CAPTURING AND MAINTAINING THE CLIENTS REQUIREMENTS

Full Paper

STANDARDISATION AND PRE-ASSEMBLY – CAPTURING CLIENTS REQUIREMENTS

Martyn C Pendlebury PhD
Department of Civil and Building Engineering
Loughborough University, UK
m.c.pendlebury@lboro.ac.uk

Alistair G F Gibb PhD C Eng
Department of Civil and Building Engineering
Loughborough University, UK
a.g.gibb@lboro.ac.uk

ABSTRACT

Rethinking Construction (Egan 1998), commissioned by the UK Government, identified barriers and recommended solutions for the construction industry in the UK. Standardisation and Pre-assembly (S&P), or off site production, was a principal recommendation from the Egan Report.

Loughborough University, in partnership with the Construction Industry Research and Information Association (CIRIA) and their core membership of industry clients, identified that negotiating project drivers (Gibb & Isack 2003) and constraints helped clients and their designers set out their requirements for a project. How to capture and maintain client requirements was a principal objective for the Project Toolkit.

The Project Toolkit is the output from a multi faceted demonstration project for the Department of Trade and Industry on behalf of the UK Government. It followed on from earlier research projects that investigated the extent and scope for S&P in the UK. The current work, a result of extensive field trials, focuses on the needs of occasional clients. Live and historic construction projects are used to demonstrate the benefits achievable from S&P.

This paper discusses:

- The application of the Toolkit as an instrument for advising the construction industry about S&P
- How project drivers and constraints were conceived to capture and maintain the clients project requirements for S&P
- The improved communication and design processes that deliver a project strategy and add to:
  - Understanding of S&P between players in the construction process
  - Delivering quality results

- Managing requirements through project delivery

Current findings indicate both designers and clients do benefit from the Toolkit by:

- Understanding the meaning of S&P
- Defining their strategy and creating a plan of action for S&P
- Measuring the benefits
- Generating S&P indices for their project

INTRODUCTION

The concept of using off site production (OSP) techniques to deliver solutions that satisfy the building requirements of clients, their designers and contractors is not new to the UK construction industry.

Manufacturing off site for later assembly in construction on site in its various forms provides solutions for all types of construction application. These solutions can be mass-produced and are able to use innovative materials and techniques previously unavailable to traditional construction.

Manufacturing off site has variously been called pre-fabrication (White 1965) or as in the Rethinking Construction report (Egan 1998) standardisation and pre-assembly (S&P) to try and disassociate it from the prefabrication disasters of the 1960/70's. The technique is currently termed OSP in a current Department of Trade and Industry initiative called prOSPa (www.prospa.org) that aims to consolidate then build on previous research information and then disseminate that knowledge through an open web portal. Standardisation and pre-assembly was a favoured part of the Egan led initiatives of the late 90's and early part of the new millennia but the solution, though seen as a saviour of UK construction by the UK Government, had many unanswered questions posed by both the construction industry and it clients.

The UK Government is currently making OSP an obligatory consideration as part of their funding process whether it be for housing, defence, health service or infrastructure. The construction industry is also listening to its clients needs who are demanding better performance in terms of cost, time and quality (Gibb & Isaac 2001). Some of these solutions in their various forms are now being manufactured off site. The manufacturing process is conducted in a controlled environment using a multi skilled workforce to deliver a product designed to satisfy market driven needs. These manufactures are providing better quality products for the construction industry without escalating costs and they can supply their products to site with a guaranteed time of delivery.

Though being fostered through the need to meet a current skill shortage in traditional construction there is an underlying belief that there will be no turning back from OSP this time. However not all parts of the industry are happy that the current initiatives are providing the right solution to that problem with some believing that the initially enthusiastic reception for OSP will be short lived if history repeats itself and the products again fail to endure as indeed they did in the 1960's and 70's (White 1965). Recognising both opportunities and pitfalls, the UK Government through the Department of Trade and Industry (DTI) asked the Construction Industry Research and Information Association (CIRIA) to produce the Project Toolkit for Standardisation and Pre-assembly (Gibb & Pendlebury 2003) for the construction industry. The Project Toolkit asks clients and their designers to consider respectfully their approach to OSP. To develop sustainable strategies, monitor carefully the integration of different building techniques and measure their project outcomes.

