurance of construction projects as a general contractor often out-sources most of the construction work to other members in the supply chain i.e. its suppliers and subcontractors. Therefore, this paper aims to delineate the supply chain management issues in total quality for construction projects. Through the use of an in-depth case study on the TQM system of a leading construction company in Hong Kong, the strategy, structure and tasks for managing supplier/subcontractor relationships are examined. The study concludes with identification of some supply chain management issues in the construction industry, as well as future research topics in integrating supply chain management with total quality management.

INTRODUCTION

Total Quality Management (TQM) is concerned with a holistic approach to continuously meeting customers' needs in most competitive ways. As defined by Rampey and Roberts (1992), "TQM aims at continual increase in customer satisfaction at continually lower real cost. Total Quality is a total system approach (not a separate area or program), and an integral part of high-level strategy. It works horizontally across functions and departments, involving all employees, top to bottom, and extends backwards and forwards to include the supply chain and customer chain." Dale (1990), Oakland (1990), Kanji (1993), Stahl (1995) share the view that TQM should incorporate the integrated quality management activities of members in the supply chain.

The supply chain context is especially salient in the quality assurance of construction projects. In the construction industry, the owner i.e. the customer requires a project completed in such a way as to meet his multiple objectives of quality, cost, safety and speed (Oglesby et al. 1989). In contracting with the customer, the general contractor further relies on suppliers and subcontractors for goods and services that match this customer's quality requirements. The supply chain management issues in a TQM system of a general contractor therefore lie mainly in how suppliers' / subcontractors' resources and activities are channeled to meet the multiple and often changing needs of the customers.

This paper aims to delineate the supply chain management issues in total quality for construction projects. Through the use of an in-depth case study on the TQM system of a construction company in Hong Kong, the strategy, structure and tasks for managing supplier/subcontractor relationships are examined as they form an integral part of total quality pursuits. The study concludes with identification of some supply chain management issues in the construction industry, as well as future research topics in integrating supply chain management with total quality management.

METHODOLOGY

In the first part, descriptive research is carried out to study the characteristics and process management of firms in the construction industry. This paves the way for further examining the need for and the design and implementation of a total quality management system in construction firms, to raise the capabilities and motivation of the suppliers/subcontractors subsystem.

In order to gain an interpretative insight into TQM and supply chain management issues in construction, an intensive rather than extensive research strategy was adopted (Sayer, 1984). Therefore, an in-depth description of the TQM system of a company was carried out, supported by analysis of the structure and culture of supplier/subcontractor relationship with reference to the technical, behavioral, inter-functional and inter-organizational aspects of the TQM system. Data, opinion and chain of evidence were sought from senior management, quality and human resource management professionals in the Company. Informants from both inside and outside the firm were interviewed in validating the findings of the issues that unfolded.

CHARACTERISTICS OF THE CONSTRUCTION INDUSTRY

The industry is often criticized for poor performance. There are many reasons for this. First, this industry is comprised of a multitude of occupations, professions and organizations (Sommerville, 1994; Milakovich, 1995). The owner perceives a need to invest in a building project so as to meet the needs of the public. The owner employs consultants like architects and engineers to design the project. General contractor or main contractor is then selected to construct the project according to the design. The general contractor will employ its own subcontractors as well as other subcontractors named or nominated by the client. Suppliers will supply the required materials either to the general contractor who hands them to the subcontractors to fix and install or directly to the subcontractors. The contractor, architect, engineer, etc. have profit as their goal, and the owner has the goal of minimum costs. Many service providers want speedy completion but that can often result in sloppy workmanship. Goals tend to conflict as different parties have different priorities.

In the construction phase of a project, general contractors want to ensure quality throughout the project. According to Rowlinson and Walker (1995), the construction industry is characterized by its non-standardization. Very often, products are one-offs and the production processes are to some extent different from each other. Hence, no universal standard or specification can be applied to the product, which leads to difficulties in quality assurance. Changes to the details of the design of a project are typical and may be frequent throughout the construction process. They may be attributed to the lack of buildability of the design produced or variations by the contractors for the sake of speed and cost of production. Quality is often at risk when there are excessive changes.

