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A case study on the management of the development of a large-scale power plant project in East Asia based on design-build arrangement

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Abstract

The purpose of this paper is to present a case study on how a US$621 million power plant was developed in East Asia. The scope of the paper covers the project environment in which the electricity industry is privatized, the method of dividing the project into 16 design-build (DB) work packages to encourage domestic contractors with limited capabilities to participate in the project, and the planning and control system. It was found that six of the 16 work packages were successful, eight were satisfactory only, and two were unsuccessful. The analysis of the problems encountered provides lessons to be learned for application to future large-scale and complex projects.

Keywords: Design-build; Performance; Develop and construct; Turnkey; Large scale complicated project; Power plant

1. Introduction

This paper describes the management of the development of a US$621 million power plant in East Asia. For project implementation, the power plant was divided into 16 work packages (Table 1 and Section 3). The aim of the paper is to investigate the level of success of the different work packages vis-à-vis the project environment, contract forms used, organizational format adopted by contractors, and planning and control system. The focal point for discussion is the issues that arise because of the use of multi-contract design-build (DB) system.

The project environment (Section 2) led the client to choose DB contract form. However, the extent of design information provided by the client for the different work packages differed. This gave rise to four DB formats; develop and construct, DB with single-stage tender, DB with two-stage tender, and turnkey [1] (Section 5). Contractors managed the design and construction of these work packages using three organizational forms; pure DB, integrated DB and fragmented DB [2] (Section 6).

The contribution of this paper is that the project management of a large power plant project is analyzed, and the problem areas scrutinized. Further, lessons learned were also distilled. The significance of this paper is that in future, clients who need to procure large scale projects can adopt the successful practices of this project and learn from the failures, to ensure that their projects have higher chance of success.

The exact location of this power plant and the actual names of project participants could not be provided in this paper because the client wanted to remain anonymous. This is not surprising as some areas of project failures were client generated. As such, while the facts of the case are genuine, pseudonyms were used.

Data were collected by interviews and unstructured discussions with 15 project participants, comprising five of each are from the client, project management and contractors' organizations. The clients and project managers interviewed were selected on the basis that they played major roles in the project development. Contractor-interviewees were construction and contract managers who were responsible for the management of five major work packages. The interviewees were selected in such a way as to ensure a good mix of profiles, so that rich and even conflicting views on the project could be obtained.

2. Project environment

In late 1990s, country 'X' in East Asia needed more power to support its economic development. It had just opened up its electricity industry to the private sector. Infra-Power Ltd (not its real name) undertook feasibility

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Table 1
Summary information of the work packages

Work Package No.	Work package title (approx contract sum)	Contractor's origin	Type of DB procurement system	Type of contractor's organisation	Brief project description	Complexity Level[a]	Budget performance	Schedule performance	Meeting specification	Conform to expectation	Quality of works	Minimum construction aggravation
WP 1	Site investigation (US$ 0.3 million)	Domestic	Turnkey	Pure	Soil investigation and surveying	2	✓	✓	✓	✓	Δ	Δ
WP 2	Site Preparation (US$ 24 million)	Domestic	Develop & Construct	Fragmented	Site levelling, sewage and road works	2	✓	✓	Δ	Δ	Δ	Δ
WP 3	Piling Works (US$ 18 million)	Domestic JV	Develop & Construct	Integrated	Piling for foundations and buildings	2	✓	✓	✓	✓	✓	Δ
WP 4	Foundation Works (US$ 59 million)	Domestic	Develop & Construct	Integrated	Foundations for equipment and buildings	2	✓	✓	✓	✓	✓	Δ
WP 5	Fuel Oil Unloading Jetty (US$ 18 million)	UK	Turnkey	Integrated	Jetty for tankers to deliver fuel oil to the power plant	4	Δ	Δ	✓	✓	✓	×
WP 6	Cooling Water Conduits (US$ 88 million)	Domestic	Develop & Construct	Integrated	Concrete conduits to circulate sea water for condenser cooling	2	✓	✓	✓	✓	✓	✓
WP 7	Stack Superstructure (US$ 6 million)	Domestic-China JV	Turnkey	Integrated	Stack for discharge of boiler combustion flue gases	3	✓	✓	✓	✓	✓	✓
WP 8	Administration Building (US$ 18 million)	Domestic	DB (Two-stage tender)	Fragmented	Offices for power plant staff and laboratory	3	×	×	Δ	Δ	Δ	×
WP 9	Buildings for P&E (US$ 12 million)	Domestic	Develop & Construct	Fragmented	Industrial buildings to house P&E	1	✓	✓	✓	✓	✓	Δ
WP 10	Central Control Room (US$ 3 million)	Domestic	Develop & Construct	Fragmented	Building for power plant control and operation	3	✓	✓	✓	✓	✓	Δ
WP 11	Workshops and Stores (US$ 6 million)	Domestic	DB (Single-stage tender)	Integrated	Buildings for machine tools and stores for spares parts	1	✓	✓	✓	✓	✓	✓
WP 12	Fuel Oil Storage Facilities (US$ 59 million)	Korea	Turnkey	Integrated	Steel storage tanks and pump stations for fuel oil handling	3	✓	✓	✓	✓	✓	✓
WP 13	Boiler Plant and Auxiliaries (US$ 116 million)	Japan	Turnkey	Pure	Mechanical plant to produce high pressure steam	5	✓	✓	✓	Δ	Δ	Δ
WP 14	Turbine Plant and Auxiliaries (US$ 116 million)	Japan	Turnkey	Pure	Mechanical plant to turn the generator for producing electricity	5	✓	✓	✓	Δ	Δ	Δ
WP 15	Electrical Equipment (US$ 24 million)	Germany	Turnkey	Pure	System to supply electricity	4	✓	✓	✓	✓	✓	✓
WP 16	Switch House Equipment (US$ 53 million)	Japan	Turnkey	Pure	Electricity system to export electricity from power plant	5	✓	✓	✓	✓	✓	✓