This paper discusses the development of the Project Toolkit from an academic point of view and describes:

1) The Toolkit's historical evolution and the methodology that delivered a robust solution to a collection of aims and objectives.

2) How the construction industry and its clients influenced the research process.

3) How the Toolkit uses the concept of project drivers and constraints to engage clients and their design teams.

4) How project drivers and constraints can be used to determine a project strategy for OSP.

(1) M. C. Pendlebury is a Research Associate, Department of Civil and Building Engineering Loughborough University

(2) A .G. F. Gibb is Professor of Construction Management, Department of Civil and Building Engineering Loughborough University

THE HISTORICAL PERSPECTIVE

The Construction Industry Research and Information Association (CIRIA) choose their projects from requests by their Core Programme members who communicate their needs for detailed surveys of current trends and thereby influence CIRIA's collaboratively funded research programmes. Following the Government sponsored report, Rethinking Construction (Egan 1998), their members wanted to know how standardisation and pre-assembly (S&P) might benefit the construction process and the ways in which it was already being delivered over a variety of construction arenas. It was clear that opportunities existed and that some clients were already benefiting from the off site production (OSP) process both at home in the UK and overseas. As a result CIRIA, after first securing research grant funding from the UK Government's then Construction Directorate at the Department of Environment Transport and Regions (DETR), entered a competitive tender process and engaged Loughborough University as part of a research team that included both the Laing Technology Group and Arup & Partners as consultants, to deliver a series of authoritative reports. Table 1 lists a summary of all the CIRIA projects.

TABLE 1:
Summary of CIRIA research projects

No.	Reports significance/limitations	CIRIA Project No.	Deliverable/Output
1.	Designed to provide clients and their advisors with a summary of the potential benefits of standardisation and pre-assembly in design, specification and construction but not how to achieve those benefits for themselves.	RP532	Standardisation and Pre-assembly - adding value to construction projects (R176). a) SNAPSHOT report b) Full Report
2.	Designed to combine information on the benefits and critical success factors together with a toolkit to help the user identify opportunities, maximise benefits and measure the success of a particular project or series of projects.	RP579	Standardisation and Pre-assembly - Client's Guide and Toolkit (Publication C544)
3.	Turning the unwieldy paper version of the Client's Guide and Toolkit, by listening to industry professionals and their clients requirements, into a user friendly interactive CD version that uses project drivers and constraints to create a strategy for different stages in a project.	RP618	Standardisation and Pre-assembly – Project Toolkit CD (C593)

4.	Identified the shortcomings with the content of the Standardisation and Pre-assembly – Project Toolkit with respect to occasional clients.	RP652	Internal report to DTI on viability of a revising the Toolkit for use by Occasional Clients
5.	Designed to deliver a revised Standardisation and Pre-assembly – Project Toolkit CD that will include 150 example case studies, additional information and demonstration projects for occasional clients.	RP689	Standardisation and Pre-assembly – offsite Project Toolkit CD revised for Occasional Clients (not yet published).

Reports 1 and 2 provide construction industry clients and their principle advisers with a summary of the potential benefits of S&P in design, specification and construction.

These reports employed a robust research methodology that involved a comprehensive literature search and review, a series of workshops, interviews and site visits.

Formative workshops involved an assembly of key individuals, strategic thinkers able to use the input from the literature search and review to hone project definition and flush out the appropriate issues.

Project specific workshops were set up to discuss different aspects of S&P in its respective categories of standard components, non volumetric pre-assembly, volumetric pre-assembly and modular building.