TQM IN CONSTRUCTION INDUSTRY

TQM is increasingly being adopted by construction companies as initiatives to solve the quality problems in the construction industry and to meet the needs of the final customer. As suggested by Oakland and Aldridge (1995), if ever an industry needed to take up the concept of total quality management it is the construction industry. Alfeld (1988) advances the view that construction very probably promises a greater payback for performance improvement than any other service industry because of its magnitude. There are differences in the degree of adoption of TQM among different countries. According to Milakovich (1995), "the Japanese were among the first to apply quality control techniques on a large scale, although they did not embrace this concept until after the oil crisis of 1973.....Subsequently, several U.S. construction companies adopted the more familiar TQM programs used by U.S. manufacturers." Trends in the application of quality management systems as identified from a research on 19 construction firms appear positive: 12 companies had formal TQM, 4 had quality assurance/quality control programs, and 3 had informal TQM (Burati et al., 1991). In the U.K., it is only recently that quality assurance has been taken seriously in the construction industry, and even then only by large contracting companies (Tyler and Frost, 1993). The industry does not appear to understand the concept of TQM, and at best sees it as concerned only with BS5750 and quality systems (Oakland and Aldridge, 1995).

In Hong Kong, at the end of 1995, there were 80 construction companies that have obtained ISO9002 certificate (Hong Kong Report, 1995). Some companies believe that nominal execution of an ISO system does not, in itself, meet the TQM objectives of continuous improvement through integrated functions and processes. Therefore, they further implemented TQM upon successful ISO 9000 certification.

Examples of companies adopting TQM to improve their performance are Morrison Construction Group Ltd.(Sommerville, 1994), Takenaka Corporation (Jido, 1996), and Shui On Construction Co. Ltd. (Fung and Wong, 1995). Higher customer satisfaction, better project quality, and higher market share often come with the adoption of TQM by such companies.

ROLES OF GENERAL CONTRACTORS AND SUBCONTRACTORS IN THE CONSTRUCTION PHASE

As depicted in fig. 1, the client, the consultants, the general contractor and its subcontractors and suppliers together form a supply chain. Christopher (1992) defines a supply chain as the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer. In constructing a project, the responsibility of meeting the needs of the client falls on the general contractor who has to depend on its subcontractors and suppliers to carry out the major construction work. Communication with different parties and operating as a team among different parties are essential to provide best performance. Supply chain management adopts a systems and integrative approach in managing the operations and relationships among the different parties in a supply chain. According to Berry et al. (1994), supply chain management (SCM) is aimed at building trust, exchanging information on market needs, developing new products, and reducing the supplier base so as to release management resources for developing meaningful, long-term relationships. When applied to the construction industry, SCM would focus on how a general contractor can better manage and leverage the resources of its subcontractors and suppliers through working closely and cooperatively with them.

[Insert Figure 1]

Unlike subcontractors, a general contractor is usually large and has a direct contractual relationship with the client. In turn, the general contractor contracts with its subcontractors and suppliers. In the construction industry, subcontracting is a widespread practice (NEDO, 1978). According to O'Brien (1991), the general contractor in today's construction world has a very difficult and important function: to execute satisfactorily all accepted contracts. The contractor must take an owner's ideas and turn them into reality. These ideas are usually in the form of drawings and specifications developed by a third - party architect engineer.

There are several reasons for a general contractor to use subcontractors. They are :

- A subcontractor possesses specialized technical, engineering, or construction skills.
- The general contractor's in-house abilities are limited in a particular area.
- A subcontractor can augment the general contractor's labour force at a lower cost by relieving the general contractor of developing and maintaining an in-house capability.

In fact, subcontractors act as a buffer between the general contractors and unpredictable work-loads. When the general contractor has a lot of work, the subcontractor will have to be able to supply increased work crews, but when the general contractor is having a low level of jobs the subcontractor will have to reduce his workforce or attempt to find work with other contractors. The use of subcontractors helps the general contractor to reduce his commitment to long-term resources such as owned plant or permanent wage workers.

PROBLEMS WITH THE SUBCONTRACTING SYSTEM

In general, the subcontractors are smaller in size and financially not strong. Works carried out on construction sites are labour intensive and control of the workers is difficult. It is often difficult to hold subcontractors responsible for problems. Policy and procedures in small firms are normally not well established and provide little or no guarantee of quality and professional competence (Ganesan et al. 1996). Therefore, the general contractor should

oversee the performance of his subcontractors to ensure that they are in compliance with the owner's requirements.

