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Purpose of the Series

The aim of this publication is to provide an opportunity for students to publish the findings of their undergraduate or postgraduate work. Guidance on publication will be given by staff who will act as second authors. It is hoped that by providing a guided transition into the production of papers that students will be encouraged throughout their future careers to publish further papers. Guest papers are welcomed in any field relating to the Built Environment. Please contact E.A.Laycock@shu.ac.uk. A template will be provided on request.

Acknowledgements

The editorial team would like to acknowledge and thank Will Hughes, Professor in Construction Management and Economics, University of Reading for permission to use the ARCOM template and the associated resources.

EDITORIAL

This is the second special edition of the Built Environment Research Transactions done in partnership with students from Kier who have been enrolled the B.Sc.(Hons) Construction and Commercial Management course.

Students have used the unique opportunities arising from working in the industry to undertake their research and present this as a paper in this volume. The skills resulting from this reflective practice with the associated self-development and vocational orientation is seen as a key strength to the course.

The course continues to provide opportunities for those individuals identified as having great potential but who would not have been able to study for a degree without company support. This strategy addresses the ongoing shortage of intermediate level skills in the national and regional economies and meets the widening participation agenda.

The papers included in this volume showcase some of the student research work undertaken as part of their Dissertation Module and highlight the high levels of achievement.

Staff and students have worked extremely hard to meet the deadlines, and as always I would like to extend my personal thanks to the students, their academic co-authors and to the members of the Editorial team who spent so much effort in producing this edition.

Dr Elizabeth Laycock

Editor, Built Environment Research Transactions

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EVALUATION OF SCHEDULE MANAGEMENT SYSTEMS WITHIN A MEDIUM-SIZED CONSTRUCTION ORGANISATION

Robert Hughes[1] & Norman Watts[2]
Robert is a Planner at Kier Construction. Norman is a Senior Lecturer at Sheffield Hallam University where he leads on BIM related issues and teaches Project Management.

This research project was undertaken to explore the concepts of planning and scheduling systems within a medium sized construction organisation. It uses a case study approach to define the methods by which planning and scheduling are currently performed, exploring the divergences between a theoretical best practice and actual methods in use in order to identify potential improvements. The research found both limitations and consistencies which agree with previous research. The study concludes that the current systems in use are not as effective as they have the potential to be, and that by implementing simple strategic change to current practices improved planning and scheduling across the organisation could be achieved.

Keywords: Schedules, Scheduling, Planning.

INTRODUCTION

Time, cost, quality and safety performance have long been identified as the critical factors for the successful completion of construction projects (Gidago, 2002; BSI, 2006; Johansen &Wilson, 2006; Kerzner, 2009), and adequate planning and scheduling are both important aspects of the management of time, cost, quality and safety.

There has been debate in recent years as to the effectiveness of construction project planning and scheduling (Kelsey & Winch, 2005). As the modern aggressive and competitive marketplace inflicts more demands on the already constrained project environment (Stephenson, 2006), there has never been a

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more important time to have a fully developed, properly sequenced and robust schedule (Gidago, 2002; Smith 2007).

Research has suggested that planning and scheduling is deficient. Progress made in technology has created the misconception that scheduling techniques have progressed likewise (Laufner &Tucker, 1987). However in most organisations there seem to be no clear planning and scheduling systems; planning is undertaken in a multiplicity of ways and systems vary between contractors and projects. There is no defined 'best practice' or standardised procedure which is capable of accurate predictions of cost and time (Gidago, 2002; Kelsey & Winch, 2005). The scheduling profession is lacking in professional guidelines and standards and with increasing use of software and reliance on automation there is a need to establish precise rules for schedule development and use (Basu, 2008).

The design, development, execution and implementation of solid, fundamental planning and scheduling procedures, protocols and guidelines will greatly improve an organisation's effectiveness and efficiency in their ability to produce plans and schedules that are usable, reliable and most importantly, provide predictability (Stephenson, 2006). To this end, research was undertaken to determine the essential elements of a schedule management system and to review current schedule management systems in order that improvements needed may be identified and recommendations proposed.

RESEARCH RATIONALE

The rationale behind this research was to determine the essential elements of a planning & scheduling system within a construction organisation and to review current practice in order to identify weaknesses in current methods and advocate measurable improvements. The overall project aim was devolved into three separate objectives in order to provide a framework for the research project:

To determine the essential elements of schedule management system by reviewing existing studies and literature in the area.

1. To investigate how the planning and scheduling function is currently performed and determine how successful it is through structured interviews.
2. To compare and contrast theoretical tools with current applied methods.

The research project was conducted within the local division of a leading construction group specialising in building and civil engineering projects with annual revenues exceeding £2bn. Data gathered was analysed, compared and contrasted with a review of current literature. The resulting data was used to

support and facilitate suggestions for improvements within the organisations' schedule management systems.

The primary research was designated as qualitative research, generally accepted to be exploratory and suitable for research where the aim is to diagnose a current situation where little or no information is known about the subject of research (Naoum, 2007).

Semi-structured interviews were considered the most appropriate type of interview for the purposes of this research and required the interviewees to have experienced the planning and scheduling for a project. According to Naoum (2007) the interview technique is often selected as the method of data collection for exploratory qualitative research. The research questions and topics were in part developed from the research model presented by Faniran *et al* (1994).

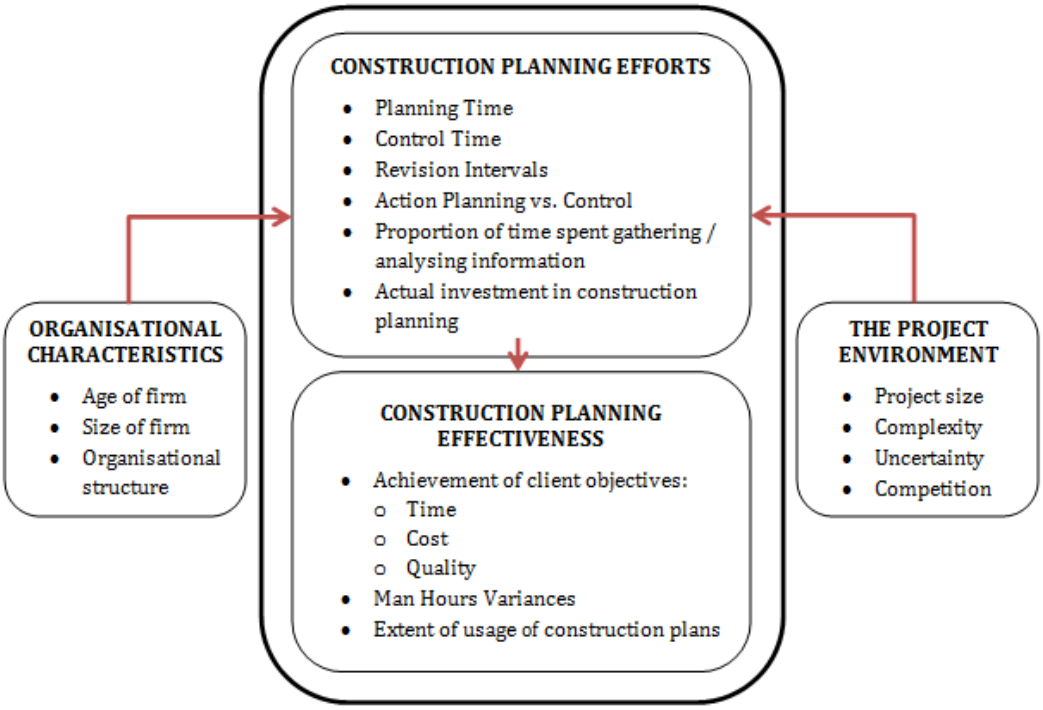

Figure 1 Research Model (Faniran et al. 1994)

In Faniran *et al* (1994)'s work (Figure 1) the research purpose was to determine the relationship between different project variables, namely; organisational characteristics, the project environment, construction planning efforts and construction planning effectiveness. Although developed for a different objective, this model provided a useful framework of the variables which define planning and scheduling and measures its effectiveness. Consequently, the

framework was used to develop the questions for the semi-structured interviews undertaken for this work.

LITERATURE REVIEW

The Planning and Scheduling Function

Planning and scheduling are two terms which are often been considered synonymous, however, although allied disciplines they are not one and the same. Planning has been defined in many ways, but in short planning is a team operation undertaken in order to eliminate or reduce uncertainty, improve the efficiency of the operation and obtain a better understanding of the objectives. By planning a project, the team should be able to determine what needs to be done, by whom and by when in order to reach the project objectives. Project planning, involving all of the project team, provides the logistical strategy for the completion of the works (Kerzner, 2009; CIOB, 2011).

Planning supports other related project management functions such as cost estimating, scheduling, project control, quality control, safety management and others. Scheduling takes place after planning and incorporates the decisions made during planning in order to determine the timing and sequencing of project operations (Mubarak, 2010).

Whilst planning comes before scheduling in the initial planning and scheduling there is overlap and elements of both activities throughout the project lifecycle for schedule maintenance. Planning and scheduling are related not just in the initial planning but throughout project execution, decisions made during planning have a significant effect on the schedule and decisions made during scheduling have a significant effect on the plan. Planning is the initial step which must precede scheduling, and as schedules are amended or adapted for any reason sound planning is required to incorporate those amendments in the most efficient way (Ahcom & Shash, 2005).

Planning and Scheduling Objectives

According to CIOB (1991) the planning and scheduling functions can be categorised by their main objectives, namely:

- That which evaluates various construction strategies, options and or contractual routes in order to determine project durations, rates of spends etc. and;
- That which is required for performance assessment and control purposes.

The first objective defined by CIOB (1991) is evaluative; it is rare that the most efficient solution to a projects completion is found initially. Through planning and scheduling the options available and reviewing and developing the outcomes the most suitable strategy can be selected. CIOB (1991) aligns this process with the work of a contractor at tender stage, where they must be satisfied that the project is feasible and can be completed within the timescale proposed. Ahcom & Shash (2005) describe planning and scheduling at this stage as involving the development of a concept for performing the various elements of work necessary to execute the contract efficiently and on time. This stage has been termed initial, first, front-end, bid and pre-bid planning (CIOB, 1991; Miyagawa, 1997; Baweja, 2003; Gidago, 2004; Kelsey and Winch, 2004; Ahcom & Shash, 2005; Johansen & Wilson, 2006; Mubarak, 2010, CIOB, 2011).