All project specific workshops involved representatives from a minimum of four of the case studies for each category of S&P and where appropriate other experts were invited to take part (see table 2):

TABLE 2:
List of Experts

Purpose	Expert
Client\owner representative	May be an appointed project manager
Form and function	Architect
Structure and fabric designer	Structural engineer
Internal environment designer	Building services engineer
Manager of construction	CM, MC, main contractor D&B contractor etc
Supplier\installer	Works, trade, specialist contractor
Financial advisor	Quantity surveyor, cost consultant etc

Strategic workshops were used to validate the findings from the project specific workshops and conduct gap analysis to ensure nothing had been missed.

Individual interviews and site visits collected information from case studies, a strategic thinkers forum and other industries and sectors.

The first publication, *Snapshot* (CIRIA 1997) confirmed that the construction industry needed to change its culture. It was followed by *Standardisation and pre-assembly, adding value to construction projects* (CIRIA 1999). The reports investigated how OSP manufacturers designed and constructed their products. Led by an industrial

steering committee the reports looked at a variety of construction arenas ranging from the off site assembly of integrated components to the manufacture of modular buildings prior to final delivery to site.

The *Snapshot* was delivered as a high profile report. It defined what was implied by the term S&P and confirmed that whereas both standardisation and pre-assembly are complementary there are distinct approaches for both with different implications for the various participants and the construction process. It suggested that construction should change from dirty, dangerous and difficult to a customer focused service that involves change and cost friendly products to continuously improve both design and production.

It confirmed that standardisation was not new but that when combined with pre-assembly significant benefits were achievable over a range of headline issues.

At the same time it warned that the critical 'window' of opportunity significantly changed when adopting these new processes when compared to traditional on site construction. Therefore a clear procedure should be in place for individual designers and\or project teams to follow. The report also listed the prompts and pitfalls that organisations should take account of to ensure these do not frustrate the project, such as understanding and commitment by everybody involved, establishing critical information ASAP in the project process, the different effects on design decisions and the significant change required in project management.

The *Standardisation and pre-assembly - adding value to construction projects,* report that followed was produced as a book. The full report, initially for CIRIA Core Programme members listed numerous case studies and cited successful examples of pre-assembly on construction projects to show that it need not lead to standardised buildings. This book provided valuable recommendations on the procedures for gaining maximum advantage from S&P. The authors drew on experience from the construction industry overseas including Japan and the USA and from other activities that make extensive use of S&P, such as the automotive and aerospace industries, with input from David Gann (then at SPRU now at Imperial College). The report went into extensive project detail discussing and defining value for money. It also argued the principle case for S&P, that of increased predictability and efficiency and described how to best achieve practical implementation by applying a simple, standardised procedure for optimising S&P. This it claimed should be applied at agreed evaluation points, where the project team should briefly evaluate the opportunities for improvement by the use of standard frameworks or conventions for geometric fit and compatibility as well as using project specific standards. They should also consider standard components and methods, together with pre-assembled components and/or modules.

Adding value to the construction process with its companion publication Snapshot became an authority for anyone interested in standardisation and pre-assembly and greatly informed the next stage in the CIRIA research process, that of delivering practical guides and toolkits.

The *Standardisation and Pre-Assembly - Client's Guide and Toolkit* (Gibb 2000) followed (we call it the Client's Toolkit for short). It investigated the optimised use of standardisation pre-assembly and modularisation and presented a clients guide for construction industry clients and their advisers. The output was a practical guide and toolkit that contained a list of actions, options and rational procedures backed by detailed supporting information. The Client's Toolkit built on the previous research and suggested that its users investigate client drivers to help them understand how they impact on the pre contract decision making process. The research derived a list

of client needs and found that, above all, client's want value for money in terms of lower whole life cost, lower costs for a given quality, higher quality for a given cost and a consistency in the level of quality.

Research by Gibb and Isack (2003) qualified those drivers in terms of what clients see as the benefits of pre-assembly, i.e. cost, time and quality. For the Client's Toolkit (Gibb 2000) the drivers were extended to include the terms profitability, predictability and productivity. Gibb and Isack (op cit) later confirmed that client's also perceived disadvantages to S&P and cited a variety or reasons from products that are poorly built to inadequacies in the supply chain.