The application of TQM by the general contractors will surely help them improve their own performance. However, in the construction industry, a lot of the construction work is subcontracted out. Therefore, the message of TQM should also spread to one's subcontractors in order to get quality performance from firms in the supply chain.

THE CASE COMPANY

The Construction Environment - Government Demands

Hong Kong's construction industry is booming in both civil engineering and building works. A major client in the construction industry of Hong Kong is the government. Under its auspices, there are the huge Port and Airport Development Strategy (PADS) projects and the enormous public housing construction programme. The 10 Airport Core Programme projects are projected to cost HK$158.2 billion (Hong Kong Report, 1996). In the period 1996-97, HK $9.8 billion will be spent purely on public housing construction and HK$5 billion on public housing maintenance (Construction & Contract News, 1995). Quality has always been a problem to the Hong Kong construction industry. The government made its decision to redevelop 26 public housing blocks which was built just about 20 years ago because of quality problems. The Hong Kong Housing Authority took the lead to promote quality assurance in construction in 1991. It now requires all contractors, concrete suppliers and nominated subcontractors to attain the ISO9000 series quality standards, as accredited by the Hong Kong Quality Assurance Agency. It also adopted the Performance Assessment Scoring System (PASS) to assess the performance of different contractors. Given that ISO certification is a pre-requisite in conducting business, construction firms are increasingly building TQM on their ISO-certified operations to compete with one another.

Background of the Company and History of QUALITY Concern

Shui On Construction Company has over 20 years' experience and nearly 2000 employees. It has always put much emphasis on providing quality products and services. It first formulated its Mission Statement in the early 1980s with the emphasis on providing its clients with quality service and products. The Company embarked on the road to ISO9000 certification in 1990 in response to the requirements of Hong Kong Housing Authority. In 1992, it was the first contractor in Hong Kong to obtain the ISO9002 Certificate. The Company adopted TQM by the end of 1993. It was recognised for good performance in building housing projects, and was awarded "Contractor of the Year" in 1995, 1996 and 1997 by the Housing Authority. Over the years it has also obtained numerous Safety Awards from the government.

Adoption of TQM

Surveys on employees were carried out in 1994 and 1995 to determine how best to satisfy the Company's customers through collective effort, with greater efficiency and decreasing costs. The Company has tried to ensure that suggestions for improvements are implemented. The Company puts emphasis on developing the capability of its staff through training programmes and through encouraging open communication, individual initiatives and team work. It also established a structure for quality management with some quality monitoring devices.

Awareness - Top Management and Staff

In the implementation of TQM which started in 1993, the Training Department has organized conferences for `Management Staff' to raise their awareness of the essence of TQM. Then there was a series of courses which disseminated the principles and concepts of TQM to all the staff. By 1995, the training department has completed offering the basic awareness programme on TQM to all existing staff. It now turns to reinforcement programmes on TQM such as the Personal Quality Programme and Quality Improvement Tools.

The management communicates its emphasis on quality performance to each employee. The mission statement and quality policy are issued to all staff members. Banners with messages like `Commit to Quality' and `Safety First' are displayed both in offices and in construction sites. In addition, Housing Authority's assessments on the performance of each site are made known to all staff to encourage sites lagging behind in performance to catch up.

Internal Structure

The Company also established a structure for quality management and quality monitoring devices. At the top, there is the Quality Management Committee which consists of 8 to 9 members coming from such key departments as project department, quantity surveying department, engineering department, and estimating and procurement department. A Quality Department was also established to help coordinate and execute quality activities. A Site Quality Team and a Project Team are formed for each construction project. Members are drawn from both the head office and the individual site. The Site Quality Team will monitor and review the quality aspect of a construction project e.g. workmanship and conformance to specification while the project team will be responsible for the overall progress and operation of the project. Teamwork can be observed both within The Company and between the Company and its subcontractors/suppliers. The structure adopted by the Company does facilitate the development of teamwork. Within the Company, there are Site Quality Teams and Project Teams which bring different functions together to handle project issues. Therefore, teamwork among different functions helps to provide good, efficient and effective management to different projects. This will also lead to better support and quicker response to subcontractors/suppliers.

There are different types of meetings to review the quality performance of different sites. There is a monthly Management Meeting to discuss the progress and problems of various sites. Apart from site management staff, there is the Site Quality Team which has some members drawn from the head office. The Site Quality Team will have a meeting monthly on site to discuss any quality problems arising from the site.

