STANDARDIZATION OF BRICKWORK CONSTRUCTION: PROCESS IDENTIFICATION

N. Dawood, B. Hobbs and A. Fanning

The Environment Section, School of Science and Technology, the University of Teesside, Middlesborough, TS1 3BA, UK

Bricks are the ultimate standardized component and highly suited to bespoke solutions in construction. Facing brickwork provides an environmentally attractive and functionally durable external fabric. To date, very little previous attention seems to have been given to the potential for standardization to improve the conventional on-site processes. A range of attempts has been made to develop 'generic' prefabricated masonry systems. However, in the housing sector, previous attempts at prefabrication have been unsuccessful.

There is considerable potential for improvement in masonry construction business processes in order to meet client's needs. Standardization of site procedures, partial prefabrication and full prefabrication are potentially useful masonry production techniques. Their relative cost and process effectiveness needs careful investigation in the context of the proposed research. The project addresses the scope for improving the efficiency of construction involving brickwork by harnessing the synergy between technological developments and supply chain and materials management.

To date, the research project has draw upon case studies and the technical expertise of its industrial partners to establish a series of semi structured interviews forming the basis of the research methodology.

Keywords: brickwork, production procedure, standardization, process synergy.

INTRODUCTION

The concept of dexterity and innovation producing process savings is not a new idea. This rationale has been responsible for producing cost effective supply chain mapping data in alternative market-driven manufacturing industries.

Conversely, construction is plagued by 'uncharted' activity based functions and complex production sequence co-ordination problems. The combination of, 'actual' interactive processes and the critical effective use of the 'Three Ps', people, products and process, should result in enhanced process identification (Straker 1995: 37–45). Therefore, identifying and re-engineering these performance gaps is the solution to unlocking the future development of construction product through process, and not the costly, high-risk process of product wrapped around production process route. As an example of global advancement in general practice, Toyota have adapted their motor industry information lean production technology and applied the process to prefabricated housing projects. These applications of prefabrication provide higher quality control, improved safety conditions, reduced financial risks, a reduction in deliveries to site, enhanced inter trade synergy and minimized construction time (Evans 1995).

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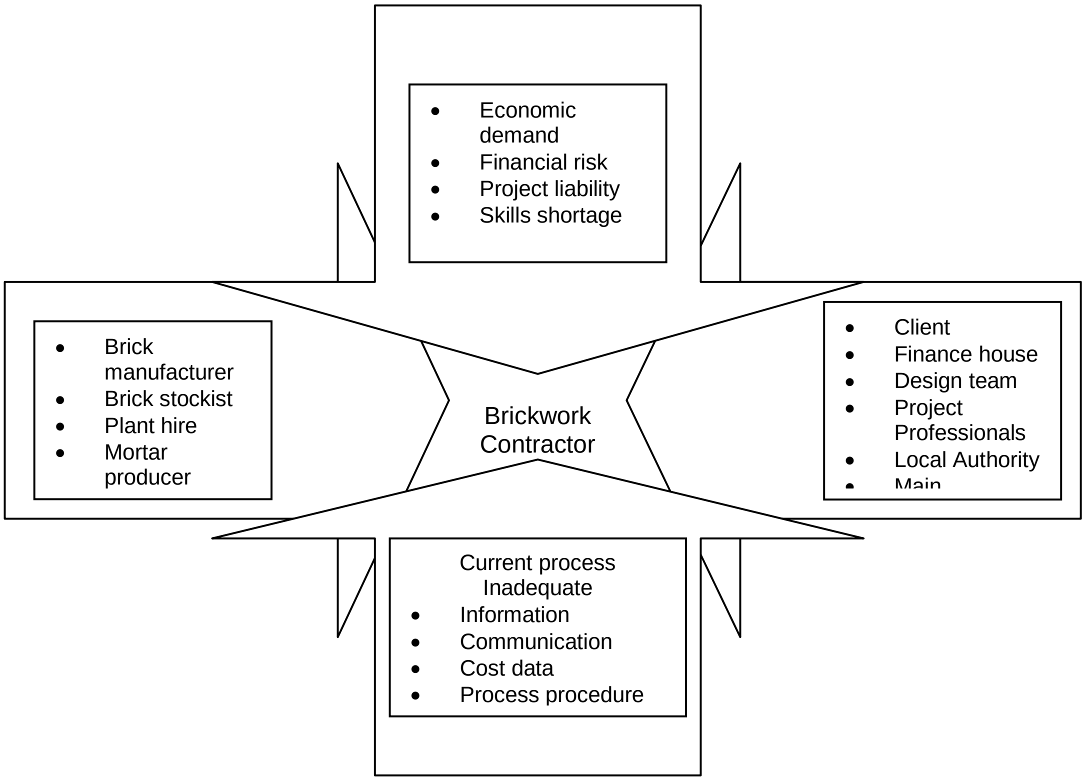