The principle drivers were presented as part of a collection of issues that might have either positive or negative effect on a project. It was clear that where there were advantages and there were also disadvantages and that they could have a significant impact on the successful implementation of standardisation and pre-assembly. Those positive and negative attributes were revisited in the next CIRIA\Loughborough research project RP618 called the Demonstration of the *Client's Toolkit for optimised use of standardisation and pre-assembly in construction,* it was won in open tender to the then DETR and its objectives were to provide a much wider appreciation of the advantages that can be gained from appropriate application of standardisation and pre-assembly to construction projects. To demonstrate that the Client's Toolkit, developed in the earlier project (RP579), can be used effectively to improve construction projects in terms of productivity, predictability, quality and speed and provide better value for money. It would use feedback from the experience of detailed practical application of the Client's Toolkit to refine the procedures and techniques and deliver them in a user friendly electronic system (CD-ROM or equivalent), for ready application in design offices by all members of the professional team.

One of the aims was to expand the portfolio of case studies to better explain the benefits achievable by adopting S&P, CIRIA and its partners proposed the demonstration project would have five major outputs:

1. Six detailed case studies which would test the Client's Toolkit on live projects.
2. Examine the response of industry and produce a revised Client Guide and Toolkit.
3. Provide a final output deliverable in the form of an interactive CD.
4. High Impact publicity document.
5. A final report to the DETR.

This research project which we called the Project Toolkit was later published by CIRIA as the *Standardisation and Pre-assembly - Project Toolkit* (Gibb & Pendlebury 2003).

PROJECT TOOLKIT METHODOLOGY

The research programme for the Project Toolkit employed formative demonstration workshops on live projects to collect data and strategy review by steering committee focus groups to direct and guide the research progress. The programme included review workshops, specialist interviews to examine historical data and Delphi surveys to deliver the CD content.

The Delphi Study methodology (Linstone & Turoff 1975) was considered appropriate as the research team needed a method of generating ideas and facilitating consensus among individuals who have special knowledge to share. The research team would collect data from a variety of real world sources where they would need

to facilitate consensus among individuals with special knowledge, conduct personal interviews and then convene focus group workshops to examine and test all the developing theory. The focus group would need to be available for workshops and separately, to receive and analyse the data at different stages in the process. CIRIA identified a collection of specialists from their Core Member programme and some would serve both as steering group members and form the Delphi panel later in the project. Using a data collection method called a "ranking-type" Delphi survey (Schmidt 1997) allowed the research team to canvas a rank-order list of issues for the drivers and constraints, developed for the CD. This served the dual purposes of soliciting opinions from experts and having them rank the opinions according to their importance. Schmidt's (op cit) methodology involves three general steps:

1. Brainstorming for important issues.
2. Narrowing down the original list to the most important ones.
3. Ranking the list.

After consolidating the data it was returned to the panelists, as a grouped list of issues, for validation.

Project Drivers and Constraints

During the formative workshops, the merits of standardisation and pre-assembly (S&P) were debated and the applicability of the toolkit questioned. One of the findings was the existence of a close similarity in the project drivers for both traditional and S&P techniques. What stood out as missing and what construction professionals needed was an appropriate balance to the Client's Toolkit's pro S&P bias. Working together with the research team they found that by identifying disadvantageous project attributes and aligning them against the project drivers a project strategy started to evolve.

These attributes were used to engage invited clients and design professionals during a series workshops used to test the accessibility of the Client's Toolkit. The initial part of the research found that most design professional were already aware of the benefits S&P offered to them. They were not looking for an educational tool but were looking for a tool that would help them determine viability and influence the outcome when applying S&P techniques on their particular project. They required this tool to involved their clients in the decision process, to help with the creation of a project strategy and to assist in the measurement of benefits from the implementation of that strategy.