The Range of Subcontractors / Suppliers

As conveyed by the senior staff of the Company, normally, the overhead or preliminary items of a project takes up about 18 % of the total construction costs while 82 % is represented by materials and services costs contributed by subcontractors and suppliers. Hence, the Company depends very much on the cooperation of the subcontractors and suppliers in controlling or cutting their cost. Moreover, since most of the work of a project is done or provided by the subcontractors/suppliers, their co-operation significantly affect the progress and quality of the project they handle.

The general contractor has a responsibility to align the resources of its subcontractors and suppliers to meet the needs of the client. The Company has a group of long established subcontractors and suppliers for each major trade of work such as excavating, drainage laying, formwork, concreting, metalwork etc. and for those key construction materials such as the supply of tiles, sanitary wares and ironmongeries etc. The length of relationship may last more than 10 years. It is the policy of the Company to develop something like a permanent in-house construction team through these long-term subcontractors and suppliers. The top management of the Company believes that the Company will have more influence on these long-term subcontractors and suppliers because of the long working relationship and the personal relationship built up between the top management of the Company and its partners. Therefore, in case of urgent needs, it can more easily get the assistance and support from its partners. Moreover, these partners are more likely to comply with the requirements of the project. This group of subcontractors and suppliers are usually more responsive to the needs of the Company. They are also more cooperative and display good performance record. The Company keeps motivating them to perform by giving them continued business. Though they also have to compete on price, they are given preference over other subcontractors.

The Company also maintains some short-term or even once-off relationships with subcontractors and suppliers. This is suitable for processes or materials that are not important or when its partners are overloaded with orders. It may also be a way to keep its partners from getting complacent. Some of the short-term subcontractors and suppliers may be developed into long-term ones provided their performance is satisfactory. Sometimes, a project may require some special technology or materials. In this situation, the relationship will be a

once-off relationship. An example may be the subcontracting of the work of constructing a cold storage room to a specialist subcontractor. This job is not so common in housing jobs. Therefore, the relationship will be once-off.

With reference to recurrent needs, e.g. for the supply of concrete, the Company obtains all its requirements from a ready-mixed concrete company which belongs to the same group. This backward integration has brought benefits to both companies, i.e. the Company can have secured supply of concrete while the concrete company can have a guaranteed order.

When the market supply of some important trades or materials is very limited and if the Company cannot develop a close relationship with the subcontractor or the supplier, the Company will attempt to develop its own subcontractors or suppliers so as to secure its supply of the service or material and control its quality and cost. This happened in the supply and installation of aluminum window, steel gate, precast concrete sink bench and wooden door. The Company selected cooperative subcontractors and gave them technical and financial support in setting up their plants in China. The factories are managed by its partners, while the Company maintains accounting control over its partners.

Monitoring of Subcontractors / Suppliers

The Company has a strong management team on site to support and monitor the performance of subcontractors. Apart from site management staff, there is the Site Quality Team with some members drawn from the head office. The Site Quality Team will have a monthly meeting on site to discuss any quality problems arising from the site. The subcontractors are given guidelines on their workmanship. The contractor monitors the performance of subcontractors with checklists. Any defective works found have to be rectified. There is the weekly Project Review Meeting with the subcontractors to review their performance. As a form of recognition to those subcontractors that are performing well, there are the `Best Performance' award and the `Best Safety' award given in annual dinner to the subcontractors.

Regarding the quality of some building components supplied by its partners in China, the Company maintains quality control through inspection of the production processes and the

finished products. A checklist has been compiled for this purpose. The Company also sent its people from the Quality Department to help its partners to apply for ISO9000 certification. All the four joint venture companies have now been ISO certified. For the supply of goods from suppliers other than the four joint venture partners, incoming inspection and sometimes source inspection are carried out to ensure the quality of the goods. The procurement department maintains close communication with the site staff to understand how different suppliers are performing.