Once the optimum solution for the method and sequencing of the works has been determined it becomes the target for the execution of the work and provides the basis for measurement and management of the works (CIOB, 1991). Despite serving an essential function to the main contractor for evaluation, Mubarak (2010) argues that project control is the most important use of a schedule. Further to this, Lewis (2001) states that the only reason for producing a plan is so that control may be achieved. In the context of project management, control consists of the monitoring of performance against a plan, and taking corrective action when performance is not as expected (Lewis, 2001; Lester, 2007). CIOB (1991) and Mubarak (2010) describe the control process as a four part cycle of forecast, measure and record, report and review, analyse and action. The purpose of which is to compare actual performance with planned performance in order to discern any deviations, so that those deviations may be analysed, and actions taken to bring the project back on track (Mubarak, 2010).

CIOB (2011) provides further context and describes not just project control through measurement and comparison but schedule management alongside execution, incorporating activities aimed at maintaining the relevance of the schedule. A point echoed by Sarkar (2008) stating: “Relevance is the most important criterion to judge the quality of a schedule.”

The schedule’s overarching aim is to reliably and accurately predict when work is likely to be performed in the future. The schedule must be a predictive practical model for the future conduct of the work (Stephenson, 2006; CIOB, 2011). Only when given an accurate indication of when work is to be performed in the future can an accurate assessment as to whether or not the prediction is acceptable. A schedule which is not up to date and not relevant cannot fulfil this function. As sound planning and scheduling is required in the first instance to

produce an accurate schedule and to ensure a project is feasible it is equally necessary during project execution to ensure that all necessary changes are incorporated into the original plan (Ahcom & Shash, 2005). Additionally, should problems be encountered a relevant schedule is the best method of recording delays and proving entitlement to extensions of time (Mubarak, 2010).

The Schedule Management Framework

The planning and scheduling of construction work is a continuous and iterative process divided by milestones. At each milestone deliverables are produced for communication purposes, as a contractual document, or both (Gidago, 2004). The main tangible deliverable of the planning and scheduling function is the schedule; this is one way of identifying its work processes and their relation to the construction stages. Figure 2 shows the sequential approach to understanding the levels of schedule detailing.

Figure 2: Project Schedules (CIOB 2011)

A 'development' schedule is firstly produced by the employer prior to the contractor's involvement and will focus on the employers and consultants activities but may contain a start and finish date only for construction activities. The second 'tender' schedule is produced by the contractor; it is based around the development schedule which will usually be provided as part of the tender documentation in some form. This will also include the construction method, major resources, costs and key durations. The working schedule is developed from the tender schedule and used for control during the projects execution. The occupational commissioning schedule belongs to the employer and will lay down their dates for possession, furnishing and operation and maintenance training once the project is complete. The as-built schedule is the final schedule to be completed and is evolved during construction as part of the project control process (CIOB, 2011). The principal contractor is a stakeholder in all five schedules, either to extract information from or provide information to, but is only responsible for three: the tender schedule, the working schedule and the as-built schedule.

Three work processes then can be defined as the output to planning and scheduling functions for the principal contractor:

1. Development of the tender schedule from the development schedule.

2. Refinement of the tender schedule to develop the working schedule.

3. Evolvement of the working schedule to the as-built schedule.

To put these processes into context they need to be aligned to the stages of a construction projects lifecycle. Through the research no clear and unanimous structure existed, planning and scheduling was defined through the headings of schedule development and project control which do not align with the planning and scheduling work processes as Stephenson (2006) recommends that they should. As such a schedule management framework around which further research may be conducted was formed:

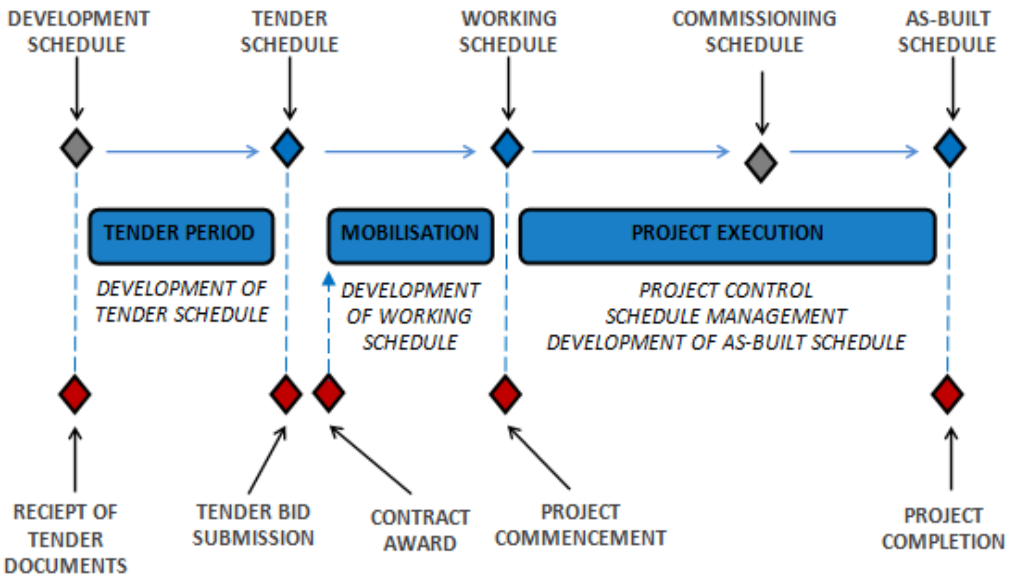

Figure 3: Schedule Management Framework

Development of the Tender Schedule

The model shows that the schedule development for the principal contractor commences with the development of the tender schedule during the tender period. There are various techniques which exist for project scheduling. Critical Path Method however has gained considerable prominence and become the method of choice for construction contractors for projects of all sizes and is

often a contractual requirement in the construction industry (Ahcom & Shash, 2005).

The preparation of a CPM schedule has been widely defined as consisting of a number of steps (Mubarak, 2010; CIOB, 2011); the process is represented in Figure 4.

Figure 4: CPM Schedule Development Process

Activity definition is the first element of a schedule which requires design; projects are normally be broken down into its individual tasks or activities to aid control. The amount of activities and the level of detail which they are broken down into will depend on both the nature of the project and the requirements of the schedule. Each activity should be a uniquely identifiable and defined element of work (CIOB, 1991; Mubarak, 2010).

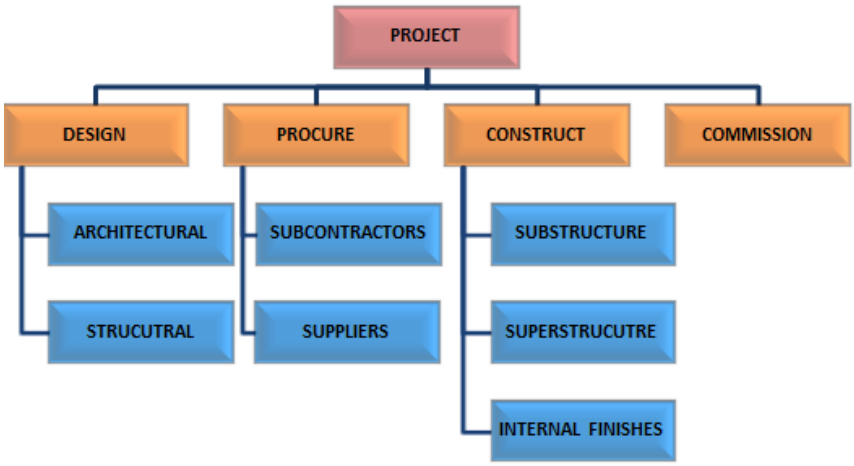

Figure 5: Typical WBS (Adapted from CIOB, 2011)

Mubarak (2010) defines two schools of thought when considering the degree of activity breakdown: minimising activities to retain schedule simplicity, and breaking the project down into considerable detail to support better control during execution. Both methods serve different purposes and both are necessary depending on who is using the schedule and to what end. By using a hierarchical structure different levels of detail can be extrapolated and most computer scheduling software can show the same schedule in a number of different formats, meeting the criteria of simplicity and detailed analysis in one schedule.

The project breakdown is defined through a work breakdown structure, or WBS. An example of a project WBS adapted from CIOB (2011) is given in Figure 5.

A clear and well thought out Work Breakdown Structure (WBS) should be defined as one of the first steps of CPM scheduling as part of activity definition (CIOB, 2011). Assigning clear and unambiguous descriptions at all levels of the WBS hierarchy that may be understood by all is essential to the schedules success. As the project is broken down into a higher detail at lower levels of the WBS the descriptions will also need to be more explicit. CIOB (2011) defines three levels of detail for an activity as low, medium and high density. Figure 6 provides useful illustration of low to medium and medium to high density detail for substructure works.

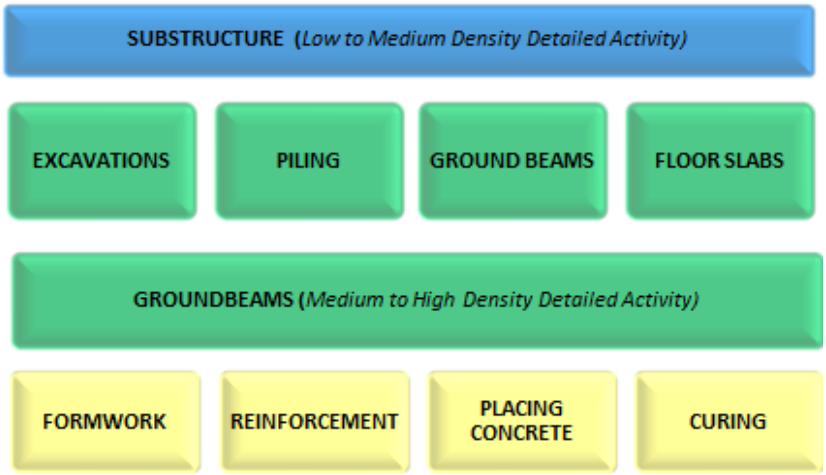

Figure 6: Typical Detail Densities (Adapted from CIOB, 2011)

Determination of the individual durations for activities requires techniques which will vary depending on the nature of the activity and its purpose. CIOB (1991) defines three methods for which duration may be determined: calculation, quotation and assessment. Calculation is an arithmetical method of determination, based on the quantity of work, the productivity of a unit of resource and the amount of resources which will be employed. Quotation uses a duration supplied from a source such as a specialist subcontractor or supplier. Assessment is the least accurate method and is used when limited data is available and is based on experience from previous projects (CIOB, 1991). Where a WBS as described previously is employed, durations are determined at the bottom of the hierarchy and they in turn determine the durations of the higher levels of the hierarchy.

