FLOWCHARTED MODEL FOR INFORMATION FLOW IN DESIGN AND BUILD PROJECTS

Kassim Gidado

The School of the Environment, Faculty of Science and Engineering, Cockcroft Building, Lewes Road, University of Brighton. Brighton. BN2 4GJ. U.K.

Information is the most important resource in project delivery, and the management of its flow in construction is a critical project success factor. With a variety of procurement systems in the construction industry, the nature of information flow between project teams varies due to the differences in organisational and contractual structures. The problem facing the industry is not the lack of information, but the lack of standardised systems, strategies and formats for flow between the numerous teams. Information is often not accessible at the right time or in the right form to parties so that the construction of the project can achieve its time, cost, and quality objectives. This research therefore, aims at developing a flowcharted model that can be used by practitioners to effectively manage information flow in projects executed using the design and build procurement system. It is expected that the use of the model in practice would bring about consistency in approach that improves communication between the major parties directly involved in the process.
The paper is based upon literature search and questionnaires to practitioners. The questionnaires were sent to a selection of 50 top construction contractors and project management consultants in the United Kingdom with the aim of studying the "state of the art" in information management in design and build projects."

Keywords: design and build, information flow, procurement system.

INTRODUCTION

The aim of this paper is to investigate the factors affecting information flow in design and build projects and to develop a flowcharted model that can be used in practice to effectively manage the flow of information.

The paper starts with a brief description of D&B projects. Questionnaire survey has been used to identify the constraints or barriers that affect the flow of effective design information in practice. An indicative flowcharted-model that can be used in practice has been developed. The developed flowcharted model aims at providing a system upon which information flow can be effectively managed in practice. The adoption of the developed model will produce consistency, transparency and reliability of approach. The model is a robust framework that is capable of enhancing innovative developments in the integration of design and construction for D&B projects.

It is important to note that the developed model did not consider the social and behavioural characteristics of good information flow. It mainly concentrates on the technical aspects of data capture and processing. It also did not consider the involvement of suppliers but assumed that they are part of the construction team.

Gidado, K (2000) Flowcharted model for information flow in design and build projects. *In:* Akintoye, A (Ed.), *16th Annual ARCOM Conference*, 6-8 September 2000, Glasgow Caledonian University. Association of Researchers in Construction Management, Vol. 2, 781-92.

THE DESIGN AND BUILD SYSTEM

In the recent past, the mainstream of building construction had followed the traditional method of procurement using the standard form of building contract. This approach entails the client engaging separate organisations for three key services: design, cost advice, and construction. However, many clients have become dissatisfied with the traditional method's operational characteristics. The problem is exacerbated by today's extremely competitive construction market that requires building contractors to respond to client needs quickly, effectively and give real value for money. The dissatisfaction and the requirement of the industry's quick response to client's criticisms have induced changes in attitude, leading to wider range of organisational forms and a greater flexibility in the services offered to meet the client's objectives. This resulted in the proliferation of alternative procurement methods such as management contracting, construction management, design and manage, and design & build.

Indication by Bennett et al (1996) has shown that the design and build approach has been the most popular of these alternative procedures in the UK. There is also evident in the increase in volume of design and build contracts in the US (Songer et al 1996). In addition to this changing scenario, the UK construction organisations have become increasingly aware of the need for strategic management for competitive advantage.

The Design-Build Institute of America (1994) suggests that design and build is not a new concept, it originates from the ancient Master Builder concept where the responsibility of design and construction lies with one person. The design and build as we know it today, started after the second world war but failed to make a real impression until the late 1950's when a number of building contractors began to offer a package deal. Janssens (1991) outlines that a spirally rise of the use of this alternative form of procurement started in the early to mid-1980's. During this period, only a few architects were willing to accept the concept of working for or under the direction of a contractor. This made the contractors' personnel to carry out the design work, and the quality of design inevitably suffered. However, the concept did not completely loose favour because its characteristic of lump sum and single-point-responsibility contracting was still attractive to clients.