[a] Complexity Level: 1, very simple; 2, simple; 3, neutral; 4, complex; 5, very complex. Legend for performance: ✓, successful; Δ, satisfactory; ×, unsuccessful/failure.

studies and found that it would be profitable to build a power plant comprising two oil-fired steam units to generate 1200 megawatts of power.

In the new project environment where the electricity industry is privatized, the client's objectives were to maximize profitability and cost savings, and minimize risks. Early project completion and price certainty are also important because of debt financing.

As regards procurement strategies, the client considered the two major methods used in country 'X', design-bid-build (DBB) and DB. DBB was found to be unsuitable because it did not allow for fast tracking. DB was considered a suitable procurement option, as it allows price certainty and early completion. DB also has other advantages such as single point of responsibility [3], minimum changes [4], better relationships among project participants [5] and higher constructability [6]. DB is also able to achieve the client's objective of risk avoidance because it allocates design and construction responsibilities and associated risks to contractors.

3. Packaging of work

After deciding to procure the power plant using DB approach, the client next considered whether to have a single DB contract, or a multi-contract DB system. A single DB contract is advantageous, as there will be one party, with single point of responsibility, who has overall control with regard to the design and construction of the whole project. The single party will co-ordinate all the interfaces with its sub-contractors and will have all liabilities and guarantees accruing to it. The client is aware that it may have to pay a premium to the contractor for taking on the liabilities and co-ordinating the works.

However, the major drawback of a single DB contract is the client's loss of control. The client felt that under a single DB contract, the contractor is more likely to skew design decisions towards minimum capital cost option, or to charge exorbitantly for change orders. The client also realized that, for a large-scale power plant development, diverse expertise and specialized trades are required, and it would be risky to depend only on a single contractor. It would also be difficult for the client to take remedial actions once the contractor encounters problems such as financial difficulties. A single contractor approach also does not allow the client to engage specialized trade contractors who have cutting edge technology. The client also wanted to provide opportunities to domestic contractors to participate in the project wherever possible. No domestic contractor in country 'X' was capable of handling the large project by itself.

Given the disadvantages of single DB contract, a multi-contract DB system was then considered. The whole project was divided into various work packages in such a way to minimize ambiguities and conflicts during implementation. The client considered the following factors when it designed the work packages:

1. Experiences of the client's staff in managing the work packages.
2. Types of support from external consultants and advisors.
3. Availability of contractors with the necessary expertise, in particular, how domestic contractors could be engaged.
4. Risk allocation.
5. Interfaces and co-ordination requirements.
6. Ease of controlling the schedule, budget and quality of each work package.
7. Sequence of the construction works.
8. Involvement of specialized trades.

Based on the above factors, 16 work packages were formulated (Table 1). Each package was treated as a standalone contract as far as possible.

Domestic contractors were engaged for civil and building works as far as possible because they could offer competitive prices, especially where labour intensive activities are involved. Foreign contractors were engaged for specialist work packages which involved the design, installation and commissioning of heavy mechanical and electrical P&E because country 'X' lacked the expertise.

Tenders were preceded by prequalification. Four prequalification evaluation criteria were used: proven track records of the contractors, contractors' previous working relationships with the client, financial strength of the contractors, and contractors' project execution and subcontracting approaches.

To improve the chance of securing the contracts, foreign contractors proposed cost-effective designs and to finance the project during the construction stage. They also offered to help build up local contractors' capabilities by sub-contracting the works to them, and helping them with the design.

As it was important for the client that the budget was not exceeded, the contracts were based on lump sum fixed price, in order to provide price certainty. However, contract sums could be revised to accommodate the client's change orders. Payments to contractors were based on achievement of milestone events.

To ensure the project is completed on time, the solicitation documents, also known as Request for Proposal (RFP), contained the preliminary project schedule which showed the critical milestone events and appropriate liquidated damages clauses. The contractors were required to confirm that they could comply with the schedule.