A close examination of how the Client's Toolkit presented its information was made, the output of that examination was brainstormed with an industry led focus group to establish the best way to respond to the needs identified in the formative workshops. The toolkit was then redesigned into a format that delivered three principal components:

1. Background information that includes opportunity identification and case study sections.
2. Strategic tools and advice aligned to a generic process map.
3. Measurement advice for both benefits and the creation of indices.

Redesigning the Client's Toolkit also necessitated a change in the way its information was accessed and a study group for the CD design was assembled to test the toolkit proposals. They elected to start the strategic tools by asking the Toolkit user for project information and then use this information to help create a project strategy.

The sets of positive and negative attributes were re-examined. It was decided to restate original project driver sets of cost, time and quality and in addition create sub-sets to accommodate the major variables under those headings. These drivers would be used in the initial creation of a project strategy. It was noted that the verified list of benefits in the original Client's Toolkit provided both positive and negative benefits for S&P and it was these attributes that would determine the use of S&P on a project. The positive influences evolved into generic driver subsets and the negative influences, termed constraints to the process, focussed on the applicability of S&P. Initially these were presented as a list of nineteen drivers and twenty two constraints. The constraints being the most likely to inhibit implementation of S&P on a project or reduce the likelihood of achieving the potential benefit when applying S&P techniques. These drivers and constraints now required testing and verification by industry.

Further workshops with construction clients and their designers were convened to examine the new toolkits conformity to their brief. Some beneficial changes were made with the addition of environmental issues and the transfer of some constraints to the drivers section when it was discovered they sat in both camps, i.e. both driver and constraint at the same time.

The list was again presented to the focus group for them to negotiate both context and meaning before re-presenting the proposed mark two version of the toolkit to designers. Some reviewers thought the systematic layout employed by the drivers should also be used for the constraints section. Consequently a set of headings were provided to separate out the constraints into site constraints, process constraints and procurement constraints. The final negotiated list of drivers and constraints is given in Table 2.

When the drivers and constraints had been finalised the Delphi study group were again employed to help generate and deliver appropriate advice under the headings

- Standard processes.
- Standard components.
- Pre-assembly.

The process proved so successful that when the final draft content for the CD was completed a separate group of experts were convened to wordsmith the content before presenting it back to CIRIA for publication.

CONSTRUCTION INDUSTRY INFLUENCE

It is often said that researchers for construction seek topics that they believe will benefit their benefactors most, then they pursue their holy grail without listening to the real and changing needs of clients and industry. At CIRIA the research is driven by their membership for their membership. When a research project is given the go ahead a steering committee is assembled, first from the Core Programme members then from others able to contribute their specialist knowledge to the research focus. Throughout the research period workshops and committee review meetings direct and validate the research findings. The steering committee have under the authority of their chair person, where they feel the original aims and objective are not being met, the ability to change the course of the research. They can also introduce additional resources when in their professional opinion they consider it prudent to do so. Throughout each of the profiled research projects a variety of industrial input was sought. At the strategic level, forward thinking captains of industry set objectives that were tested with clients on live projects, then re-examined by practitioners at grass roots level to confirm the theory generated before final publication.