Changes in character of the UK construction industry occurred in the early 1980's due to recession. It brought about a new commercialism being forced upon all industries which demands value-for-money and guarantees on time and cost. This coincided to the publication of the UK Joint Contracts Tribunal (JCT) 'With Contractors Design' (WCD) Form of Contract. The JCT-WCD form of contract provided a framework for securing competitive tenders from contractors and introduced the concept that client's may engage consultants to carry out the majority of design work before the contractor is brought in to complete the design. With this form of arrangement, consultants then became willing to work for contractors, in-house or externally, resolving the design problem and increasing the advantages of design and build.

One of the most significant features of design and build arrangement is the lack of an independent certification role in the contract. There is no independent architect or contract administrator to settle differences between the parties and there is also no independent quantity surveyor responsible for preparing the basis upon which contractors tender. Also, there is no standard method of measurement, no bill of quantities, and no contractual role for the quantity surveyor. The contractor may choose to employ a quantity surveyor as part of his team. The client too may choose to

employ architects, quantity surveyors and engineers as advisors. (Murdoch and Hughes, 1996)

Pain and Bennett (1988) indicated the key features of design and build as: the "employer's requirements" (which may provide as little as a description of accommodation requirements or as large as a full design prepared by the employer's consultants), and the "contractor's proposals" (which respond to the employer's requirements). These are in a form of a set of drawings or specifications and/or any other documents that describe the design. The contractor also provides a contract sum analysis that is used to assist in the valuation of any agreed future changes.

The design and build procurement route is referred to by various names within the industry, including design & build, design-build, turnkey, package deals and numerous others, each having minor variations depending upon the contract agreement. Pain and Bennett (1988) have identified four principal ways of organising design and build using the JCT-WCD as follows:

The client appoints a design team of an architect and other consultants. The design team then works out what the client needs and then develops this information as far as is appropriate in the circumstances.

The client places himself entirely in the hands of the contractor and has his own advisors, other than a quantity surveyor.

The client employs an architect and design team to work out a solution. A contractor is then brought in as the design is worked up until it is priced and the sum agreed. After the contract is signed, the design team is employed by the contractor to complete the design and construct the building. Also the contractor takes over the complete responsibility for the completion of the contract.

The client agrees to buy a building to a standard design.

In this paper, design and build is a procurement method where one contracting organisation is contractually responsible, normally on a lump sum fixed price basis, for both the design and construction of a client's project. This suggests once the contractor is appointed, he/she is responsible for the whole of the design and construction of the building. The contract involves direct negotiation between the client and contractor. The design is fully developed when both parties have reached an agreement regarding specification and price.

It may be summarised that the design and build system commences when the client identifies the need for a building. The client then states the project requirements, referred to under the contract as the 'Employers Requirements'. In preparing the employer's requirements the client may receive help from his appointed professional advisors. The employer's requirements are issued to prospective contractors who prepare a planned and costed design proposal known as the 'Contractors Proposals'. Each proposal submitted is evaluated by the client and a contractor is selected. The contractor then prepares fully detailed design, co-ordinates and manages all aspects of the site works through to the final completion of the project.

In most design and build projects the contractor appoints a project co-ordinator (D&B co-ordinator) who plays an important role in co-ordinating the various activities at each stage of the project and in establishing effective lines of communication between the professionals involved. There will be the design team that is directly responsible to the contractor with a functional line of responsibility to the construction team. The

project budgeting and cost control may be provided by a quantity surveyor that reports directly to the D&B co-ordinator and acts in a functional capacity to the client's professional advisor. The construction team takes the form of a site manager who reports directly to the D&B co-ordinator and has a functional relationship with the design team.

CONSTRAINTS TO D&B INFORMATION FLOW

A great deal of research has been carried out into the problems related to information flow within the construction process. As early as 1966 research by Higgin and Jessop (1966), of the Tavistock Institute, indicated that there was a problem with the communication process, causing abortive design and construction. In the intervening years since the Tavistock study, the professions and the industry have had to change. This led the Building Research Establishment (BRE) carrying out a study which involved an investigation of 38 building sites aimed at determining the causes of variations and the poor level of quality being achieved. The conclusion of the study was lack of care in workmanship and unclear or missing project information. Both the Tavistock and the BRE studies suggested that improvements can be made by using systematic methods that are aimed at improving the transmission of information between the design and construction teams.