To ensure that the power plant would be fit for its purpose, the RFP contained detailed client's requirements and preliminary conceptual design. The RFP contained performance based specifications, which described quality or end results desired, instead of prescriptive based specifications which predetermine the materials and methods to be used [7]. Bidders were encouraged to use proven design, technology and construction methods. Contractors were also required to guarantee the performance of the plant, such as efficiencies of equipment. If the equipment failed to perform as guaranteed, the contract provided for liquidated damages to be paid to the client.

4. Roles and responsibilities of project participants

The development process of the project was divided into four stages: conception and feasibility studies; project planning; bidding and contracting; and project implementation (Table 2). For each phase, a specific task team was formed to carry out the required activities.

The contractual relationship of the project participants is illustrated in Fig. 1. The client's organization was divided into several departments, and three entities were directly involved in the development of the new power plant; Management, Project Group and Operation and Maintenance (O&M) Group. The Management was the project sponsor, which provided project funding and made the relevant strategic decisions. The Project Group and the O&M Group provided specific inputs and comments to the designs. The O&M Group also participated in the commissioning of the facilities.

The client appointed Asia Project Management Pte Ltd (not its real name; hereinafter referred to as the APM) to be its project manager. The APM is a domestic engineering consultancy and project management firm which specializes in power plant development. The roles of the APM included performing feasibility studies,

Table 2
Roles and responsibilities in the power plant development

Phases	Activities	Task team
Conception and feasibility studies	1. Define the need for the development 2. Evaluate plant capacity 3. Analyse technology 4. Evaluate site(s) 5. Environment impact assessment 6. Obtain permits and regulatory approvals 7. Prioritise project objectives 8. Analyse project risks 9. Prepare conceptual scopes and estimates 10. Prepare preliminary design options 11. Define project implementation approach 12. Establish project control approach	Project Development Committee comprising: (a) Client — Management Group and Project Group (b) Project Manager
Project planning	1. Plan and develop project requirements 2. Process requirements and prepare design brief 3. Prepare conceptual design and specification 4. Prepare bid documents and RFP 5. Establish pre-qualification evaluation criteria.	(a) Project Development Committee (b) Client's O&M Group provides inputs on specific requirements.
Bidding and Contracting	1. Conduct pre-qualification exercise 2. Shortlist pre-qualified contractors for tender 3. Contractors submit bids and proposals[a] 4. Evaluate bids 5. Negotiate contracts 6. Appoint contractors	Contract Committee comprising (a) Project Development Committee (b) Legal and other advisers
Project implementation	1. Administer contract 2. Contractors develop detailed design[a] 3. Review design and give approvals 4. Approve sub-vendors and sub-contractors 5. Contractors proceed with condstruction and commissioning[a] 6. Control quailty on site 7.Commissioning[a] 8. Training operators[a]	Project Management Team comprising (a) Client's Project Group (b) Project Manager

[a] By contractors.

preparing the client's requirements, basic design and RFP, formulating contract strategy, obtaining and evaluating proposals, and advising the client on the appointment of contractors. The APM also reviewed designs and undertook the co-ordination of the different contractors. It was responsible for monitoring progress, budget and quality of the works. It was also responsible for project planning, co-ordinating and controlling the DB contractors. The APM appointed a foreign specialist consultancy firm as its sub-consultant to provide technical support.

As the client had decided to use DB procurement system, contractors were required to design as well as construct, manufacture and supply the facilities and products. Contractors were also required to engage experts to design and supervise works of a specialized nature.

5. Contract forms

As discussed earlier, the project environment necessitated the used of DB procurement system. The Federation Internationale des Ingenieurs-Conseils (FIDIC) standard conditions of contract for DB form was adopted.

Within the DB procurement system, there are hybrids, which arise because clients undertake some design work before employing contractors [1]. The APM considered two major criteria when deciding which DB form to use: the amount of external input that had to be provided to the work package, and the complexity of the work within each package. Generally speaking, each work package may have one of the following types of client-supplied design; scheme design, outline design, sketch plans, or no drawings. These correspond with the *develop and construct*, *DB-single-stage tender*; *DB-two-stage tender*, and *turnkey* forms, respectively (Table 1). A client-supplied design may be drawings provided by the client's APM, or drawings obtained from contractors working on other work packages, and supplied through the client to the relevant contractor.