The sequencing of the activities requires the placement of the construction activities in to an appropriate and logical order (CIOB, 1991). Between the start and finish of certain activities exist logical relationships, for instance - the concrete cannot be poured until the formwork has been setup. Mubarak (2010) identifies three types of logic, a logical relationship, a resource based relationship and an external constraint. The logical relationship exists where one activity must be completed prior to the commencement of another, such as the formwork and concrete example given previously. A resource relationship exists where two or more activities could have been conducted simultaneously if the resources were available to do so, but due to limitations on the available resources they must be completed consecutively. These two types of relationship have previously been referred to as hard logic, or engineering logic, and soft logic respectively (Mubarak, 2010; CIOB, 2011); defining that hard logic is immovable whereas soft logic could be modified should more resources, plant or space (which can be considered a constrained resource) become available. A further type of logic is an external constraint, this may exist due to a fixed date defined from outside of the schedule so cannot be linked logically to another activity.

Once the activities have been defined, durations estimated and logical relationships and constraints applied the CPM calculations can be carried out. Where the schedule is constructed using computer software the calculations are carried out automatically. The CPM calculations will determine the earliest and latest start and finish date of each activity, the critical path of the project and the availability of float on any non-critical activities. The schedule should then be reviewed for the need for adjustment to suit seasonality and weather.

The final step in schedule development is the validation and approval process. All previous steps, all data used and assumptions made, construction sequences and resource allowances need to be checked and agreed with production management to ensure feasibility prior to execution, and prior to the schedule being passed outside of the organisation (CIOB, 1991).

Development of the Working Schedule

According to CIOB (1991) a tender schedule is not required to be in high detail as it only has to convey a broad understanding of the project and a sequence of general activities, whilst the working schedule has to show sufficient detail to support management, control and analysis of the works, an argument supported by CIOB (2011). Johansen & Wilson (2006) however argue that as it is during tender planning that the contractor irretrievably commits themselves to a contractually binding construction schedule; adequate planning and scheduling

at tender stage, which requires highly detailed analysis, is essential for success during the projects execution. These views are supported by Gidago (2004) who recommends that more detailed planning is required for tender schedules to improve their efficiency, Johansen & Wilson (2006) support this on the basis that no amount of control will be able to reconcile a tender schedule which was never feasible from the outset and, according to Kelsey & Winch (2005) the project team rely on a high level of project detail to ensure plan reliability at tender stage, promoting highly detailed schedules at tender stage.

Conversely however, it has been found that the greater the time elapsed between the planning and the implementation of the plan the greater the variance of actual schedule and cost against the plan, as such detailed planning of activities which will not be executed until more than three months into the future is futile as there are uncertainties which cannot be quantified (Kelsey & Winch, 2005). This view is also supported by CIOB (2011) who proposed that the tender schedule should only be developed to low or medium density detail, and then prior to execution further developed to high density detail in the working schedule for the first three months of the project, and reviewed and revised during execution to build the higher density detail, three months into the future, over the course of the projects execution.

The development of detail during execution makes a degree of practical sense as during execution subcontractors are engaged, final design details are available and the project team, who, according to Kelsey & Winch (2005) are best placed to make planning and scheduling decisions, are available to be involved in planning and decision making. This also means that subcontractors can be involved in the high density detailed planning process. Kelsey & Winch (2005) provide background to this argument, stating that the principal contractor can only realistically plan to a low density detail and that the trade contractors (sub-contractors) need to prepare or be involved in the detailed planning. This supports the progressive development of high density detail planning during execution as the principal contractor is not best placed to produce high density detail plans for the subcontractors at tender stage, so they must be developed during mobilisation and execution with the subcontractors input and advice.

A high level of detail for planning and scheduling is required for analysis during tender preparation to ensure adequate decisions are made and that a feasible schedule is constructed to prove the construction period which is being agreed to. However, high detail planning and scheduling at tender stage is arguably futile as there are too many uncertainties to produce a realistic and accurate schedule that is useful to the site team during execution. Kelsey & Winch (2005) concluded that the two schedules serve a different purpose and therefore it is

illogical to argue that one way is better or worse as each schedule is produced to satisfy a different objective.

Planning and Scheduling During Execution

Management of the schedule during execution has been described as an iterative process of forecast, measure and record, report and review, analyse and action; the purpose of which is to monitor performance against a plan in order that corrective action may be taken if performance is not as expected (CIOB, 1991; Lewis, 2001; Lester, 2007; Mubarak, 2010). Management of the schedule also includes regular review of the assumptions and decisions made initially and development of the as- built schedule through the recording of actual as-built information (CIOB, 2011). The concept of regular review and revision of the schedule has received approval widely; Faniran *et al* (1994) commented that the effectiveness of the planning and scheduling function can be improved by regularly reviewing the original plan during project implementation and that any schedule update and review should include a 'critical re- examination' of the schedule. Baweja (2003) proposed that schedule updates should include an effective modification of the original plan, based on the projects current situation and on improved project knowledge. Ahcom & Shash (2005) identify regular monitoring and updating of schedules as being necessary to evaluate if the original schedule was correct and to determine whether the project completion date is still achievable. Smith (2007) also recommends keeping the schedule 'alive' and making changes' as you go' to maintain the schedule alongside execution.

Schedule updates serve to incorporate as-built data, including time of occurrence and amount of work completed, thus evolving the as-built schedule during execution and importantly, determining the true effect of as-built progress (or lack of) on the future project activities. The schedule update also requires review and revision of the planned activities of the schedule in order to incorporate changes and maintain the schedule's relevance in light of new or improved information (Mubarak, 2010; CIOB, 2011).

Several models have been proposed for the process and order of schedule updating, however that provided by Mubarak (2010) is the most concise and encompassing (Figure 7).

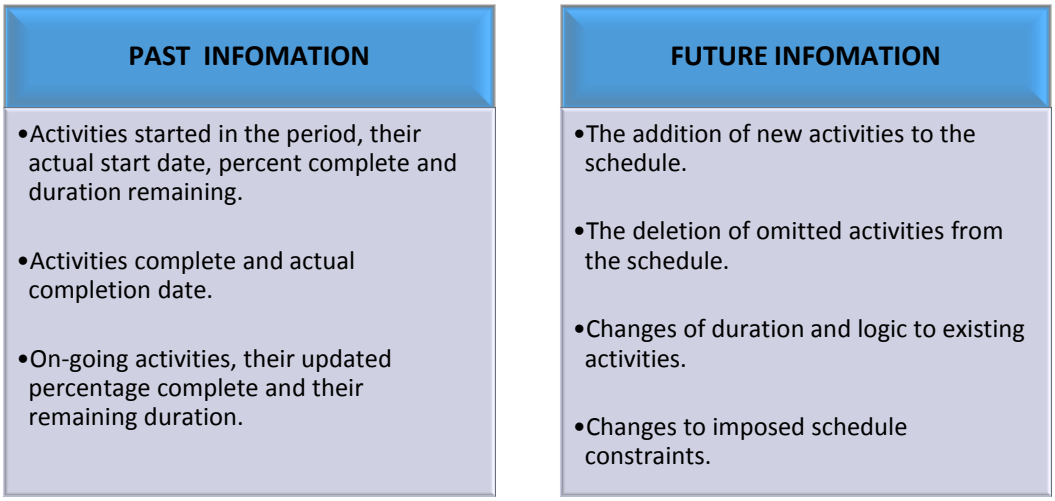

Figure 7: Schedule Update Information (Mubarak, 2010)

Schedule updating should incorporate changes based on new and better information which has become available as the project has progressed. The frequency of the updates, and the review and revision of the schedule depends on the project's bespoke complexity, size and nature (Baweja, 2003). Less frequent progress updates can be de-motivating for those involved (Mubarak 2010) and more frequent progress updates have been found to be beneficial (Faniran et al 1994). Research undertaken by Veteto (1994) which studied the relationship between planning and safety found that more frequent updating of the schedule allows participants to better identify areas of potential conflict. The research also found that the best safety performance was on projects where performance was updated frequently. Clearly there is a balance to be achieved as more frequent revision periods result in more time allocation and progress updating becomes a nuisance.

ANALYSIS AND DISCUSSION OF RESULTS

The results from the structured interviews are summarised in a cross-case format with further discussion to deepen the information learnt from the interviews. The 4 projects on which the case study was based encompassed a range of types and size with values from £1.7m through to £21.m including refurbishments, new builds and extensions. All of the projects were in the education sector.

Project 1: New 3 Storey School Academy

- Least complex with fewest uncertainties.
- Design had minor details outstanding

- Experienced and knowledgeable team.
- The weather had little impact on the build.
- The cost per m^2 £1,909.
- Large number of subcontractors and on site.

Project 2: New Lecture Theatre & Seminar Spaces

- The most complex project
- The cost per m^2 £2,978
- Constrained site adjacent to a vibration sensitive building.
- Deep basement excavation.
- New and innovative type of hybrid structure
- The team had limited experience of the construction method.
- High uncertainty due to lack of design information
- Very weather dependent.

Project 3: New 2 Story Pupil Referral Unit

- Constrained site.
- Piled foundations.
- Significant design changes ran concurrently with the construction.
- The cost per m^2 £2,300.
- Adverse weather conditions caused delays.
- Newly formed site team in new roles.

Project 4: School Refurbishment

- Least complex.
- Cost per m^2 of £840
- Large phased refurbishment project.
- No major structural changes.
- Significant site team experience.
- Early discovered design errors, large uncertainties but little impact.
- Team had limited knowledge of NEC contract.

Tender Planning and Scheduling Results

This section investigated the opinion of the site team on the suitability of the tender stage planning and scheduling through the assessment of the designated

tender period, the degree of site team involvement in the tender process and the level of detail to which the tender schedule was produced.

	Project 1	Project 2	Project 3	Project 4
Tender schedule accuracy:	Accurate	Accurate (no risk)	Accurate	Accurate
Tender planning involvement:	No Involvement	No Involvement	Very little involvement	No Involvement
Tender schedule detail level?	Medium	Medium	Low and Medium	Very High

Table 1: *Tender schedule accuracy, planning involvement and level of detail for projects* 1 *to 4*

- The contract periods for each project were set during the tender stage by the tender team.
- All interviewees considered the tender duration to be accurate if all went well but lacking in any risk allowance.
- The schedules would have been more accurate had they included for potential winter weather delays.
- All interviewees recognised that the tender schedule was both a commercial and a planning document, and that the organisation may not have been successful in tendering for the project had the risk been allowed for.
- The interviewees all had either none or very little involvement in the project at tender stage.
- The tender schedules were all but one produced to a low level of detail with some areas expanded to a medium level of detail.
- A highly detailed tender schedule was found to be more of a hindrance to the site team.
- All other schedules went to a package or sub-contractor trade level of detail at the most and generally this was felt to be an acceptable and realistic level of detail for this stage.