Ndekugri and McCaffer (1988) identified that the construction industry had recognised the need for more effective exchange of information between project participants. The integration of project information could optimise the operations of the industry however these are still not being utilised on numerous projects. Austin et al (1994) stated that to ensure the smooth and harmonious achievement of construction realisation it is essential to have a properly managed and systematic approach to the design process, which involves the production of design information and its flow.

In the early stages of a project, the flow of information is often minimal and simple, but as the project progresses so does the flow of information to and from the client, architect, other designers, contractors and suppliers therefore increasing the complexity of the flow of information. Jaafari and Manivong (1998) gave an analogy that the flow of information in a successful project resembles traffic in a metropolitan city, heavy with noisy movement of all types of conveyances.

For the research to achieve its aim, it is paramount that the constraints or barriers affecting the complex flow of information in D&B projects are identified. Therefore, the use of questionnaires has been employed to collect views and opinions of practitioners on the current 'state of the art' in the building industry.

A six-page tick-box questionnaire was mailed to 50 selected individuals working with a selection of UK leading construction contractors and project management consultants. Although the primary purpose of the was to identify the constraints of information flow in D&B, other subsidiary issues have been explored. Every question provided an opportunity for the respondent to add to the list of issues and make comments. A 54% response rate was achieved, out of which 22 were good and reliable responses. The positions and work experiences of the respondents may infer that the respondents have adequate knowledge of the theme of this research to support confidence in the data received.

The results of the questionnaire confirmed that the traditional and design and build are the most commonly used procurement systems. All respondents indicated that most of

their current projects are D&B projects. There is also an indication that most of the construction companies are currently involved in a strategic or project specific partnering with most arrangements in the vertical integration of design and build.

The results indicated that practitioners consider the ease of information flow in design and build projects as being adequate. It is rated higher than in any other procurement system.

The results also indicated that there is a wide variety of procedures used for information flow management. Information Technology Document Control Systems are commonly used in medium to large projects for document handling and control. Although all the practitioners seem to highly rate the information system they currently use for information management, a great number of them are using unsuitable IT tools for information flow and control. But, all agreed that there is a need for a significant improvement.

The results of the questionnaires also identified the current practical constraints or problems faced by practitioners when managing flow of information in design and build projects. These are:

Lack of clear procedure for information flow.

Lack of clearly defined and agreed strategy for format and content of information.

Too much information is often generated at the same time. Due to badly structured information exchange events.

Lack of clear channel of communication

Time delay in communicating. This is due to some subcontractors have no knowledge or experience in the use of I.T.

Incomplete information due to lack of clear definition of deliverables.

Communication breakdown. Due to variety of definitions of terms used in the industry.

Poor quality of information due to lack of clearly defined standards.

Lack of control of individual interests/objectives.

Status of design documents is often not controlled.

Relevance of information to different parties.

Overlapping roles and responsibilities not clearly defined, especially between consultants and subcontractors.

Unclear delegations of responsibilities within teams.

Poor working relationships in a team or between teams.

Inadequate design team due to lack of using standard selection and appointing methods.

Inadequate subcontractors due to lack of using standard selection and appointing methods.

Inadequate I.T. and communication system

Inadequate training of personnel, especially in the use of I.T.

Rushed design work due to unrealistic deadlines

Poorly managed meetings and meeting preparation

Lack of agreed project structure/hierarchy

Contractual issues/disputes

Lack of design programming

Time wasted by external professionals in checking information

Poor client interface with designers.

Client changes and delay of client approvals.

Cost constraints resulting from the attempt to submit lowest bid.

High work load on most parties due to bad planning.

Although most constraints identified above may be originating from lack of planning, it is important that none is overlooked if an effective model is to be developed.

THE DEVELOPEMNT OF INFORMATION FLOW MODEL

For the flowcharted model to be developed, it is necessary to highlight some key issues that have been identified by a number of researchers regarding information and information flow systems. These issues are then used, together with the identified constraints obtained from practice, as a base upon which the model is developed.