In the *develop and construct* approach [1,3], clients, with the help of their own architects and engineers, undertake design up to the schematic design stage, leaving the detailed design only to the DB contractors. They are responsible for ensuring structural sufficiency,

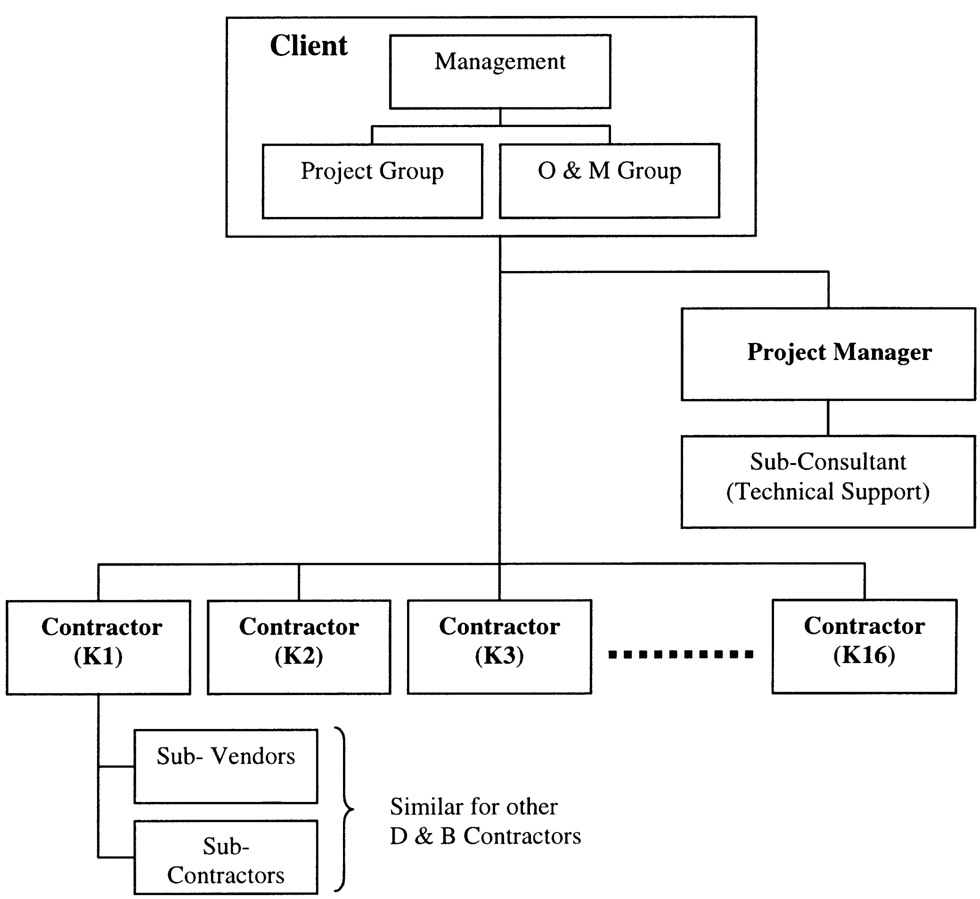

Fig. 1. Contractual relationships of the project participants.

method of construction and other special requirements. Develop and construct was used for civil engineering and foundation work packages (WP 2, 3, 4), as well as buildings to house P&E (WP 6, 9, 10). Contractors were provided with schematic design instead of being given a free hand to propose their own design because these work packages had substantial design provided by other contractors.

In *DB-single-stage tender* [1], contractors were provided with client-supplied outline design. This form was used for workshops and stores work package (WP 11) because design and construction of such facilities were quite standard.

The Administration Building contract (WP 8) was based on *DB-two-stage tender* [1]. The client wanted a prestigious building to house laboratories and offices for various departments such as operations, maintenance and engineering services. The RFP contained sketch plans showing the building layout. In the first stage of bidding, contractors were required to submit their design proposals for evaluation. After clarification and confirmation of the building materials to be used, three contractors were short-listed to proceed to the second-stage of design. The design was developed further, and bid prices were submitted. These were re-evaluated, and finally, a domestic contractor was appointed.

In the *turnkey* approach, clients do not provide any designs at all. Instead, they employ contractors to undertake complete design, construction, fit-out, installation of P&E, and commissioning, from inception to completion of the project [1]. This arrangement may also include site acquisition, arranging for financing, leasing, and training of personnel and being paid only on completion [3]. Turnkey was adopted for specialist work, and those that required minimum interfaces with other contractors (WP 1, 5, 7, 12–16). Performance and functional requirements were provided in the RFP. The contractors were required to design, procure, install, and commission the P&E to meet the required performance levels. They also provided training to the client's O&M staff.

6. Organizational forms

DB contractors may arrange their organizations into three main forms; *pure*, *integrated*, or *fragmented* DB organizations [2] (Fig. 2). In this project, the different contractors used all the three forms (Table 1).