Interactions With Subcontractors / Suppliers - Mutual Learning

Since subcontractors are normally not well established, have poor financial backing and provide little or no guarantee of quality and professional competence, the general contractor has to manage them and help them to develop so as to increase subcontractors' capability and technology level. The Company often communicates its emphasis on quality performance to its subcontractors/suppliers. Training courses on quality management are offered to the subcontractors. The Company is ready to provide technical and financial support to its subcontractors and suppliers in order to help them improve their performance. On the other hand, sometimes, some specialist subcontractors or technically advanced equipment/materials suppliers will provide their expertise in the design of the construction method of a project. For instance, in the use of steel or aluminum formwork instead of the wooden formwork, the Company gets the support and advice from the formwork subcontractor/supplier. It ends up with a shorter formworking time and better concrete surface finish. Sometimes, in the bidding of a project, the general contractor will solicit information from some technically more advanced subcontractors and put forward some innovative construction methods which in the end can help the general contractor get a better rating in the tender.

Management of Goal Congruence - Continued Business

The subcontractors/ suppliers often have different objectives from the general contractor. They want to spread their labour force and resources very thin on different projects so that they can lower their own cost and serve more than one general contractor. This may cause delays to projects. They may also want to finish their work as fast as possible

to save time but at the sacrifice of quality of their work. On the other hand, the general contractor has the responsibility of meeting the needs of the client by building quality project on time. Therefore, the general contractor has to align the objectives of its subcontractors and suppliers to the objective of the client. The Company motivates its subcontractors/suppliers by giving more businesses to those long established and competent subcontractors/suppliers, and being punctual in payment and reasonable on any retention of money from them. Subcontractors/suppliers who want to have continued business from the general contractor must try to perform according to the contractor's requirements.

Cost Concerns Coming Between Established Relationships

The building of long-term relationship with its subcontractors/suppliers is sometimes difficult given the market/tendering mechanism adopted by clients in awarding building contracts. The general contractors often have to switch to subcontractors / suppliers that offer the lowest price. In addition, the benefits from long-term relationship is often difficult to assess compared to the benefits from using the lowest quotes. Therefore, there exists the cost-oriented business relationships between the general contractor and its subcontractors / suppliers. The contractor has to strike a balance between this cost-orientation and relation - orientation in managing its portfolio of subcontractors and suppliers. However, the Company often maintains a good working relationship with its subcontractors /suppliers in order to ensure their performance in quality, speed and safety.

Managing and Controlling Basic Requirements By Equity Joint Venture

To get around the control by a few companies in Hong Kong on the supply of some basic materials like wooden door sets, aluminum windows, and precast concrete sink bench units, the Company tried to integrate with its subcontractors by forming some equity joint ventures in China with some of its subcontractors. The partners were selected based on their co-operativeness with the Company, their expertise in the particular field, and their connection in China. The Company provided help in site selection, setting up of the factory, technical and management support to its partners. The quality department helped the joint venture companies obtain ISO9000 certification. Besides, the Company also supported them with orders. The factories are managed by its partners, while the Company maintains

accounting control over its partners. These joint-venture companies are found to be even more cooperative and responsive than the common domestic subcontractors. The Company managed to get lower cost and better quality in obtaining services from these joint-venture companies.

Relationships between the Company and its subcontractors and suppliers in the supply chain are not without problems. There are cases where claims and disputes happened between the subcontractors/suppliers and the general contractor. In general, the general contractor has tried to settle the problems through open discussion and without breaking the working relationship as it understands that they are mutually interdependent. Even in the case of joint-venture in China, the Company experienced late deliveries, e.g. of the wooden doors by one partner company. It led to the final acquisition by the Company of the other half of its shares in the wooden door business, turning the joint-venture into a wholly owned company. The ex-partner committed resources and time to the orders of other general contractors in Hong Kong and diverted resources away from the needs of its J.V. partner in Hong Kong.

CONCLUSION:
SUPPLY CHAIN MANAGEMENT ISSUES IN A TQM SYSTEM

Supply chain management is mandatory in the total quality objectives of a general contractor in the construction industry. The quality management tasks of a general contractor are complex, given the totality of quality features demanded by customers, as well as the multitude of actors in the supply chain, each bearing differing objectives, technology, resources, level of interdependence with other upstream and downstream actors. The case study of the Shui On Construction Company in Hong Kong shed light on some of these supply chain management issues that underpin a TQM system, notably

- The design and implementation of the TQM system in a construction firm must incorporate an assessment of its relationships with supply chain members, who provide invaluable materials supply and subcontracting services in meeting customers' needs.

- In managing the supply chain as an integral part of a TQM system, the general contractor maintains a portfolio of contractual relationships with supplier/subcontractors, ranging from competitive tendering to long-term contractual agreements.