Abudayyeh (1991) stated that the first stage of the design procedure or defining facts starts with examining the inputs to the information system. Each collection of data is independent of each other and has to be maintained separately. This suggests that the D&B co-ordinator must integrate the information coming from various sources in order to increase the efficiency of obtaining meaningful information and making prompt and fully informed decisions.

Information is generally processed through a project control system that the co-ordinator should employ. Gidado and Barter (1996) state that effective information flow is seldom achieved unless the application of a project control system tackles three main problems faced in managing projects. These are the volume and complexity of project information and information flow; the diversity and number of participants; and the intrinsic complexity of modern building projects. One other problem is the cost implication of setting up a good project information system. Many clients are very reluctant to spend money on such systems especially on small to medium size projects. An integrated project information system should be able to provide an aid to the management of safety, quality and the environment. This suggests that any reasonable spending on an integrated project information management system should be wise and essential. Another problem is the lack of consistency in approach used which result in always re-inventing the wheel from project to project. There is a need for a standardised system to be developed for the whole of the industry.

Lucey (1997) has argued that good information is that which is:

Relevant for its purpose

Sufficiently accurate for its purpose

Complete enough for the problem

From a source in which the user has confidence

Communicated to the right person

Communicated in time for its purpose

That which contains the right level of detail

Communicated by an appropriate channel of communication

That which is understandable by the user

This identifies that many details need to be present before the information can be considered as ‘useful’. It is also noted that some of the factors relate to social and behavioural characteristics that are beyond the scope of this research.

Jaafari and Manivong (1998) state that with multi-point information entry and ‘free-for-all’ communication approach on projects there is a potential for chaos in information management and creeping in of errors, as well as conflicts among project team members. There are also many points in time and space on projects where faulty lines of communication can occur. Therefore, there is a need to have a disciplined approach to the management of information on projects. The information that is required in construction projects consists of the design information; product information; process information; and management information. These information types comprise the core of communication content among the various professionals involved in a given project. To achieve the required degree of proactive management of the whole project activities, the D&B co-ordinator must adopt a ‘control centre’ strategy for the management of core information transactions. This means the D&B co-ordinator must have all the core information collected, validated, stored and brought under a centralised control with appropriate degree of discipline, authority and security.

From the above literature review, there seem to be an indication that any model of information flow must:

consist of systematic methods for transmission of information;

have an integrated approach;

be capable of managing the complexity of flow;