In *pure DB*, the contractor strives for a holistic, complete and self-contained system. All design and construction expertize resides within one organisation and

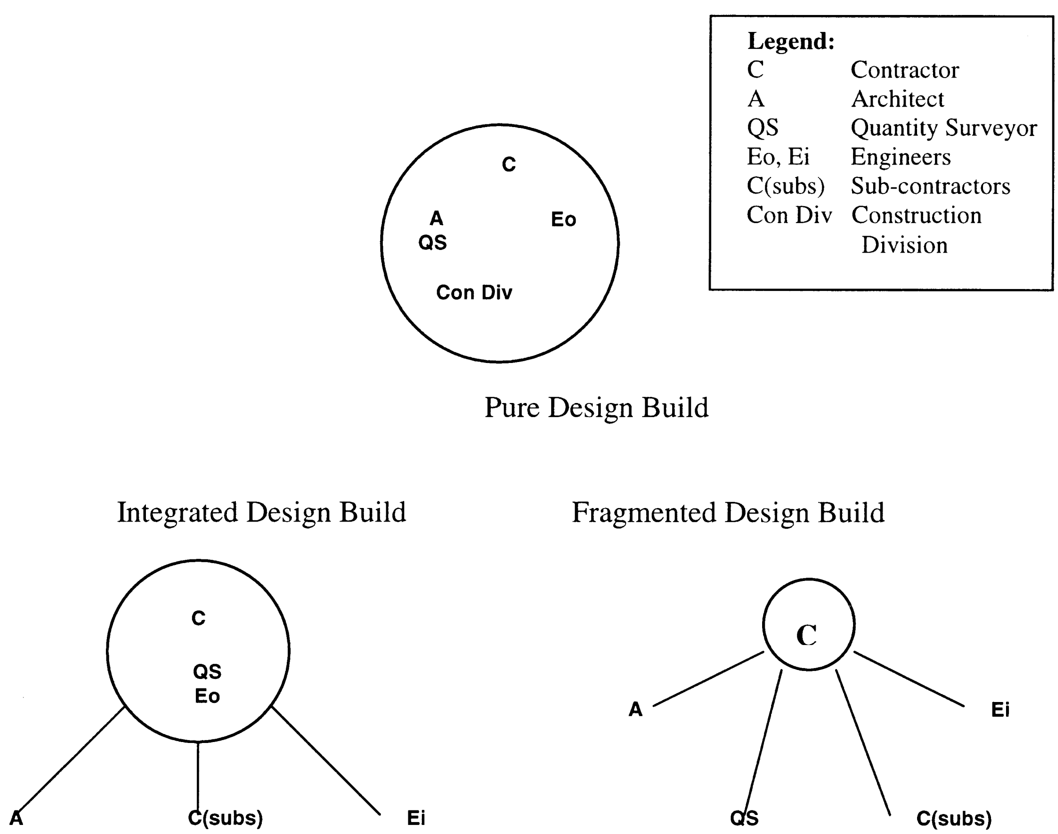

Fig. 2. Methods for contractors to organise their DB projects. Adapted from Rowlinson (1987) [2].

this is sufficient to complete any task that arises. Pure DB was used in WP 1, 13–16.

The *integrated DB* contractor takes a less holistic approach to the design and contraction team and is prepared to buy design expertise whenever necessary. The design and construction teams may well be separate organizations within an integrated group co-ordinated by the DB contractor. Integrated DB was used in WP 3–7, 11, 12. The contractors' in-house designers prepared engineering designs. These contractors completed most of the work under direct labour with the equipment that they purchased for the job. Sub-contractors may be engaged for labour intensive works.

In the *fragmented* approach, the DB contractor's task is to appoint consultants to develop designs. The DB contractor needs to integrate the work of the external consultants and to co-ordinate the works of many sub-contractors. Fragmented approach was used in WP 2, 8–10. These contractors employed a team of core project staff for co-ordination and supervision.

7. Planning and control system

To ensure smooth execution of the works, contractors' operational procedures and co-ordination with the APM were formalized. The APM acted as the co-ordination and communication centre which was the main point of contact for information flow (Fig. 3). Officially, each contractor communicated with the others through the APM. Because of the multi-contract system and the use of DB, many of the work packages required information from other work packages. Therefore, all contractors had to furnish a list of information that they required from others, and the time that such information was required. The APM then forwarded such requirements to the other relevant contractors.

In terms of control, the APM had to approve DB contractors' schematic drawings during the design stage. Detailed working drawings for construction were submitted to the APM for information only.

DB contractors also had to seek the APM's approval before they could appoint sub-contractors and sub-vendors to supply critical materials such as turbines, steam generators and high voltage switchgears. The APM also retained the function of approving the use of these critical materials.

For non-critical materials and equipment such as steel sections, piping materials, pumps and fans for general purposes, the APM's approval was not required, but contractors had to ensure that these comply with international codes and standards. Certificates of conformity had to be submitted.

The APM, DB contractors and the client's Project Group conducted joint inspection so as to minimize unnecessary co-ordination and delays. Similarly, an integrated commissioning team, led by the contractors' commissioning personnel with the client's O&M staff, was formed to ensure the facilities were properly commissioned, and the client's staff were trained.

8. Success and failure of the work packages

The performance of the projects under the multi-contract DB system were evaluated based on six criteria [8]; staying on budget, staying on schedule, meeting specifications, conforming to the client's expectations, achieving acceptable quality of work, and minimizing construction aggravation.