TABLE 2:
List of Drivers and Constraints

DRIVERS		CONSTRAINTS	
Section 1: Health and Safety Driver		**Site Constraints**	
1.1	Reducing health and safety risks	C1	A problem transporting manufactured products to site
Section 2: Cost Drivers		C2	Limitation to movement of pre-assembled units around site
2.1	Ensuring project cost certainty	**Process Constraints**	
2.2	Minimising non construction costs	C3	Short overall project time scales
2.3	Minimising construction costs	C4	Unable to freeze design early enough to suite pre-assembly
2.4	Minimising overall life cycle costs	C5	Limited capacity of suppliers
Section 3: Time Drivers		C6	Not possible for follow-on projects to use the same processes
3.1	Ensuring project completion date is certain	C7	No opportunity for component repeatability on this or future projects
3.2	Minimising on-site duration	**Procurement Constraints**	
3.3	Minimising overall project time	C8	Project team members have no previous experience of S&P
Section 4: Quality Drivers		C9	Obliged to work with a particular supply chain
4.1	Achieving high quality	C10	Not willing to commit to a single point supplier
4.2	Achieving predictability of quality	C11	Obliged to accept lowest cost rather than best value
4.3	Achieving performance predictability throughout the lifecycle of the facility	C12	Key decisions already made preclude S&P approach
Section 5:Sustainability Drivers		C13	Limited expertise in off-site inspection
5.1	Reducing environmental impact during construction	C14	Early construction/manufacturing expertise and advice unavailable
5.2	Maximising environmental performance throughout the lifecycle	C15	Obliged to accept element costing based on SMM
5.3	Implementing Respect for People principles		
Section 6: Site Drivers			
6.1	Restricted site layout or space		
6.2	Multi trade interfaces in restricted work areas		
6.3	Limited or very expensive available skilled on-site labour		
6.4	Live working environment limits site operation		
6.5	Site restricted by external parties		

CONCLUSION

This paper has presented a catalogue of research that has examined the process and development of a Toolkit for off site manufacturing or standardisation and pre-assembly for the UK construction industry. It confirms the fluid nature surrounding the reintroduction of these techniques for construction and the care taken by the UK Government to ensure it dose not become another short live construction initiative. In addition it has demonstrated how the Construction Industry ant its clients directly influenced the research process and explains how academic research has responded to the needs of industry, with its reports and the development of both the Standardisation and Pre-assembly - Client Guide and Toolkit and the Standardisation and Pre-assembly - Project Toolkit CD. The research projects were designed to both inform and assist design team professionals and their clients create and implement a project strategy for standardisation and pre-assembly in construction. The paper has

explained how academic rigor has necessitated the application of a variety of research techniques to satisfy the demanding aims and objectives presented to the research team by the CIRIA research managers at the outset.

CIRIA and the research team are currently developing a toolkit for occasional clients that will be the subject of further papers in this series. They will discuss case study research and the development of interactive IT teaching media for higher education.

References

CIRIA *Snapshot – Stansardisation and Pre-assembly,* Compiled by Gibb, A.G.F.; Groak, S.; Neale, R.H. & Sparksman, W.G. (1997) Construction Industry Research and Information Association, London

CIRIA *Adding Value to Construction Projects through standardisation and pre-assembly,* Compiled by Gibb, A.G.F.; Groak, S.; Neale, R.H. & Sparksman, W.G. (1999) Construction Industry Research and Information Association, London Report 176 ISBN 0 86017 498 0.

Egan, J. (1998) *Rethinking Construction,* Department of the Environment, Transport and the Regions, London.

Gibb, A.G. and Isack, F., (2001) Client drivers for construction projects: implications for standardisation, *Engineering Construction and Architectural Management*, 8(1) , February 2001, pp. 46-58, ISSN 0969 9988

Gibb, A.G., *Client's Guide and Tool Kit for Standardisation and Pre-assembly*, (2000) Construction Industry Research and Information Association (CIRIA), Report CP/75, pp. 70, ISBN 0860 175448

Gibb, A.G.F. and Isack, F., (2003) Re-engineering through pre-assembly: client expectations and drivers, *Building Research*, 2 , pp. 146-160, ISSN 0961 3218.

Gibb, A,; Pendlebury, M., (2003) *Standardisation and Pre-assembly –Project Toolkit,* Construction Industry Research and Information Association (CIRIA), Publication C593, ISBN 0 86017 593 6.

Latham, M. (1994) *Constructing the Team.* HMSO, London.

Linstone, H. and Turoff, M., (1975) *The Delphi Method: Techniques and Applications,* Addison-Wesley, 1975.

Schmidt, R., (1997) Managing Delphi Surveys Using Nonparametric Statistical Techniques, *Decision Sciences* 28(3) pp. 763-774

White, R., (1965) *Prefabrication: A history of its development in Great Britain,* National Building Studies Special Report 36, HMSO, London.