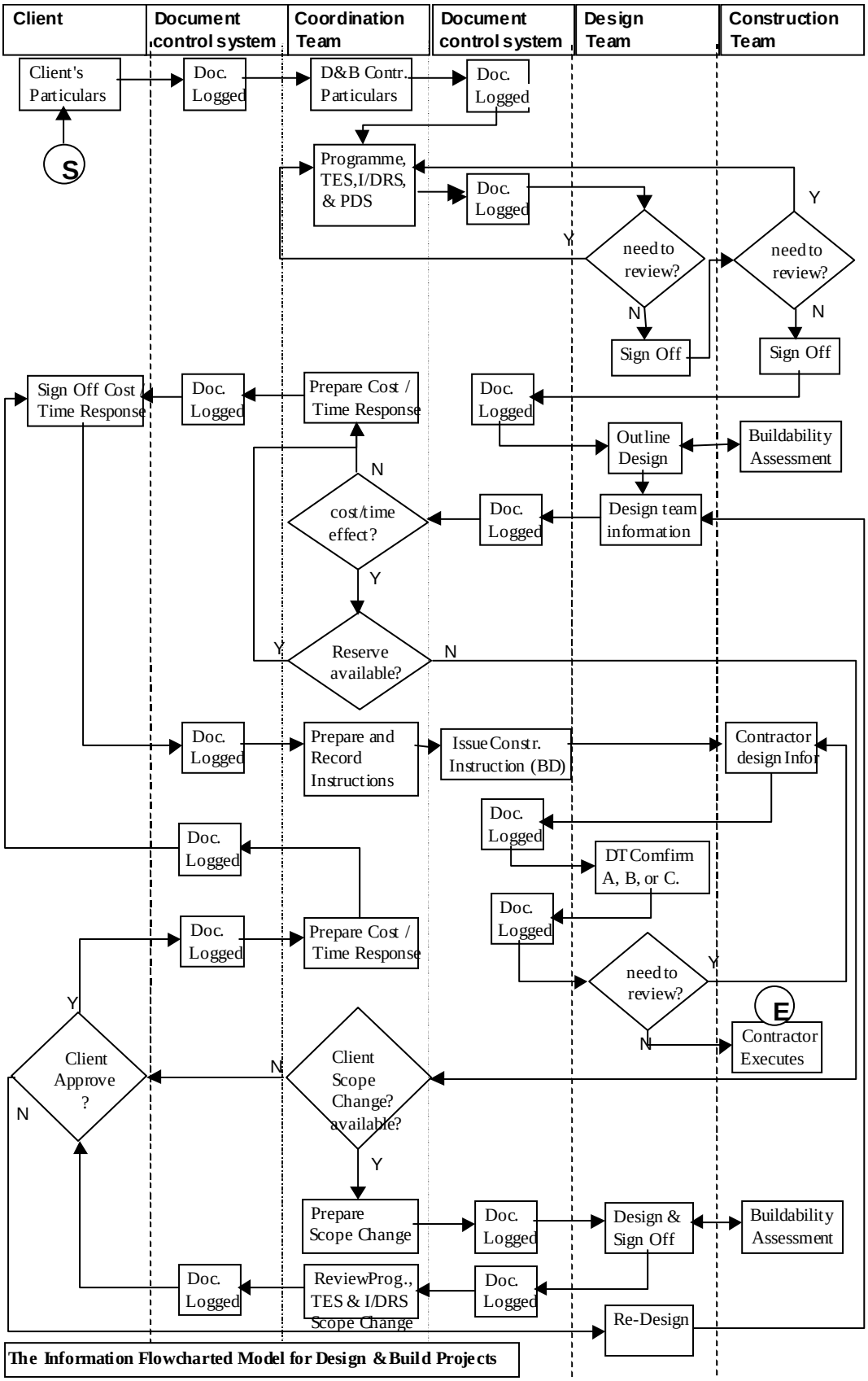
use information that is good, complete and useful;

have a disciplined approach with a central control system.

The core information on a project are those that determine the physical nature of the end facility, its functions, elements, its delivery timing and associated capital and operating cost limits, as well as information related to the management of the external affairs (stakeholders, media, the statutory bodies and so on). In design and build projects, the content of the core information should be controlled through the "Client's Particulars" and the "Contractor's Particulars".

The proposed developed flowcharted model is illustrated in Figure 1 showing four different columns representing team responsibility with two others representing document control systems.

Figure 1:


Client
Document control system
Coordination Team
Document control system
Design Team
Construction Team
Client's Particulars
Doc. Logged
D&B Contr. Particulars
Doc. Logged
S
Programme, TES,I/DRS, & PDS
Doc. Logged
need to review?
need to review?
Y
N
Sign Off
Sign Off
Sign Off Cost / Time Response
Doc. Logged
Prepare Cost / Time Response
Doc. Logged
Outline Design
Buildability Assessment
cost/time effect?
Doc. Logged
Design team information
Reserve available?
Doc. Logged
Prepare and Record Instructions
Issue Constr. Instruction (BD)
Contractor design Infor
Doc. Logged
DT Comfirm A, B, or C.
Doc. Logged
Doc. Logged
Prepare Cost / Time Response
need to review?
E
Contractor Executes
Client Approve ?
Client Scope Change? available?
Prepare Scope Change
Doc. Logged
Design & Sign Off
Buildability Assessment
Doc. Logged
ReviewProg., TES & I/DRS Scope Change
Doc. Logged
Re-Design
The Information Flowcharted Model for Design & Build Projects

The processes included in the flowcharted model in Figure 1 starts from the "Client's particulars" and terminates at the "Contractor executes" process boxes. The client's particulars should comprise of the project's objectives; project details; functional information and project brief; single point and hierarchy responsibility; funding approvals and flow; planning permissions; allowable periods for schemes; and method of interface with designers and other specialists. The D&B contractor's particulars is expected to comprise of:- details of organisational structure; details of project teams and participants; channels of communication; strategy and format for information, I.T. network system; programming system; document control system; cost control system; scope and change control system; procurement strategy; quality management system; safety management system; value management system; risk management system; and reporting systems.