Data on the success and failure of the work packages were collected by interviewing the 15 project participants described in Section 1. Interviewees were asked to rate whether a work package was successful, satisfactory, a failure, against each of the six success criteria. The final rating of each work package's performance was based on the majority's opinion (Table 1).

Six of the 16 work packages (WP 6, 7, 11, 12, 15, 16) were successful in all the six criteria. WP 6 and 11 were the only two successful work packages undertaken by domestic contractors. Due to their limited DB capability, they correctly chose the integrated organization for their non-complex projects. The other three successful work packages were undertaken by foreign contractors based on the turnkey approach. The APM correctly selected this procurement method, which is suitable for these complex projects which required a high level of skills in undertaking the specialized design and installation works. One of the reasons why WP 6, 7, 15 and 16 were successful was because they required minimum co-ordination and interfacing with other contractors.

Fuel Oil Loading Jetty Contract (WP 5) failed to meet several performance criteria. This contract involved offshore marine and piling works. The client wanted the technical risk associated with the seabed condition to be borne by the contractor. The RFP therefore required bidders to conduct their own site investigations, notwithstanding the inclusion of a preliminary soil report of the seabed conditions (obtained from WP 1) in the bid documents. The successful contractor's bid was based on the RFP's soil report. During construction, the contractor claimed that the actual seabed condition was significantly worse than that shown in the RFP's soil report. This led to major changes in the design of the piling system, leading to a 20% cost over-run, and about 1 month of schedule over-run. Construction aggravation was tremendous, with suits and counter-suits threatened. It is interesting to note that the interviewees have rated the quality of works of the Site Investigation contract (WP 1) as satisfactory, given the dispute about the seabed conditions described above.

This may be because WP 1 contractor was only required to conduct *random* soil tests of the seabed, and WP 5's RFP had specifically required bidders to conduct their own investigations.

The Administration Building Contract (WP 8) was another work package which failed to meet several performance criteria. This contract involved the construction of offices and laboratories. It was based on the two-stage DB arrangement, and the contractor adopted a fragmented organization. The performance of this contract was the most unsatisfactory among all the other work packages. The work package failed to stay on budget and schedule. Cost over-run was more than 20%, and schedule over-run was more than 1 month. It performed only fairly satisfactorily in meeting specifications, conforming to the client's expectations and achieving the expected quality level. There was unmitigated construction aggravation.

The contractor claimed that unsatisfactory performance arose because of extensive change orders by the