Planning and Scheduling During Construction Results

	Project 1	Project 2	Project 2	Project 3
Schedules used during execution:	Contract Project Mech. & Elec. Short Term	Contract Project Short Term	Contract Project Site Team Use	Contract Project Site Manager
Mobilisation planning:	More than five months	Approximately twenty weeks	Less than two weeks	Eight Weeks
Planning and scheduling time:	On average half a day per week	On average half a day per week	On average half a day per week	On one day per week
Site team involvement:	Project Management Site Management. Site Agent Quantity Surveyor	Project Management. Site Management. Site Agent Quantity Surveyor	Project Management. Site Management. Quantity Surveyor	Project Management. Quantity Surveyor Site Management. Site Engineer Employers PM
Subcontractor and supplier involvement:	Involved in short term schedule	Involved in short term schedule	Involved in site team schedule	Involved in site managers schedule
Update, review and revision frequency:	Short term updated fortnightly	Short term reviewed a weekly	Site team use updated	Short term updated fortnightly
Working schedule detail level:	High level of detail	High level of detail	High level of detail	Medium to high detail

Table 2: Tender schedule accuracy, planning involvement and level of detail for projects 1 to 4

This section of the questionnaire sought information about the schedules use during execution, the time put into them, who was involved in their development, their review and revision frequency and the level of detail they contained.

- Every project used a contract and project schedule as required by the organisation's quality management system.
- The contract and project schedules were developed from the tender schedules, except for one project where the tender schedule was considered to be in too much detail to be useful.
- Every project used a contract and project schedule as required by the organisation's quality management system.

- The contract and project schedules were developed from the tender schedules, except for one project where the tender schedule was considered to be in too much detail to be useful.
- The site teams all used a further schedule for managing activities at a site level developed independently by the site team away from both the employer and the senior organisational management.
- One of the sites used the short term schedule for only the final eight weeks of the project, to ensure they hit a phase completion date.
- The time spent planning and scheduling prior to project execution varied between 5 months and 2 weeks (2 weeks provided exceptional hardship for the site team).
- Three of the projects were procured with a two stage method, consequently planning occurred during the second stage of the procurement.
- For the most part an average of half to a day per week spent on planning and scheduling the project.
- An NEC contracted project required more time in planning & scheduling.
- The time spent on planning and scheduling for all the sites was divided between subcontractor progress meetings and site team meetings planning project operations.
- All members of the site teams had involvement in the planning and scheduling process.
- The NEC contracted project involved the employer's project manager in the planning and scheduling.
- Subcontractors were always given the opportunity to comment on their element of the schedule.
- The contract and project schedules were not updated with actual dates but tracked with a percentage complete against a baseline schedule.
- Short term schedules were updated frequently (daily-fortnightly) with changes to future information or when new information became available but past information was not recorded.
- Schedules were only revised to reflect a change to the work's by the employer, in some cases a change in sequence by the project team was not reflected in the current project and contract schedules.

- One interviewee noted the danger of changing schedules too often and losing sight of what is actually achievable.
- The working schedules were viewed as short term schedules and were used to manage works at a site level.

The Working Schedule in Use

This section of the questionnaire centred around how the site team used the working schedule, its benefit for decision making, its accuracy and whether or not they felt ownership of the schedule.

	Project 1	**Project 2**	**Project 3**	**Project 3**
Key driver for decision making:	Team very schedule orientated	Yes, key in decision making	Key for sequencing + procurement	Referenced for every site decision
Working schedule accuracy:	Short term always accurate	Short term schedule only accurate	Short term schedule most reflective of all	All schedules accurate
Site ownership of working schedule?	Ownership of short and project	Ownership of short schedule only	Ownership of short term and project	Ownership of all schedules

Table 3: Decision making drivers, working schedule accuracy and site ownership of the working schedule for projects 1 to 4

- All used the schedules for decision making and was always referenced to determine the impacts of a decision.
- One interviewee commented that their project and the site team used the short term schedules exclusively for decision making.
- The contract schedule was in the main not considered as reflecting the true scope and sequence of the works, the project schedule as providing a ‘bullet-point framework’ of the sequencing but not reflecting the full scope and the short term schedules as being accurate and reflective throughout.
- The contract schedule considered to be the employer’s schedule for monitoring progress which they had no ownership of and could not change. The site teams had ownership over the short term schedules.

Improvement Concepts Results

This section sought to look at some of the issues identified through the literature review which are debated and to discuss if and how these issues are currently experienced and their benefits and pitfalls with the interviewees.

	Project 1	Project 2	Project 4	Project 4
Progressive elaboration:	Good idea, time and resource dependent	Happening in short term schedules	Already happening through short term schedule	Would improve the site managers safety management
Action planning vs. control:	Preferred to stick to an original plan	Action planning is more useful but control is necessary	Both important, control raises awareness	Both are necessary, action would require more time
A 'live' working schedule:	Could see the benefits of a live schedule	Would be more useful, may lead to criticism if behind	Short term schedule is effectively live	Supportive, but would require more time input

Table 4: Decision making drivers, working schedule accuracy and site ownership of working schedule for projects 1 to 4

- Progressive elaboration (developing the detail of a schedule over the duration of a project) was generally well met. Training on this method was needed by all interviewees
- There was a feeling of a smoother running site where detailed schedules were used.
- Increased level of detail was considered better in identifying potential constraints and clashes.
- All extolled the benefits of a live working schedule regularly updated with as built past information and as planned future information but could leave the site team very open to criticism.
- Consistently displaying an accurate picture of current progress would avoid surprising senior managers.
- Although some may be inclined to adapt the live schedule so it showed the project finishing on time regardless.

CONCLUSION & RECOMMENDATIONS

The aim of the research project was to determine the essential elements of planning & schedule system within a construction organisation and to review current literature in order that improvement needs may be identified and recommendations for a defined schedule management system may be proposed.

Through the literature review approaches to planning and scheduling was explored and three stages of work for planning and scheduling to achieve the contractor's deliverables were defined, namely:

1. Development of the tender schedule from the development schedule.
2. Refinement of the tender schedule to develop the working schedule.
3. Evolvement of the working schedule to the as-built schedule.

Existing models of schedule management systems described only two elements of work: schedule development and project control. As this did not align with the deliverables and work processes identified, the information from the literature review was compounded and a framework for a schedule management system which met the requirements was produced. The process for the development of the tender schedule through the critical path method was explored following the defined work flow for CPM. The principal of the use of a work breakdown structure to facilitate different levels of detail and the definition of low, medium and high detail were identified and example templates given for each. The debates surrounding levels of detail and progressive elaboration alongside construction against the development of a fully detailed tender schedule were put forward and evaluated and the conclusion developed by Kelsey & Winch (2005) provided an answer to the debate. The planning and scheduling effort for execution was then defined (fig 9) and the processes required for regular updates discussed and it was found that all literature agrees on what must be done, though they may call it by a different name and do it in a different order.

From the literature review the basis of a schedule management system has been defined, settling the criteria of the first objective. The second objective was to determine how planning and scheduling is currently performed and to determine how successful it is. This was performed by undertaking interviews with the principal stakeholder in the planning and scheduling function for four current and recently completed projects.

Tender planning and scheduling was explored as it is the basis of the planning and scheduling performed during execution. Tender planning and scheduling was found to be accurate and successful. The comment from one interviewee about the difficulty of a highly detailed tender schedule provides a relevant link back to the literature; the interviewee noted that they could understand the need for a highly detailed tender schedule for planning but that it was unhelpful for managing the site as it constrained their planning too much. This reiterates the

debate for developing highly detailed tender schedules and the need for action planning, where sites are able to adapt organically and find better methods rather than being tied to a schedule based on decisions made with limited information. The fact that the detailed tender schedule was abandoned demonstrates the degree to which it was not considered useful.

The use of short term schedules was not anticipated during the early research, and it is interesting to see that despite there being no instruction or procedure that all of the projects have developed this method to manage the schedule at a high level of detail. The use of the project schedule as a framework within which the short term schedules are developed is very similar to the progressive elaboration as described by the literature. The short term schedules expand on and detail the framework which is the project schedule. What would appear to be the missing link in this process is the feedback of the decisions and information made in the short term schedules back to the project schedule to support overall decision making, instead the short term schedule remains an independent and separate document. Despite this shortcoming and being developed organically with no theoretical basis, as was criticised in the initial research hypothesis, this would appear to be a successful system for site planning. The site team have complete ownership over the short term schedules as they are not used for reporting, and they are used extensively for decision making on site which is one of the key success factors identified in the research by Faniran *et al* (1994). Reflecting on the literature review this use of short term schedules should not have been completely unexpected as Johansen and Wilson (2006) highlight the practice of project teams adopting their own flexible approaches to planning and scheduling outside of the rigid organisational systems when the organisational systems do not meet their needs.

The regular progress monitoring of the contract and project schedules was found to have deficiencies when compared to the update information specified from the theory, as they do not accurately record work to date, nor do they accurately display the future works as intended. The project and contract schedules are also not used for decision making on site, although they may be used for head office decision making as this is the only reference head office have. Due to the use of short term schedules on site, this does not affect site management; although it does however suggest that the information being received by senior management for monthly reports is not accurate, potentially affecting the accuracy of their senior management decisions.

After exploring the way in which planning and scheduling is currently performed the final section of the interview discussed some of the potential improvement concepts which were identified from the literature review. The

concepts all tied into one another – progressive elaboration of the schedule, which in itself supports action planning rather than control, and maintaining a live schedule both of the past and future as recommended in the theoretical part of the research which also supports both action planning and progressive elaboration.