Figure 1: Fulcrum of production activity

TRADITIONAL HAND SET MASONRY

The methodology for this investigation was based on interviews with industrial partners and industry case and on site process work-studies. The investigation highlighted that, traditional masonry construction packages place the onus of variable financial risk and rigid contractual performance on the brickwork contractor. The housing sector brickwork contractor can be described as the 'fulcrum' (see Figure 1) through which all areas of 'transferable risk' production activity balance.

Further positive identification of the 'uncharted' actual interactive process sequence, in construction (see Figure 2) all hinge on the radical change in direction and the absorbing of process dexterity and standardized value added production.

The traditional brickwork contractor is often forced to 'stand alone' resulting in minimal communication, production process synergy and counter claim project culture. The current on-site based problems include inaccurate costing rates in relation to production activities and poor weather protection. This combination of fragmented site activity results in financial conflict and project delay (Masonry 2007, 1997).

The combination of poor process identification and variable risk factors compound the problems of site-based activities and production procedure. The production fragmentation results in minimal product guarantees. Construction litigation has been to date the only way to resolve simple process bottlenecks.

Pre laying operations (Unskilled)

- Mixer operation
  Silo mixing, ready spread traditional batching.
- Ancillary work
  Collect dpc, ties, fixings, adhesive insulation, profiles.
- Other work
  Clear away site obstructions, maintain plant, protect and store materials.
- Unload bricks
  Using forklift truck, HIAB crane, tower crane, mobile crane, pallet truck.
- Distribution of mortar
  Using forklift truck, tower crane using mortar bin and pallet truck wheelbarrow, bucket, shovel, hod
- Distribution of bricks
  Using forklift, pallet truck, barrow, hod.
- Recovery
  Time over and above normal breaks

Laying operations (Skilled)

- Instruction
  Site management/Foreman
- Read drawing Set out
  Foreman/Bricklayer
- Waiting for material
  Measure, set line.
- Erect profiles cut bricks
- Fetch/pick up mortar
- Spread mortar
- Pick up brick
- Butter brick
- Lay brick
  Tap brick/rub brick into place, fill joints, joint/point
  Check for plumb.

Post laying operations (Unskilled)

- Clean away work, place
- Clear away rubbish to skips
- Protect green work
- Protect materials at workplace
- Protect materials in storage

Figure 2: Identification of the 'uncharted' actual interactive process sequence (Source Gilbreth 1974, Jayawardane *et al.* 1995)