- Structured relationship with key subcontractors and suppliers will facilitate the achievement of the total quality requirements of the customer especially in turbulent and competitive market environments. The supply chain relationship should promote collaborative behaviour from the suppliers/subcontractors in meeting quality objectives. Structured relationships apply particularly to subcontractors and suppliers with long - term relationship.

- A range of quality management, supplier development and involvement techniques is instrumental in maintaining structured relationships with subcontractors in a TQM system. Such involvement reflect the significance and level of interdependence in the supplier/subcontractor relationship; and should induce a quality culture in the suppliers/subcontractors in the longer run where the parties understand and fulfill the roles expected of them.

- The general contractor will have to constantly review its governance of subcontractors in the light of relational performance and changes in supplier/customer environments.

- In managing the supply chain for total quality, the general contractor will have to develop an enabling structure and efficient communication system for effective relationship management in project management.

This case study research has its limitations in only investigating the supply chain issues of a quality system from the perspective of the company itself. Further research in the topic should incorporate the role and behaviour of suppliers and customers, so that ways on how effective supply chain management practices are integrated in a TQM system can be examined in-depth. It is also necessary to measure the TQM outcomes that may vary with the effectiveness of SCM which in turn is affected by changes in the supplier and customer environments.

REFERENCES

Alfeld, Loui Edward, *Construction Productivity*, MGraw-Hill, 1988.

Berry, D., Dr Towill and N. Wadsley, "Supply Chain Management in the Electronics Products Industry," *IJPDLM*, Vol 24, No. 10, 1994, pp. 20-32.

Burati, J.L., M.F. Matthews, and S. N. Kalidindi, "Quality Management in Construction Industry," *Journal of Construction Engineering and Management*, Vol. 117, No. 2, 1991.

Christopher, M., *Logistics and Supply Chain Management*, Pitman, 1992.

Construction & Contract News, Nov/Dec., 1995, pp. 30-31.

Dale, B. G., *Managing Quality*, Prentice-Hall, 1990.

Fung P. & Wong A., "TQM in Construction Industry - Hong Kong Context," *Proceedings of Ist Int. Conference on ISO9000 and TQM*, De Montfort University, UK, 1995, pp.29-34.

Ganesan, S., Hall, G. & Chiang, Y. H., *Construction in Hong Kong*, Avebury, 1996.

Hong Kong Report, Hong Kong Government Publications, 1996.

Jido Jun'ichi, "Quality Management with TQM in Takenaka Corporation," *Proceedings of International Conference on Quality*, Yokohama, 1996.

Kanji, G. K. and Asher, M., *Total Quality Management Process - A Systematic Approach*, Carfax Publishing, 1993.

Milakovich, M. E., *Improving service quality: achieving high performance in the public and private sectors,* St. Lucie Press, 1995.

NEDO, *How flexible is construction?* National Economic Development Office, HMSO, London, 1978.

Oakland, J. S., *Total Quality Management*, Butterworth-Heinemann. Oxford, 1990.

Oakland, J. S. and Aldridge, A. J., "Quality Management in civil and structural engineering consulting," *International Journal of Quality & Reliability Management* v12n3, 1995, pp.32-48.

O'Bren, J. J. and Zilly, R. G., *Contractor's management handbook*, McGraw-Hill, 1991.

Oglesby, C. H. H.W. Parker, and G. A. Howell, *Productivity Improvement in Construction,* McGraw-Hill, 1989.

Rampey and Roberts, "Perspectives on Total Quality," *Proceedings of Total Quality Forum IV*, Cincinnati, Ohio, Nov., 1992.

Rowlinson, S. M. and Walker, A., *The construction industry in Hong Kong,* Longman, Hong Kong, 1995.

Sayer, A., *Method in Social Science*, Hutchinson, 1984.

Sommerville, J., "Multivariate barriers to total quality management within the construction industry," *Total Quality Management*, Vol. 5, No. 5, 1994, pp.289-298.

Stahl, M. J., *Management - Total Quality in a Global Environment,* Blackwell Publishers, 1995.

Tyler, A. H. and Frost, D. T., "Implementation of a construction industry quality assurance system," *International Journal of Quality & Reliability Management*, Vol. 10, No.4, 1993, pp 9-18.

Figure 1

Supply Chain of a Construction Project