To implement these concepts fully however there were a few obstacles noted:

- The current stakeholders do not have sufficient training to progressively elaborate a schedule to CPM standards
- The current stakeholders believe they do not have enough time to progressively elaborate a schedule to CPM standards
- There may be the inclination to adapt a live schedule to show the project as meeting its deadlines in order to avoid criticism
- A live schedule showing a late finish even if it is reality may leave the sites open to criticism

However, interviewees also noted that the time spent would yield a more valuable tool for managing the project and would facilitate better management of the site through the highly detailed planning and regular revision of future activities which may identify trade clashes, suggesting that the additional time and training would be beneficial to the team. One interviewee raised a point that on all of their previous projects the first ten to twelve weeks were normally on schedule, suggesting that the short term scheduling to high detail actually prevents delay, potentially preventing further workload to rectify delays.

Based on the research from the interviews the recommendations for improvement would be to:

- Further define a schedule management system around the framework developed from the literature review.
- Ensure short term schedules are being used on all sites
- Share best practice in short term schedules
- Provide a feedback loop from framework to short tern schedules to assist senior management

Finally, to improve the accuracy of the short terms schedule rather than merely tracking progress, monthly updates should encompass past and future details of tasks as explained in the theoretical research. The recording of past tasks would allow an accurate assessment of their impact on future tasks and the regular review and revision of future tasks would retain the schedule accuracy. This would be carried out at the short term schedule's detailed level, elaborating

future tasks as the project is executed and this would feed back into the project schedules supporting decision making.

A Future stage would be to develop these recommendations into an implementation and roll-out plan to test the resource, training and time required as well as whether or not they are achievable.

REFERENCES

AHCOM, Junaid and SHASH, Ali Ali. 2005. Planning and Scheduling Department: Functional Aspects, AACE International Transactions, PS (12), 1-8

BASU, Abhi. 2008 Business Rules in CPM Scheduling Software, AACE International Transactions, PS (01) 1-10

BAWEJA, Satinder 2003 What is Construction Schedule Control? Cost Engineering 45 (1) 8

BSI (BRITISH STANDARDS INSTITUTION) 2006 BS 6079-4 Project Management, Part 2: Guide to project management in the construction industry, London, British Standards Institution

CIOB (CHARTERED INSTITUTE OF BUILDING) 1991 Planning and Programming in Construction: A Guide to Good Practice, CIOB

CIOB (CHARTERED INSTITUTE OF BUILDING)2011 Guide to Good Practice in the Management of Time in Complex Projects, Chichester, Wiley-Blackwell

FANIRAN, Olusegan Oyewale, LENARD, Dermis and ULOWOYE, Jacob Oludoye 1994 Effective Construction Planning, Construction Management and Economics, 12 (6) 485-499

GIDAGO, Kassim 2002 Enhancing the Prime Contractor's Pre-Construction Planning, Journal of Construction Research, 5 (01) 87-106

JOHANSEN, Eric and WILSON, Brian 2006 Investigating First Planning in Construction, Construction Management and Economics, 24 (12) 1305-1314

KELSEY, John and WINCH, Graham 2005 What do construction project planners do?

International Journal of Project Management, 23 (2005) 141-149

KERZNER, Harold 2009 Project Management: A Systems Approach to Planning, Scheduling] and Control, 10th Ed., New Jersey, John-Wiley and Sons

KIER GROUP 2013 Welcome to Kier Group, [online], Last accessed 18th February 2013 at http://www.kier.co.uk/default.asp

LAUFER, A. and TUCKER, R. 1987 Is Construction Project Planning Really Doing its Job?

A Critical Examination of Focus, Role and Process, Construction Management and Economics, (3) 243-266

LESTER, Albert 2007 Project Management, Planning and Control, 5th Edition, Oxford, Elsevier

LEWIS, James P 2001 Project Planning, Scheduling and Control: A Hands-On Guide to Bringing Projects in On Time and On Budget, 3rd Edition, New York, McGraw Hill

MIY AGA W A, Tetsuya 1997 Construction Manageability Planning - A System for Manageability Analysis in Construction Planning, Automation in Construction, 6 (1997) 175-191

MUBARAK, Saleh 2010 Construction Project Scheduling and Control, 2nd Edition, New Jersey, John

NAOUM, S. G. 2007 Dissertation Research and Writing for Construction Students, 2nd Edition, New York, Routledge

SARKAR, Amit 2008 Construction Scheduling: Keeping Relevance, AACE International Transaction PS (10) 1-3

SMITH, Melvyn 2007 The importance of proper programming, Contract Journal, 440 (6641) 28

STEPHENSON, H. Lance 2006 Scheduling: The Good, the Bad and the Ugly, AACE International Transactions, PS (09) 1-9

VAKHARIA, Russell 2006 Innovative Approaches to CPM Scheduling Management, AACE International Transactions, PS (11) 1-6

VERETO, Craig E 1994 The Relationship Between Planning and Safety, Cost Engineering, 36 (4) 23-26

THE UTILISATION OF FRUGAL ENGINEERING WITHIN THE CONSTRUCTION INDUSTRY

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This paper addresses whether or not the philosophy of frugal engineering can be applied within the construction industry. A critical review of literature and detailed analysis of primary research has been undertaken and the findings presented. The conducted research showed that there is a definite need within the construction industry to reduce its consumption of scarce resources. The construction industry is the second largest consumer of resources after the food industry. Much of the material used in construction is unsustainable and cannot continue. Material use within the industry could definitely be reduced through the implementation of a new system during the design and construction phases, but for this to happen it requires government intervention and for the general public to bring the issue of material scarcity to the forefront, thus overcoming the many barriers.

Keywords: Sustainable Materials Utilisation, Economic Construction, Frugal Engineering

INTRODUCTION

The word frugal is defined by the Oxford Dictionary (2012) as meaning "sparing or economical as regards money or food". For the purpose of this paper the term 'frugal' will not be considered in terms of being sparing with money but rather sparing with material usage. The term engineering is defined by the Oxford

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Dictionary (2012) as the branch of science and technology concerned with the design, building and use of structures. Therefore the term frugal engineering will be accepted as the sparing or economical use of materials during the design, construction and use of buildings.

During the 20th century resource use reached unsustainable levels and this trend has continued into the 21st century. Around 50% of all global resources go into the construction industry (CIOB, 2009).

The construction industry is by far one of the main offenders when it comes to resource depletion, so therefore it is essential that designers responsible for these buildings take it upon themselves to play an active role in the reduction of material use within our industry. The obvious architectural trends from decade to decade are an example of how designers can influence consumer demand and thus material and energy consumption. It is considered that architects have always been – and have always needed to be – part artist, part technician and part politician and therefore can be the driving force behind change within the industry (Fernandez, 2006).

The main aim of this paper is to investigate, through using the appropriate research methods, whether the amount of raw materials used in the construction industry can be reduced to a sustainable level through the process of 'frugal engineering' which is concerned with achieving more with less.

METHODS

For the purpose of this paper both primary and secondary data have been collected and utilised. Feather (2012) opines that "primary data is the knowledge [one] is intending to collect for [their] study, and may be referred to as 'tacit knowledge'. That is, where the information is not in the public domain per se, but is instead, held (in the mind) by those you are targeting as your representative sample". The main advantage of primary data is that it is specific to the topic which one is researching.

According to Feather (2012) secondary data is data that can be accessed through textbooks, reports, journals, trade magazines, the internet and many other sources. Secondary data is research that has already been carried out and the results and conclusions are available for all to see. The main advantages of secondary data are that the data has already been collected and so saves time and also it may contain information that the researcher was unable to obtain. Secondary data has been collected as part of the literature review.

Quantitative Research

Quantitative research is based on scientific method used to test hypothetical deductive generalisations. It is objective and is based on the collection of statistics and other measurable, empirical data. The philosophy behind this approach is positivism. Amaratunga et el, (2002) advocates that positivism searches for casual explanations and fundamental laws, and generally reduces the whole to the simplest possible elements in order to facilitate analysis.

Qualitative Research

Qualitative research is based on subjective data items, which cannot be given a numeric data value. An example of qualitative data would be data collected through an interview which gathers the thoughts and opinions of specific individuals on a specific topic. The philosophy of qualitative research is phenomenography which is described by Amaratunga et el, (2002) as a naturalistic approach to inductively and holistically understand human experience. This approach tries to understand and explain a phenomenon, rather than search for causes or fundamental laws.

Research Rationale

For this paper the author has collected qualitative data rather than quantitative data. The rationale for selecting to adopt the qualitative method is due to the depth of explanation required. To gain a true understanding of the thought process involved with material selection and the reasoning behind it only offers itself to the qualitative approach. Collecting numerical data may give an indication of what number of participants understands frugal engineering and what number of participants have applied the philosophy on projects. But it will not give the reasoning behind their decisions and one of the key objectives of this paper is to understand what barriers the participants feel they face and what drivers there are to enforce sustainable resource use so therefore quantitative research would not be appropriate. The qualitative data has been collected be collected through semi structured interviews.

Participant Selection

The author of this paper is employed by one of the UK's largest construction companies and therefore has access to a large variety of architects and also to a diverse range of projects starting in value from £1m and increasing to £35m. The reason for solely selecting architects is because they are the ones who are responsible for material selection. Although other construction professionals may have an influence over material selection the final decision lies in the hands of the architect, so it is considered appropriate that the sole focus of this research is based around understanding the rationale behind their selection process. The

author selected six architects from six different companies. It was decided by the author that each architect who was to be interviewed should have a minimum of ten years' experience within the construction industry. It was also considered important that each architect selected had worked for both private and public sector clients and had experience within both commercial and residential projects.

LITERATURE REVIEW

In 2010 the UK government released the strategy "Sustainable Growth" in which the need to maximise the effective use of scarce natural resources was highlighted.

Materials

For simplicity materials will be defined as either 'renewable' or 'non-renewable'. Renewable resources, such as timber, can be planned to be continuously available without depletion, whereas non-renewable resources are those that can only be harvested once or those that are formed extremely slowly such as crude oil. These are often referred to as 'stocks' (Berge, 2009).