PREFABRICATED MASONRY SYSTEMS

Brief history of masonry prefabrication

The early development of prefabricated masonry in the UK started in 1934 and broke onto the European market during the 1950s. Masonry prefabrication research in the U.S.A began through The Structural Clay Products Research Foundation (SCPRF), now part of BIA (Bryup 1970). In the UK most early methods of prefabrication, such as the delta system, were attempts to mechanize the bricklaying process to produce standard panels using unskilled labour. In Europe, all-brick systems have been utilized effectively, notably on the housing projects throughout Holland and Germany (BDA 1972). Masonry prefabrication has had a much smaller impact upon the industry than at one time expected (Ferry and Brandon 1991). A justification for prefabrication is that the industry may be unable to cope with the volume of work required at busy times because of a shortage of labour (Taylor 1998). Thus, as the pressures for shorter construction times combine with increasing shortages of skilled labour the potential for use of prefabrication may be expected to increase. The use of masonry prefabrication makes possible the fabrication of complex shapes (Vetovitz 1998). These complicated shapes with returns, soffits, arches etc., are accomplished by using jigs and re-usable forms. The repetitive usage of these shapes can result in lower appreciably process costs (Munro 1993). This is of particular importance in relation to masonry construction and the following basic questions must be answered prior to a final build decision.

- Project constraint and project restraints; are they critical risk factors?
- Are design solutions and processes realistic with prefabricated masonry?
- Does economy of scale provide optimum productivity with prefabrication?
- Can sustained levels of supplies and cost control be achieved with prefabrication?

Source Brick Institute of America (BIA) 1987.

All-brick prefabricated masonry systems

This approach has been widely used in the USA. The bricklaying method for prefabrication is achieved in the same manner as traditional in-situ masonry (BIA 1987). This method is particularly suitable for low-rise structures and adaptable, for a conventional brickwork contractor to adopt (Foster 1967). The bricklaying may take place at either an off-site plant or on-site plant. *The Powergen Project* (Bennett 1995, Caine 1998) is a recent example of the on-site approach in which panels are constructed in a protective tent. *The Inland Revenue Project* (Knight 1995) on the other hand is a recent example of factory-based prefabrication, incorporating the use of production transparency principles and mistake-proof processes (Santos, Powell, Sharp and Formoso 1998).

Reinforced concrete panel prefabricated masonry systems

The casting method involves forming a Prefabrication masonry element from dry bricks in either high strength mortar or in small aggregate concrete, similar to a pre-cast concrete panel. This method of prefabrication usually takes place in an off-site plant (Hamm 1970). The cast is then stored, cured and struck in factory conditions. This system has been used in the UK on numerous projects notably, *The Sheffield Fire Station* (Ibstock 1988), through to the present day on the *Aldercastle Project in London* (Tarmac 1998). In Europe similar processes have been used by masonry manufacturing companies notably, by Fiorio of France and Portugal, Preton Keller of Switzerland, BMB of Holland, L. E. Shaw of Canada, Percom of Peru SA and in the USA The Denver Brick and Pipe Co and the Kurtz Gerry Co (Byrup 1970).

Prefabricated masonry systems for housing

Early housing designs exceeded the production cost plans due to inadequate site assembly skills, supervision and quality control and this initiated a lack of financial confidence in building systems (BRE 1983). This resulted in a negative housing innovation circle (Harlow 1998). As suggested by (Ball 1996), the UK lag factor may be due to the ‘unique’ market constraints experienced in England. Europe, unlike the UK, has never turned away from standardized systems production, therefore improving their construction business processes. The German masonry construction industry’s proactive absorption of information technology and manufacturing processes, from successful alternative component producing industries, has resulted in a greater understanding of process synergy and value added activity identification. The German construction industry identifies prefabrication dexterity, procurement innovation, software design control and standardized value added processes as the keys to unlocking the future development of construction, and envisages that the use of robots to perform repetitive construction tasks will increase (Herkommer and Bley 1996).