The design programme should be broken down into packages having each package scope clearly defined. The design programme must be agreed in detail with the designers and should reflect client approval dates/information required dates and sign off periods. It should also incorporate information required schedules, reflect value engineering studies and exercise periods for decisions, and incorporate information transfer schedules. It is also important that, during the 'outline design' and the 'design team information' processes, the designers consults with the D&B co-ordinator and the client to define for each package the services required. Each package should have a lead designer who will co-ordinate the design process of all elements in the package. Clear roles and responsibilities of all designers and specialists must be clearly defined. This will promote ownership of the internal information interchange process and provide one point of contact with the rest of the project and establish screen points to reduce occurrence of incomplete package scope.

The Tender Event Schedule (TES) must include activities such as:- initial bid information release dates; final bid information release dates; bid package compilation and approval periods; bid dispatch dates; mid-bid review periods; bid return dates; bid tabulation, evaluation and award recommendation periods; contract award dates; and mobilisation and lead in periods. The TES key dates for release of information must be agreed between the design team and the D&B co-ordinator to allow effective preparation and issue of bid documentation (BD). The BD is to be the vehicle of transformation of information from the design team to the trade contractors through the D&B co-ordinator, as a result, it must contain good information and set out in the correct format. The information contained in the BD must include among other things the project programme; trade contract bid programme; scope of works; outline method statements; drawing schedules; specifications; trade contractors technical proposals; and the environment and system boundaries of the project. It must be emphasised that during the bidding process, the D&B co-ordinator must define accurately and agree between the designers and trade contractors the information interchange process in terms of drawings and specifications to be issued.

The design deliverables and information required from the designers and trade packages for each element to achieve the strategic objectives of the project must be established. It will also display, among other things, the key design interface activities at an early stage of the project. The information collated can be communicated by using an information/deliverables required schedule (I/DRS). The I/DRS should list and reveal the detail information and deliverables required with actions required against the design team. This in turn enables the designers to clearly identify their

schedule of deliverables and drawings expected and the proposed content of drawings to be produced by the trade contractors. When defining this list, the scope of works and scope of services of designers for each package must be considered. The combination and agreement of these two exercises should result in a complete scope of deliverables for the project to be established so that the D&B co-ordinator could develop a relational database for package deliverables schedule (PDS) for each work package in the project. The PDS must contain information required from both designers and trade contractors and be able to report actual receipt dates. The use of request for information (RFI) system for the requirements of additional information should also be encouraged but integrated into the overall database system of project information interchange.

The object of the integrated DCS can be summarised as follows:

To enable everyone to know what information has been produced, by whom and what information have been planned to be produced, by whom and when.

To ensure that everyone is provided with information they need as soon as it becomes available.

To enable anyone proposing to use any information is aware of its status.

The cost scope and change control systems are other relevant and important aspects that relate to effective management of information flow. These systems must also be integrated into the model in order to enable the D&B co-ordinator to manage the project cost in a proactive manner. The integrated system should be able to highlight cost and time implications as soon as possible and thus enabling the control of costs before they become a commitment rather than merely recording them after they have been incurred.

The concept of concurrent engineering has been considered in the model by insisting that the TES, I/DRS, and PDS are signed off by the design and construction teams at an early stage. Stephanon and Spiegl (cited in Anumba and Evbuomwan 1997) states that concurrent engineering involves conducting engineering operations in such a way that any functional consideration from design to manufacture is taken into account, and solutions to potential problems developed as early as possible.

The sign off and document control principles enables everyone to know what information has been produced, by whom and what information have been planned to be produced, by whom and when. Also it ensures that everyone is provided with information they need as soon as it becomes available, and to ensure that the status of information is known to anyone proposing to use it.

The processes in the flow diagram ignore the traditional boundaries of design and build by making sure all project team members agree and sign off documents, this includes the client who would not usually have any input once the contract is taken over by the contractor. This proposed approach would enable the client to receive the building he/she wants, without any misinterpretations of the project brief, which has been identified as being a common problem in a number of design and build projects.