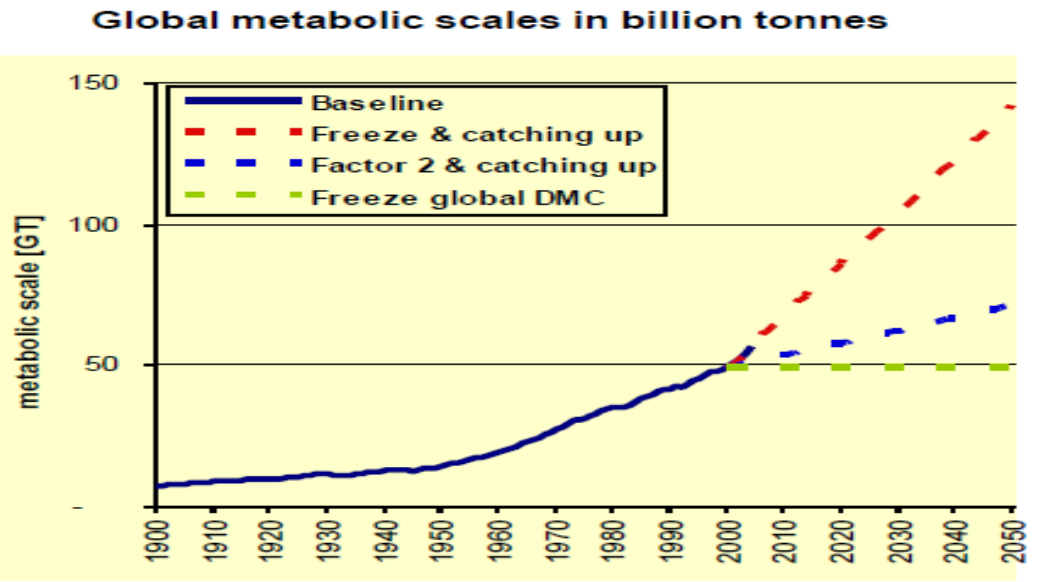

Figure 1. Global metabolic scales in billions of tonnes

The European Commission (2011) states that renewable resources are currently being used much faster than they can be replenished, for example timber. Vanegas *et al* (nd.) also points out that non-renewables only have limited

quantities and once these have gone they cannot be replenished and these are also being used at an unsustainable rate. Figure 1 shows the future predictions for resources used, identifying three possible scenarios established by Fischer-Kowalski (2009)

It is the overconsumption of resources that is contributing to the greatest environmental challenge of the 21st Century. As one of the largest consumers of resources, the construction sector is a critical contributor to this trend.

Factors Effecting Material Scarcity

Rapid Growth

There are many key factors that can be attributed to the mass increase in raw material use, but arguably the most significant is the mass increase in population during the 20th century. The population has increased from 1.6 billion at the start of the 20th century to a staggering 6.1 billion by 2005. The vast majority of the population growth has taken place in countries which are not part of the Organization for Economic Co-operation and Development (OECD). The OECD consists of around 30 countries that are of high income and are considered developed so therefore by a large majority the main increase in population has over the past century taken place in countries that are undeveloped in areas such as Africa and Asia (Wouters & Bol, 2009).

New Technology

New technology can be attributed in many ways to increased material use. Firstly technology has improved mining processes, making materials that were once uneconomical to mine now economically viable.

Wealth and Prosperity

People in the West have never been so wealthy and with this wealth they consume more materials. People now own larger homes than before requiring more and more materials. According to Berge (2009) space use per person has doubled in the western world since 1960.

Urbanisation

With the rapid population growth in the 20th century, a move from the countryside into the cities took place. The modern city is the largest accumulation of materials and harnessed energy ever assembled. It is estimated that our cities, past and present, existing and dissolved have together consumed and retained upwards of 75% of all materials ever extracted by humans (Fernandez, 2006).

Social Demand

The change in the way people live and work has dramatically changed the amount of new construction required. As the decades advance the rate of change also increases rapidly. Castles and cathedrals which were built to last for a thousand years are no longer required. Some of today's buildings are designed to have only a forty year lifespan and it is common for many properties to be torn down before then. Commercial offices are a prime example.

Reducing Material Utilisation

Increased Efficiency

Vanegas et al (nd.) postulate that one strategy for minimising consumption in the construction industry is to improve technological efficiency of materials and processes. A need to improve the efficiency with which materials meet the needs for which they are used is required. The key aim of this is to do more with less. An example of this is given by Wouters & Bol, (2009) in which they discuss the low reserves of zinc and how technologies are being developed for applying lower weighted coatings of zinc to steel, so as to preserve it for as long as possible, until a suitable alternative can be found. Berge (2009) explains how maximising the potential of certain materials can greatly reduce the amount required; leading to smaller amounts being extracted from the earth, this point needs to be considered at the design stage of construction projects.

Interviewee A supports this and claims that architects do not have the resources, nor time to carry out extensive research on materials. Architects use the materials that have been made available to them. Interviewee A explains that if each material decision were systematically based on each situation then there would often be different results in the design of buildings, but in real life scenarios where budgets are tight and clients are demanding, the time is not there to make these decisions so the decisions are simplified by making ones that have worked in the past. Interviewee C believes that for the technological efficiency of materials to be improved and for these materials to become commonly available for the architect to specify the government has to provide appropriate funding to allow this research to be undertaken by various environmental bodies such as BREEAM.

Substitution

This method requires scarce materials being substituted for materials that are not in danger of exhaustion, for example stone. Also substituting materials with renewable resources is a practice that should be adopted (Berge, 2009). In some cases however, this is not as straight forward as it may seem. Although a scarce

material may be saved, the energy required to source its replacement might be far greater so therefore outweigh any original benefit of substituting.

Reuse

Another method that can reduce the amount of materials used in construction is to reuse what has already been extracted. Fernandez (2006) explains how buildings are discarded well before there service lifetime has expired. This is due to obsolescence, as they did no longer meet the current needs required of them and so were demolished replaced with new buildings. One of the reasons buildings are not being reused is that when designing its future flexibility was not taken into consideration. It is this static approach, in a society characterized by rather rapid changes both in cultural patterns and technology, which means that buildings are often demolished well before their intended lifetime is over (Berge, 2009). This is a reckless waste of the earth's resources and a response to this must be designing buildings which have a greater adaptive capacity. To allow this the three following principles must be addressed at the design stage; 1, design general spaces which allow for a broad range of activities, 2, design buildings that are flexible and allow for easy changes to floor plans as well as technical systems. Interviewee E stated that concrete or masonry internal walls should be avoided if possible, as they do not allow for easy adaption, 3, designs should be "elastic" meaning that buildings which are designed to only have a short life time should be simple to disassemble (Berge, 2009).

Recycle

Figures taken from the HM Government (BIS, 2008) report on 'Strategy for sustainable construction' show that, on average, the construction industry uses around 400 million tonnes of materials each year of which an average 90 million tonnes goes to landfill waste. The Government is fully aware of the problems associated with waste within the construction industry and took action in 2008 by introducing the halving waste to landfill initiative. The government committed to halving waste to landfill from 2008 levels by 2012. This is now helping drive construction companies towards recycling all construction waste, rather than sending it straight to landfill.

Barriers to Material Utilisation Reduction

Global Population

The world population has increased from 1.6 billion at the start of the 20th century to a staggering 6.1 billion by 2005. This expansion has and will continue to place extraordinary demands upon the world's limited resources.

Emergence of Threshold Companies

The high consumption rate of industrial nations is currently still being compensated for by the low consumption rate of some poorer countries. However, the rise of threshold countries is leading to an increase in demand. According to the Ministry of foreign affairs (2012) non Western countries and regions such as China, Brazil and India are beginning to gain in economic and political power and with increased wealth and prosperity comes increased material use.

Geopolitical

Many raw materials can only be sourced from certain parts of the world, for example 60% of the world's iron ore can only be found in three countries: Australia, Brazil and China. Another example is rare earth metals and 95% of these are found in China. If like China other nations decide to put trade restrictions on their materials and start storing reserves for their own use this will put further pressure on raw material markets and may lead to conflict (Ministry of foreign affairs, 2012).

Client/Costs

Client and cost are paired together for the reason that any additional cost associated with frugal design is a cost which has to be absorbed by the client, so, unless the client is willing to pay the additional design fees then there will be no opportunity for frugal design. Interviewees A, B, C, D and E all agreed that one of the biggest barriers to achieving frugal engineering is the client. Interviewee A explained further, that due to the current lack of knowledge surrounding scarce materials a great deal of extra research would have to be carried out during the design stage to ensure that every possible option had been considered.

Attitude of Society

According to Weizsacker et al (2001) changing the direction of progress is not something a book [or research paper] can do. It has to be done by people – consumers and voters, managers and engineers, politicians and communicators. People do not change their habits unless they have a good reason for doing so. Motivation needs to be experienced as compelling and urgent by a critical mass of people; otherwise there won't be enough momentum to change the course of our civilisation. Interviewee B supports this opinion by stating that a change in how society perceives material usage is vital. Although interviewees A, C, and D argue that change must start with the client.

Drivers of Change

Market Conditions

The financial crisis in 2008 has hit all economies worldwide with unforeseeable consequences. China and other Asian emerging economies have seemed to recover rather quickly and have managed to maintain positive growth rates. Europe, the US and most developing countries are still struggling with secondary effects of the financial crisis, namely with high public deficits (O'Brien et al, 2011)

Therefore they are far less likely to engage with new materials or concepts of frugality.

Reducing Carbon Emissions

In 2008 the UK Government set legally binding targets through the 2008 Climate Change Act to reduce carbon emissions by 80% by the year 2050 compared to 1990 levels and at least 34% by 2020 (HM Government, 2009)

Environmental Bodies

Interviewee B states that it was the continued work of various environmental agencies such the WWF and Greenpeace who's campaigning bought the issue of global warming into the public eye. Interviewee B claims that if it had not been for the work carried out by such agencies bringing the topic to the forefront and providing evidence to show that there is a clear threat from global warming then neither society nor government would have acted and Interviewee B believes that the same push now needs to come with regards to material use.

Legislation

Although legislation is considered as one of the barriers to frugal engineering due to there not being any specific legislation in place to govern raw material use, there are a number of fiscal and legislative tools already driving up resource efficiency in the construction sector and driving down waste production. The only concern is that these measures are dealing with the materials once they have been extracted, rather than preventing their extraction in the first place, albeit by introducing such measures as those that follow will encourage more recycling.

Higher Material Costs

According to O'Brien et al (2011) survey results indicate that prices for building materials are not considered strong incentives to innovate or to search for more environmentally friendly or less scarce substitutes. The relevance of price is expected to gain momentum in the construction sector, and this is because, as materials become scarcer their price has to rise. This happens for two key

reasons, first is supply versus demand. When demand is high and supply is low the cost rises. The second reason for the price rising is to allow the mining companies to search for further stocks or mine stocks which were previously uneconomical at the lower price. Prices will begin to rise for these reasons and when this does happen it will make the unsustainable consumption of materials incredibly costly, forcing customers to reduce their material demands.

The Emergence of Frugal Engineering

The use of Frugal Engineering is beginning to gain some momentum in the construction sector. Interviewees A, B & E all noted that clients are becoming far more aware of the need to engage in the concept.