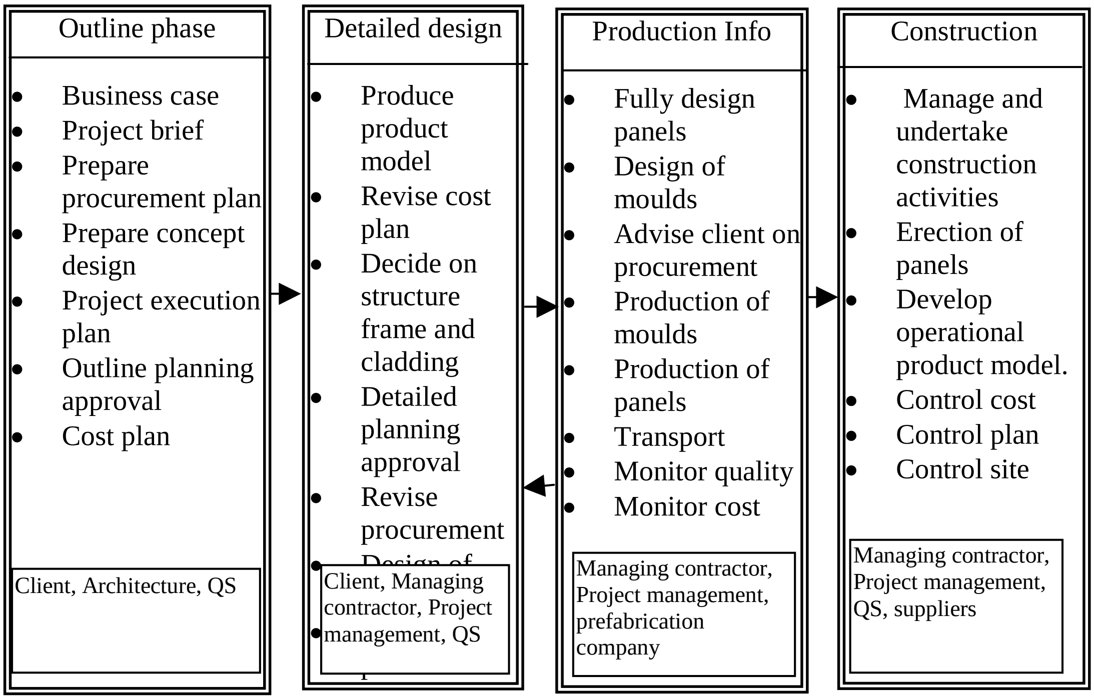

Figure 3: Outline of business processes

Partial prefabrication

There seems little doubt, that where the high fixed costs of equipment can be justified, a building designed on a modular basis and assembled largely of standard components lends itself to higher productivity (BIA 1987). Pre-assembly has made the elaborate construction feasible in terms of time and money. These standardized items such as soffits, lintels, window head and sill details may provide positive solutions to masonry detailing throughout all sectors of construction market activity (Wallace 1990).

As an example, *Asda* feasibility studies in 1988 for a retail building drew attention to the point that economies of scale and pre-assembling the arch details resulted in elements being taken off the critical path, enhancing masonry quality and finish (Brain 1988). A second project *The Trafford Park Centre* in 1998 showed that this added greater flexibility resulting in improved production process (Downing 1988).

THE BUSINESS PROCESS APPROACH

Process identification

The business process of traditional and prefabricated brickwork is a major activity of this research work. In order to develop an industrial consensus, an industry wide survey has been carried out using the semi-structured interview approach.

The identified business and supply chains in terms of logistic flows (such as resource flows, materials, information and cash flows) results in a defined process methodology. An understanding of these interactions enables a holistic approach to analyse, design and re-engineer such processes. The objective is to model the “as is” processes and evaluate their performance against prescribed measures of performance (empirical, opinion, historical data and analytical). Figure 3 shows the outline process of current practice developed through the course of this research.