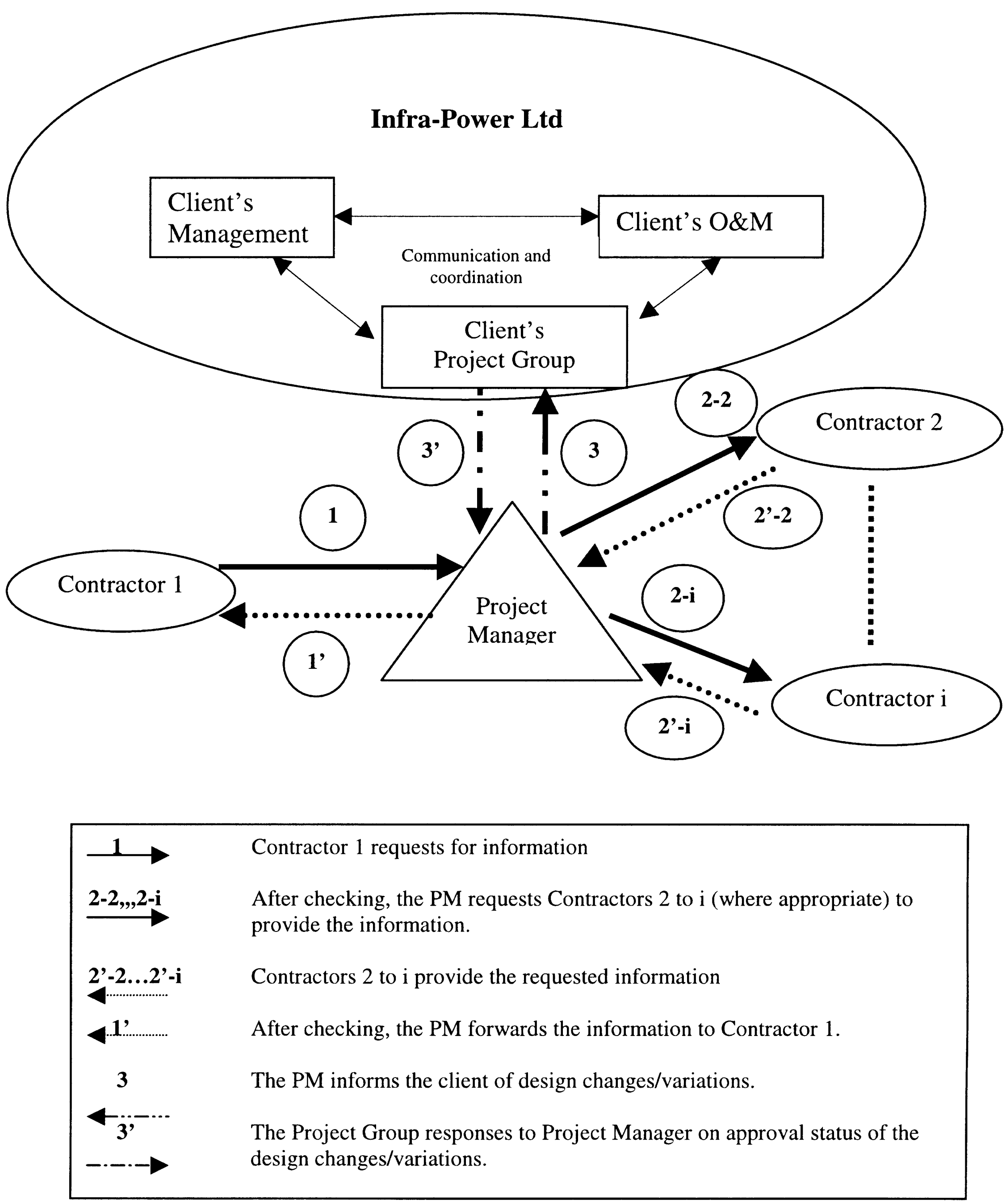

Fig. 3. Planning and control of the power plant project.

client, while the APM claimed that extensive sub-contracting by the contractor affected project performance. The quality of the works was unsatisfactory, and the client claimed that some aspects of the design and materials did not meet the specifications. The finished product did not conform to the client's expectation.

The performance of the other work packages was generally satisfactory. Six of these were undertaken by domestic contractors, who used integrated or fragmented organizational forms. Five of these were based on develop and construct, and were not complex projects. All these work packages were completed within budget and on schedule. However, many work packages undertaken by domestic contractors (WP 2, 3, 4, 9 and 10) did not minimize construction aggravations and the APM had to spend much time and effort in monitoring these contractors.

9. Problems encountered and lessons learned

Several problems were encountered in this project. The reasons why these problems arose are now discussed. The lessons learned, and how they might be applied in practice for application to future projects, are also suggested. The focal point for discussion adopted is the use of multi-contract DB system.

9.1. Problem 1: work could not progress smoothly

The first problem which arose was that work in some contracts could not progress smoothly. This is because of the use of multi-contract system. In the Site Preparation Contract (WP 2), for example, the scope included site levelling works that were required at the very early stage of the project. It also included roadwork which was only performed at a very late stage of the project. There was no continuity in the contractor's work and the client paid for this through higher contractor's overheads.

The multi-contract system also made it necessary for contractors to rely on other contractors for information, as the whole project had been divided into smaller packages. Sometimes, change orders in other contracts also caused changes in WP 2. As a result, the contractor claimed that it incurred much abortive work.

To avoid the problems described above, the client could have engaged a single contractor, instead of multiple contractors. The *lesson learned* is that clients need to balance between breaking up a project into sub-projects so as to allow some local participation, and engaging a single contractor, to reap the benefits of single point of responsibility. A private client, who has minimal responsibility to develop the local construction industry, should adopt a single contract, instead of a multi-contract system.

Multi-contract system has several drawbacks. The main drawback is that with several contractors, the client has to be responsible for co-ordinating the interfaces between the contractors. The communication and information channel is complicated. The contractors may be entitled to extension of time if information from other contractors are not provided through the client in a timely manner. As the project is divided into several work packages, the complete scope of works may not be fully covered.

9.2. Problem 2: inaccuracy of project information

The second problem which arose was the alleged inaccuracy of project information contained in the RFPs. In WP 5, for example, the contractor claimed that the soil report provided by WP 1 contractor through the client was inaccurate (Section 8). Even though it was stated in the RFP that contractors should conduct their own soil investigations, the contractor argued that it was justifiable to rely on the soil report shown in the RFP. The contractor felt that it should be entitled to additional payment, when the actual seabed condition differed from that stated in the contract. To avoid protracted arbitration, a commercial settlement was finally reached.

This problem arose because in a multi-contract project, information produced by one contractor was being used by other contractors. If the information is inaccurate, contractors who relied on the inaccurate information would claim from the client, due to privity of contract. The *lesson learned* is that the problem would not have surfaced if a single contract was used.

Another reason the problem arose is that bidders would inevitably rely on information shown in the RFP, regardless of their contractual status. The *lesson learned* is that if the client does not want bidders to rely on certain information that it possesses, it should not supply this information in the first place. When the client possesses information which it thinks may be useful to bidders, it should allow the information to form part of the contract. This does not necessarily put the client at a disadvantage, as prudent risk allocation may, in the long run, lower contract prices.