Material Rationing a Radical Solution

The concept of material rationing in construction is a theory that has been considered by this author in response to the issue of material scarcity. Material rationing could work by giving the design team a set amount of materials to be utilised on a given construction project. Each project would be given a certain quantity and this quantity would be based on the level of that materials scarcity and environmental impact. Timber for example would be a material that is allowed in large quantities as it is a renewable resource which through careful management can be regenerated to meet global demand. It is non-renewable resources such as oil whose use must be rationed. Materials which use large quantities of energy during their production must also be strictly rationed, as this uses fossil fuels, which are essential to modern industrialised ways. It would seem that this is another topic worth researching, with regard to its feasibility.

CONCLUSIONS

Due to the vast increase of material use over the past centuries it is apparent that this trend cannot continue, as many of the earth's resources are becoming scarcer, with particular concern around fossil fuels which are the driving force behind the modern world. For future generations to be able to have access to the same materials that the current generation have benefited from there needs to be a method in place which is accepted throughout the industry that reduces raw material use. Material use has become unsustainable due to the large boom in the world population during the mid-20th century. This coupled with new technologies, improved transport and increased wealth has led to levels which cannot be sustained for much longer.

Many argue that material scarcity is not a real threat as the earth has future supplies of raw materials which will last for millions of years and that solving material scarcity is simply a solution of just discovering more but this is a very

naïve approach as material scarcity is not just about physical limits. Material scarcity can present itself in other ways. This is the issue of supply and demand. The world population is continually growing putting further strain on the mining and manufacturing industries, who simply cannot keep up with demand.

The UK construction industry will need to prepare itself for major shortages of construction materials as the majority of materials used in UK construction are imported from overseas. This is why the construction industry needs to develop methods of building the same buildings whilst using fewer materials. The buildings will still perform to the same standards and will have to comply with statutory regulations but many non-essential materials could be removed.

The concept of frugal engineering will be a lot easier to implement in countries which are only just becoming developed, as they do not have the same building regulations we have in the UK. Asia is where the concept of frugal engineering was born and therefore the Asian people are already accustomed to this style of design.

It is changing the attitudes of those who already live in fully developed countries where the problem will lie, as these people have become accustomed to a certain standard of living and the challenge will be how to still maintain this standard of living whilst using fewer materials.

One of the biggest barriers to implementing a system of frugal engineering is the attitude of society. There are many reasons that society has a key role to play in making this change possible. Until the public actually demand lower material use in the buildings they require a change will not happen. The research undertaken has shown that although architects decide what materials are used it is the client who can have the biggest impact on reducing their use. This is because frugal design would initially take longer and so would cost the client more money. If the client does not have the opinion that the additional money is actually a worthy investment then they will not do it. This has already been shown in the carbon reduction push. Many clients now feel they have a social responsibility to reduce their carbon footprint and so are willing to spend additional money on introducing sustainable technologies to their buildings. This is exactly what needs to happen with material use.

A huge amount of legislation exists which is directed at the construction industry and aimed at key areas of sustainable development, such as reducing carbon emissions and reducing waste, but yet, there is no legislation currently in place to prevent irresponsible use of materials.

The key behind change is to create awareness amongst those who are responsible for design and implant the philosophy of frugal engineering into their thought process. This needs to be supported by government legislation.

Perceived that such strategies would have very limited success.

The analysis of data proves that the philosophy of frugal engineering could be implemented into the construction industry but the biggest barrier would be changing the attitude of society. Implementing frugal engineering in less developed countries would be far simpler as their building standards are not governed by such tight regulations. To implement frugal engineering within western countries would require a significant amount of research into material use. This research would require a significant amount of funding from the government. The government will not only require significant proof that material scarcity is an imminent threat; it will also require public demand for any push for change. It is the general public who are the biggest clients of the construction industry, therefore the change needs to come from them and it also requires supporting by government funding and legislation.

REFERENCES

AMARATUNGA , D., et al, 2002. Quantitative and qualitative research in the built environment: Application of mixed research approach. Retrieved online August 8, 2012, From Emerald Research: http://www.emeraldinsight.com/journals.htm?articleid=851373

BADEN-POWELL, C., 2008. Architects Pocket Book .3rd edition. Oxford: Elsevier Ltd publishing.

BERGE, B., 2009. The Ecology of Building Materials .2nd edition. Oxford: Elsevier Ltd publishing.

BIS 2008. The Strategy for Sustainable Construction Retrieved online July 3, 2012 http://webarchive.nationalarchives.gov.uk/+http:/fberr.gov.uk/policies/business - sectors/construction/sustainable-construction

CHARTERED INSTITUTE OF BUILDING, 2012, Sustainability and Construction. Retrieved online June 16, 2012, From CIOB: www.ipbassociates.com/.../Sustainability_construction_1287073859

EUROPEAN COMMISSION, 2011, Resource Efficiency: A Business Imperative. Retrieved online July 3, 2012,From:https://docs.google.com/viewer?a=v&q=cache:SLuQhi1lGfMJ:ec.europa.eu/environment/pubs/pdf/factsheets/resource_efficiency/en.pdf+resource+efficiency+a+business+imperative

EUROPEAN COMMISSION, 2013, Science for Environment Policy – Resource Efficiency Indicators. Retrieved online March 2, 2013, from European Commission: http://ec.europa.eu/environment/integration/research/newsalert/index_en.htm

FEATHER, D., 2012. University of Huddersfield: How to write a research methodology for an undergraduate dissertation. Retrieved online 18 July, 2012, From University of Huddersfield: http://eprints.hud.ac.uk/13299/

FERNANDER, J., 2006. Material Architecture: Emergent Materials for Innovative Buildings and Ecological Construction. Oxford: Elsevier Ltd publishing

FISCHER-KOWALSKI, M., 2009. A Hundred Years of Resource Use of the World Economy: Dynamics, Drivers and Impacts. Retrieved online June 18, 2012, From Institute of Social Ecology: www.worldresourcesforum.org/files/fischer-kowalski.pdf

HM GOVERNMENT 2009.2050 Pathways Analysis July 2010 Retrieved online June 18, 2012 From https:llwww.gov.uk/govemment/uploads/systern/uploads/attachment_data/file/425621 216-2050-pathways-analysis-report.pdf

MINISTRY OF FOREIGN AFFAIRS, 2012, Policy Document on Raw Materials. Retrieved online May 24, 2012, From Ministry of foreign affairs: http://www.minbuza.nl/en/key-topics/development-cooperation/dutch-development-policy/millennium-development-goals-mdgs/dutch-aim-for-mdg-7/dutch-government-policy-document-on-raw-materials.html

O'BRIEN, M. 2011 Resource-efficient construction: A systemic approach to sustainable construction. Eco-Innovation Observatory: Retrieved online June 18,2012 From http://ec.europa.eu/environment/ecoinnovation2012/1scforurn/pdf/eio_construction_ brief4.pdf

VANEGAS,J., DUBOSE, J., PEARCE, A., nd. Sustainable Technologies for the Building Construction Industry. (s.l): (s.n)

WEIZSACKER, E., LOVINS, A., LOVINS, L., 2001. Factor Four: Doubling Wealth, Halving Resource Use. London: Earthscan publications Ltd

WOUTERS, H., BOL, D., 2009. Materials Innovation Institute: Material Scarcity. Retrieved online May 17, 2012, From: www.m2i.nl/images/stories/m2i%20material_scarcity%20report.pdf

FURTHER EXPLORATION OF THE IMPORTANCE OF EARLY CONTRACTOR INVOLVEMENTS IN SUSTAINABLE BUILDS

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The timing of contractors' involvement in a sustainable build is a key factor in the success of the build. This paper explores the timing of contactor involvement from a contractor's perspective. The research adopted themes from the literature and re-examined these to establish the progress that has been made. The research has shown whilst clients are more willing to undertake sustainable construction and there are sound reasons why early contractor involvement is desirable contractors clearly perceive that they still need to be procured early and given more time in pre-construction to optimise sustainable builds for the client.

Keywords: Sustainable, Development, Contractor

INTRODUCTION

This paper explores a key finding of the dissertation "Sustainable Development: The Duties and Views of Main Contractors to Endure Future Sustainable Demands" (Musson 2013), that is, the need for early contractor involvement in sustainable builds. The dissertation examined several aspect of a main contractors views in regard to their contribution to sustainable developments including staff training, procurement issues and timeliness of involvement. This paper focuses on the timeliness aspect of the work.

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LITERATURE REVIEW

When examining the case for sustainable building Hartenberger (2009) concluded that the role of contractors going forward is to provide the best cost effective solutions to reduce carbon emissions. This would require greater investment into training the construction industry to provide information to clients and support the contractor's role. Whilst the focus on technical aspect such as energy efficiency and greater use of renewable energy sources are the main response to climate change and reducing Europe's energy import requirements from other areas of the world, to be successful in tackling climate change the construction industry must be able to bring together all stakeholders and increase real citizen participation, that is the procedural and managerial aspects are as critical as the technical solutions.

This is similar to British Standard 8900, (BS 2010) which promotes inclusivity as a key aspect of aspect of managing sustainable development.

Figure 1 shows a circle diagram presented by Hartenberger (2009) which states what each party's view is on sustainable buildings.

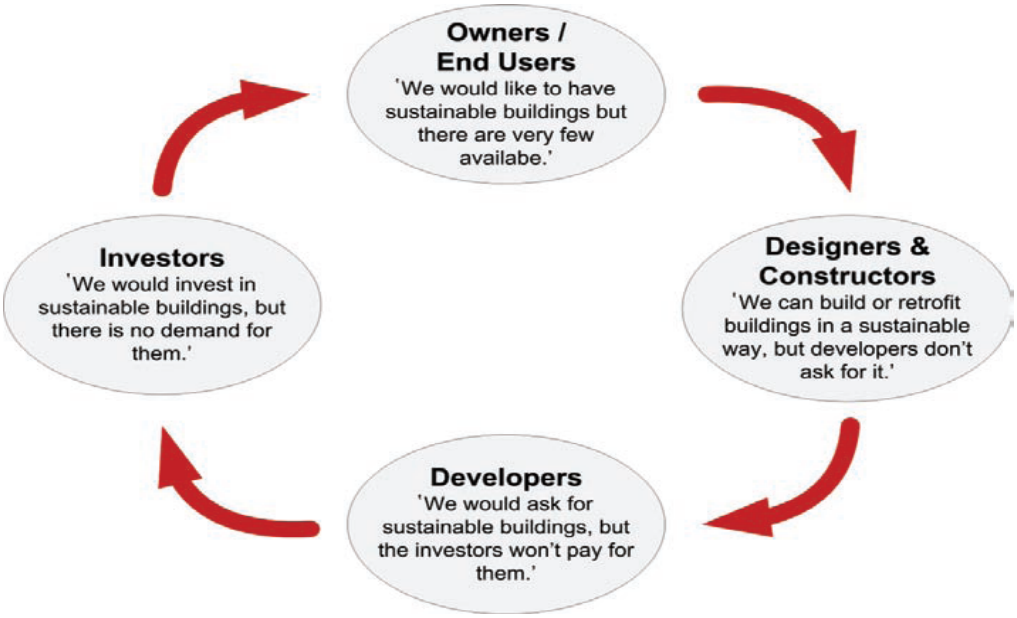

Figure 1 Vicious Circle of Blame, Hartenberger (2009, page 3)

Figure 1 shows that few developers ask for sustainable buildings because investors will not invest due to a lack of demand, even though owners would like sustainable buildings. Hartenberger (2009) concludes that investors

(funders) are the main barrier. Main contractors need to support clients in obtaining funding; this may include educating their investors on sustainable buildings and illustrating why there is a need and demand for change.