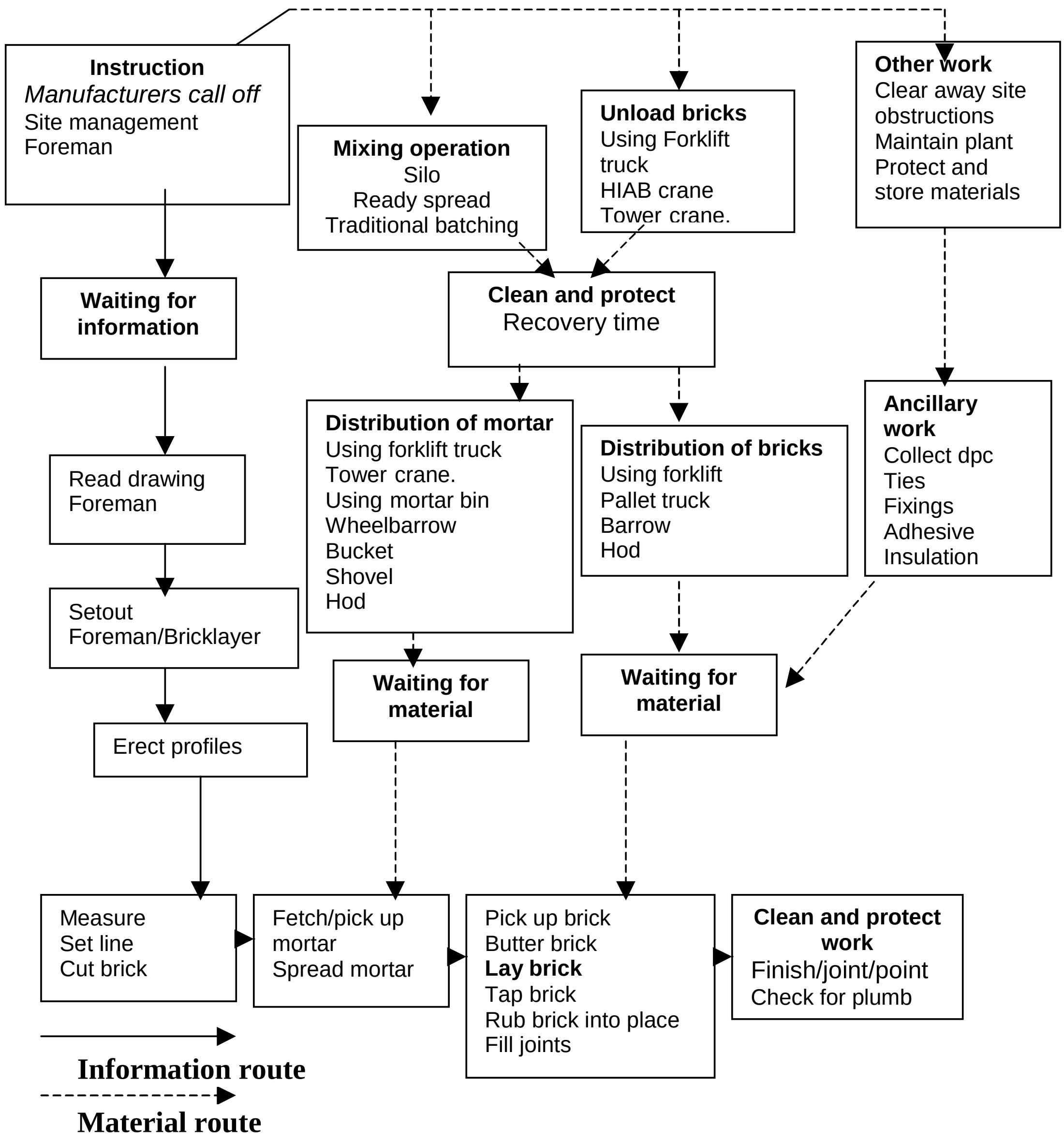

Figure 4 Brickwork production 'as is' process mapping

Prior to business re-engineering, it is necessary to target those processes that will benefit the most from the resources available. A natural costing mechanism for use with a process-oriented approach is activity based costing (ABC) and this will be used in this research. ABC will provide quantifiable evidence of cost generators when used in conjunction with flow mapping of processes.

Process information flow

Information flow of the current business process is being assessed, starting from the placing of an order by a client or main contractor, and finishing with the actual fabrication and erection on site and remedial work thereafter. Inefficiently routed information is targeted. The industrial partners, and in particular the volume housebuilders, are contributing in knowledge and case studies for the development of business processes and costing associated with such processes. To date the technological links needed to assist this particular process 'stand alone' and subsequently, the whole process remains fragmented resulting in costly rigid pathways.