9.3. Problem 3: excessive change orders

The third problem encountered was associated with excessive change orders. In WP 8, the RFP contained sketch plans prepared by the APM, after consultation with the client's Project Group. However, after the contract was awarded, the client's O&M Group requested substantial changes because it felt that its requirements were not fully considered. The contractor felt that the large number of change orders made it unclear who was responsible for design in this DB contract. It claimed loss and expense, and extension of time for the changes.

One of the reasons the problem arose is because of the use of DB arrangement. The *lesson learned* is that in deciding on the procurement form, it is important to consider the degree of client's involvement in the design. In DB projects, clients should merely define their requirements clearly, and allow the contractor to execute the design and construction without unnecessary interference. If clients want to be deeply involved, *develop and construct*, or traditional DBB would be more suitable procurement forms.

Another reason the problem arose is because the client is made up of too many entities. In this project, the client was represented by three entities (Fig. 1). Thus, the contractors claimed that they sometimes received conflicting instructions from the different client entities. The client's Management should have resolved the conflicts between the Project Group and the O&M Group swiftly and decisively, so that contractors could proceed with their work instead of waiting for the client entities to sort out their differences. The *lesson learned* is that a client who is made up of several entities should appoint a client's representative who is vested with power and authority to make final decisions and sign-off drawings.

Another improvement to this project is that user requirements should be determined and finalized at the pre-bid stage, to avoid excessive change orders that have adverse schedule and cost implications. To enable this to happen, clients should allocate sufficient time for the pre-bid stage and hold extensive consultations with parties that are affected by the output of the project.

9.4. Problem 4: ineffective communication

The fourth problem which arose was the ineffective communication among project participants. In WP 8 for example, the client's O&M Group did not channel its requests to its Project Group first, but instead liaised directly with the APM or the contractor. Subsequently, the APM was unduly burdened, as it was deeply involved in mediating among the various parties.

This problem arose because of the multi-contract project, which gave rise to a large number of project participants. This made formal communication sluggish and inefficient. The *lesson learned* is that a single contract would certainly reduce the number of project participants. Another *lesson learned* is that project participants should make the commitment to comply with the agreed format for information flow and interaction (Fig. 3). If informal communication is deemed desirable, the outcome of these discussions should be fed back to the project manager, for its consent, so as to avoid disputes later.

If a multi-contract system cannot be avoided, co-ordination meetings to discuss interfacing works, identify information needs and changes to the contracts should be conducted frequently. The interfaces between the different contractors need to be clearly identified, to enable responsibility for 'boundary' work to be clearly allocated. If a contractor needs information from other contractors, it should identify such information upfront, and communicate it to the relevant parties and the project manager. It should also state the latest date the information should be provided. When a contractor revises its design, it must inform all relevant parties so that those who are affected by the revision can make the necessary changes to their own work.

9.5. Problem 5: misalignment of client's expectations

The fifth problem encountered was the misalignment of client's expectations with respect to the contractual requirements. Both WP 13 and 14 contracts were undertaken by Japanese contractors, who had worked for the client in previous DBB projects. The client alleged that these two contractors did not provide superior design, materials and workmanship quality that they had provided in previous projects.

There are three possible reasons for this. The first is due to the use of functional and performance specifications in these DB work packages, while the previous DBB projects were based on prescriptive specifications. The client claimed that contractors sought to meet the minimum specified, and did not provide superior service and product which it had come to expect.

The second reason may be the use of competitive bidding, which gave rise to very low bid prices. The contractors conducted value engineering and adopted cost-saving approaches, in order to meet *minimum* requirements.

The third reason may be due to the shortening of the contract period. This, and the shortage of skilled construction manpower, may have caused the quality of works to be compromised, in order to achieve early completion.

The *lesson learned* is that for DB contracts, in the absence of detailed drawings, clients should specify their requirements comprehensively in the bid documents. They should expect to get only what is specified, and not more than that. This is because DB contractors would inevitably provide the minimum requirement for the facility to meet its intended purpose. Thus, clients should use the 'fitness for purpose' yardstick to assess quality, instead of hoping that contractors would provide facilities which are over and above the minimum requirements.

10. Conclusion

The case study demonstrates the project management issues involved in procuring a large and complex power plant. The practicality and usefulness of this case study are the demonstration of how the large and complex project can be successfully implemented using a multi-contract DB system. The case study shows that domestic contractors, with limited DB capability, can also be involved by adopting the *develop and construct* form.

To ensure project success, DB contractors would need to choose a suitable organization form to discharge their design and construction responsibilities. For unsophisticated domestic contractors, an integrated approach may give a better chance of project success.

Other criteria for project success include the need to be disciplined when communicating with each other by following the agreed planning and control system. This case study also shows that clients have a large role to play to ensure project success. Clients who have decided to use the DB procurement system should not be too involved in the detail design, and be prepared to trade-off certain project objectives to achieve the more critical objectives. In addition, they should get their act together, and refrain from ordering excessive changes or delay the projects while they bicker among themselves.

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