The flow diagram itself identifies that the complete process is divided between two teams: the client team and the design and build team. These teams are then broken down into the key sub-teams. All members have a common document control system that is accessible by all parties. This is to ensure both teams have easy access to the recorded documents especially for updating and revisions.

CONCLUSION

The aim of this research has been to develop a flowcharted model that can be used by practitioners to effectively manage information flow in projects executed using the design and build procurement system. It is expected that the use of the model in practice would bring about consistency in approach that will result in a better understanding and good communication.

The literature review briefly demonstrated the nature of D&B projects and outlined information flow and its complexities. The questionnaires enabled an understanding of the current state of the art and helped to reveal the issues that need to be considered for developing the model. It also identified the factors or constraints that effect or influence the flows of information in practice. It may be argued that the questionnaire survey of this nature may not necessarily provide conclusive evidence of the complete views of the practitioners on factors or constraints effecting information flow in the design and build procurement system. Nevertheless, the respondents work experience in the construction industry and the strategic position they occupy in their respective firms gave the research confidence in the opinions expressed in this research.

The developed model shows how information could be more effectively managed within the context of the design and build procurement system. The developed model has attempted to reduce or eliminate the constraints identified and promote clear objectives and definitions from the outset of a project. The model may be used for all configurations or varieties of design and build projects. It could also help to improve information flow in practice by making all project team members work more as a seamless team, each understanding the others problems and being able to mutually seek resolutions. Again, it would enable project's participants to know the status of information and thus receive the right information at the right time by having continuous access to the information or document logged.

An important factor realised by this research is the clear indication that practitioners do not take pre-construction planning seriously. Most of the constraints identified are resulting from poor planning and bad estimation of time, cost and effort required. A change in attitude is necessary if any system is to work effectively. There must be clearly defined strategies, procedures, hierarchical structures, deliverables, channels of communication, and roles and responsibilities within teams. Again, there is a need for D&B contractors to ensure that the team they set up for the project is made up of parties that are suitable and selected based upon objectively established capability and quality criteria, and not simply on lowest cost. Clients may also be required to request as part of the contractor's proposals, the details of all members of the D&B team. He/she is advised to use this information as criteria for selecting the D&B contractor.

REFERENCES

Abudayyeh, O. Y. (1991) Design of construction industry information management systems. *Journal of Construction Engineering and Management*, **117**(4): 698-715.

Anumba, C. J. and Evbuomwan, N. F. O. (1997) Concurrent engineering in design-build projects. *Construction Management and Economics*, **15**: 271-281.

Austin, S., Baldwin, A. And Newton, A. (1994) Manipulating the flow of design information to improve the programming of building design. *Construction Management and Economics Journal*. EF&N Spon.

Bennett, J., Pothecary, E. and Robinson, G. (1996) *Designing and building a world class industry*. The University of Reading, Design and Build Forum Report.

Design-Build Institute America (1994) *An introduction to design-build*. Washington D.C: Design-Build Institute of America.

Gidado, K. and Barter, G. (1996) The constraints to effective information flow in the construction management procurement system. *Journal of Construction Procurement*, **2**(2): 52-68.

Higgin, G. and Jessop, N. (1966) *Communication in the Building Industry*. Tavistock Publications.

Jaafari, A. and Manivong, K. (1998) Towards a smart project management information system. *International Journal of Project Management*, **16**(4): 249-265.

Janssens, D. E. L. (1991) *Design-Build Explained*. Macmillan.

Lucey, T. (1997) *Management Information Systems (8th Edn).* DP publications Ltd.

Murdoch, J. and Hughes, W. (1996) *Construction Contracts (Second edition).* E. & F. N. Spon, London.

Ndekugri, I. E. and McCaffer, R. (1988) Management information flow in construction companies. *Construction Management and Economics*, **6**: 273-294.

Pain, J. and Bennett, J. (1988) JCT With Contractor's Design form of contract: a study in use. *Construction Management and Economics*, **6**: 307-337.

Songer, A. D., Ibbs, C. W. and Napier, T. R. (1994) Process model for public sector design-build planning. *Journal of Construction Engineering and Management*, **20**(4): 857-876.