However, the Salford University Process Protocol Map identifies procurement procedure, construction process and project phase, subsequently enhancing the relevant position of the 'actors' in relation to logical production sequence, resulting in a flexible approach to construction business process re-engineering (Cooper 1998 Carr and Winch 1998).

Production process improvements

The construction industry looks toward alternative effective engineering methods to solve construction production process faults or 'bottlenecks' (see fig 3). Subsequently, changing criteria or outputs to meet client's needs may take the form of rationalized actions or processes, resulting in improved working relationships with suppliers to meet the new criteria and ultimately, changing validation in sequence in order to detect future problems or alleviate current bottlenecks.

The current construction project time procurement compaction provides minimal production variation to process sequence. Through increasing attention to co-ordination, and adopting single point responsibility at the outset to advise on the buildability of the projects, construction companies can monitor production and cost more effectively (see Figure 4). These factors are seen as the key points to 'mistake-proofing' construction strategies (Straker 1995, Santos, Powell, Sharp and Formoso 1998). The introduction of forming relationships between Inputs, outputs, controls, mechanisms, costs and time results in an in-depth understanding of procedure and links each activity involved in the whole process.

The transition of information technology integration into construction has been tentative. This rationalization of the umbrella term 'process,' incorporating strategic procurement, procedure, method, activity and operation, combined with communication between designers, constructors and end users, can be improved. The integration and development of the construction software interface is the key factor to identifying the 'uncharted' actual interactive processes, resulting in a flowing mistake-proof re-engineered business process (Aouad, Hinks, Cooper, Sheath, Kagioglou and Sexton 1998, Cox and Townsend 1998: 154, Laitinen 1998).

By mapping the brickwork production sub-activities through this research investigation, it is possible to identify the areas of value and non-value added activity. This combination of activity, method and chain of supply highlights the fragmentation that exists during live project time. The rationalization of procedure is the key to positive performance regarding activity-based costs and the 'actual' areas of activity (Feldman 1998).

DISCUSSION AND CONCLUSIONS

Construction system analysis

It is yet to be seen if all the radical 'lean production' changes are viable and cost effective in all project scenarios. The proactive use of information communication and project transparencies on all levels results in enhanced focus and culture change. These tentative steps to process identification and procedure mapping are currently employed at the 'flexible' prestige end of construction production. However, at the lower end of the 'rigid' traditional business process, change is expensive and to date in short supply. Consequently, the process frequently relies on costly litigation to solve production process problems.

The current time and financial planning processes produce limited information regarding the identification of 'uncharted' actual interactive processes. The subsequent activity process identification and value added enhancement pathways, from inception to completion are the sought after business process improvements providing cost effective synergy through all phases of the production procedure.

Conclusions

The current on-site production conditions are not providing the sought after synergy between traditional craft and alternative positive industry production. Providing solutions through identifiable risk-allocation combined with lean information technology based production, results in positive interactive 'actual' process mapping.

The use of 'actual value-added' activity and 'process engineering' has the potential to increase productivity, reduce the cost of the finished product, optimize the resource and enhance product and project quality, resulting in the sought after culture change.

The range of flexibility, needed to instigate confidence in the masonry market, can be achieved through identifying non-value added process and re-engineering procedure using the motor industry as a benchmark. The current negative absorption of production non-value added activities reverts back to litigation to produce financial solutions.

The UK masonry industry could benefit through absorbing some of the pro-active process re-engineering methods currently being used in mainland Europe. This would provide answers to the process imbalance currently affecting the 'traditional' on-site UK construction masonry market.

The rationalization of construction sequence, element process and the introduction of mechanical handling procedure can only produce benefits in the form of cost and time savings for all parties involved in the fierce cost cutting, high risk, UK masonry market.

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The ability of brick to resist frost attack is determined by their pore structure (in particular the percentage of fine pores in the brick). Frost attack occurs through a combination of excessively wet brickwork and freezing temperatures. When water turns to ice, there is a 9% increase in its volume. This expansion can produce stress within the brick, which causes spalling, with the brick face flaking off and/or crumbling.