The Construction Industry Research and Information Association (CIRIA) has shown that at tender stage the priority is to meet the clients brief with a competitive price and programme. Sustainable concepts if not inputted early enough are not likely to be added later on in the design stage, in fact typically sustainable concepts are lost later when detailed cost plans have been provided and the value engineering processes has begun in order to achieve the clients budget (CIRIA, 2004). Contractors, their novated designers and supply chain need to ensure sustainable concepts are not the first items to be omitted through the value engineering process; if they are the alternative needs to achieve the sustainable requirements.

The supply chain needs to be involved in the process as early as possible as they can propose services and products with better sustainable features and cost solutions as they are the specialists in their trade. If technical solutions that support sustainable concepts are achieved, they must be presented in a good "sales pitch" manner. Failure to do this will mean clients and investors will not be interested, hence the need for an early supply chain involvement. (CIRIA 2004).

CIRIA (2011) also state that contractors and suppliers can provide expert advice on sustainable solutions that can benefit both initial costs and costs over the building life cycle. Hence, ensuring a contractor and supply chain is involved early is the key to obtaining a sustainable building. Although builders do not have influence over the owner's behaviour, they do have the advantage of influencing it in the way a project is designed and through incentives to the consumers and maintenance. Surveys have shown that contractors that are already doing this have two advantages; compliance over and above legislation and influencing their company's reputation. (WWF,nd)

A survey by the Chartered Institute of Builders (CIOB) studying the barriers of the construction industry to sustainable buildings found that to progress the top four improvements needed were clients, government, end users and designers. Figure 2 shows these findings. Note compared to the RICS report the viscous circle of blame and the CIRIA, cost does not appear to be an issue being the 6th barrier with contractors being the 5th barrier. Typically, there is an agreement between all the reports that end users need to be educated with them being the 4th barrier as this will create a greater demand. CIOB (2007).

Out of the CIOB research of 847 construction industry individuals, 744 felt that zero carbon buildings could not currently be achieved. Three of the top reasons were because of no financial incentive, not enough client demand and a lack of definition to what a zero carbon building is. Figure 2 show these findings. Although contractors appeared to be a barrier in the 1st element of research, shortage of specialist skills appears to not be a barrier in delivering zero carbon projects. This may mean that main contractors are viewed as a barrier and not their specialist contractors.

The CIOB publication expressed that for clients to educate their investors and stakeholders in investing, contractors and designers need to provide the best data on products and materials to support sustainable design (Sodagar & Feildson 2008). Strategic Partnering for the supply of materials and services provides opportunities for investment and team development. Suppliers can add value to projects by contributing to the delivery of the project, which may save time, cost, improve quality and ensure compliance to the client's requirements. Contractors can improve by monitoring their performance and effectiveness of the partnership, with savings shared amongst the appropriate team members. (RIBA 2003).

The view from The Department of Trade and Industry (DTI 2006) is that to obtain sustainable construction, construction programmes with sufficient time, robust information and early input with suppliers are needed. Developing and supporting well focused and capable public sector clients, designers and contractor teams with a long term supply chain , would ensure more thought is put into the preconstruction phase of the project. This would improve the team relationship and help them work together towards a more sustainable project. Designing and decision-making based on "whole life value" would result in the building being more sustainable, reflecting the greatest amount of impact a building has on the environment, namely its use. This calls for more time and resources in the design and the preconstruction phase, before key decisions are made, to weigh up the true value of materials over long term and not just initial stages. This may mean having contractors and the sub contract team on board early to utilise their technical skills and knowledge. Using appropriate procurement and contracting strategies and working collaboratively through fully integrated teams, would ensure improvement is made by lessons learnt and troubleshooting from previous projects.

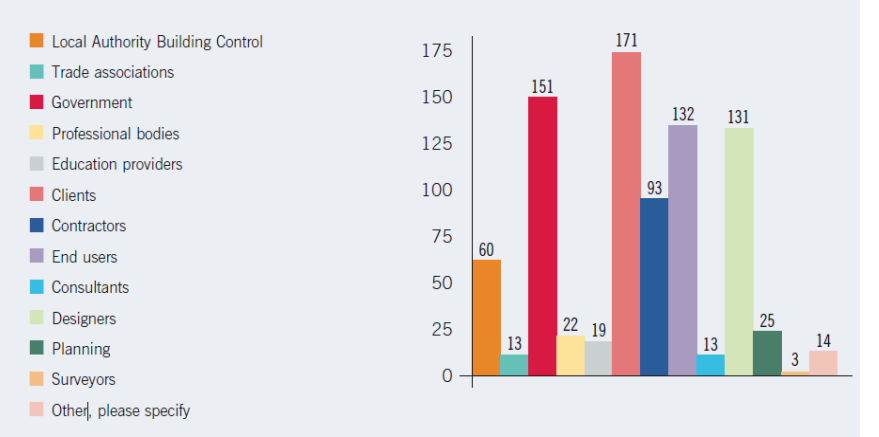

Figure 2 Who needs the most improvement in sustainability? (CIOB, 2007, page 13)

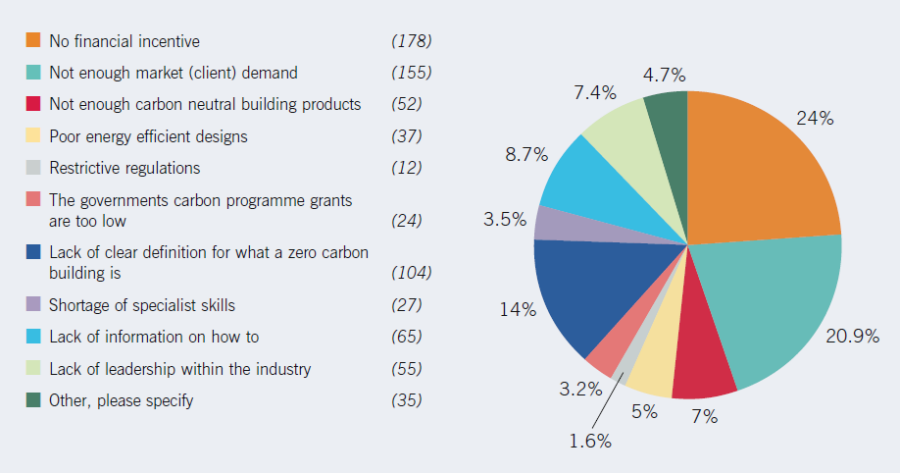

Figure 3 What is the main barrier to sustainable projects? (CIOB 2007)

Figure 4 shows research from Williams and Dair (2006) which highlights the barriers main contractors experienced in developing sustainable buildings alongside their clients. Figure 4 shows the most commonly reported barrier was that sustainability was not being considered by any of the parties including the contractor. From the contractors point of view they feel they have no power to influence sustainable projects. Materials were yet to be tested prior to having the confidence of using them. The contractor had a lack of confidence and training into sustainable projects. To allow sustainable aspirations to be met, contractors feel that they need to be involved in the pre-construction process earlier.

	Barrier to acting sustainably	Incidence of ba
1	Sustainability measure was not considered by stakeholders	By far the most cor recorded barrier
2	Sustainability measure was not required by client (includes purchasers, tenants and end users)	Commonly recorde
3	Stakeholder had no power to enforce or require sustainable measure (in some cases it was the responsibility of the client or the contractor)	Commonly recorde
4	One sustainability measure was forgone in order to achieve another (traded)	Commonly recorde
5	Sustainable measure was restricted, or not allowed, by regulators	Commonly recorde
6	The sustainability measure cost too much (in some cases the investor would not fund)	Commonly recorde
7	Site conditions mitigated against the use of a sustainable measure	Commonly recorde
8	Inadequate, untested or unreliable sustainable materials, products or systems (including long term management problems)	Commonly recorde
9	Sustainable measure was not available	Commonly recorde
10	An unsustainable measure was allowed by the regulator or statutory undertaker (so no impetus for a sustainable alternative to be used)	Infrequently record
11	Stakeholder was not included, or was included too late, in the development process to implement sustainability measure	Infrequently record
12	Stakeholder lacked information, unawareness or expertise to achieve sustainable measure	Infrequently record

Figure 4 Barriers foreseen by main contractors, Williams and Dair (2006, page 7)

Sustainably literature and early involvement of contractors.

Not only does the literature addressing contractors broad involvement in sustainable construction highlight the desirability of contractors to be involved in pre-construction activities detailed guidance on specific aspects of sustainable construction also make the case. Within the guidance on Designing out Waste in Buildings (WRAP nd.) the project design team is envisaged as including specialist contractors to ensure the best opportunities for waste minimisation are adopted with several aspects of the guidance calling on knowledge that is part of the contractors expertise such as Off-Site construction. Again within Efficient use of Materials in Regeneration Projects guidance (WRAP nd.) the role and responsibilities of the contractor include contributions to the outline design phase such as producing pre-demolition audits. Within BREEAM early contractor, involvement is envisaged, for example in addressing the issue of sustainable procurement (Man01) the contractor is required to be involved with the project judgments from RIBA stage B.

Contractual Context

Contracts such as the Joint Contracts Tribunal (JCT) have recognised there is a need to place sustainable requirements within contracts to facilitate improvements in sustainability and making sure consideration is given within

the pre-construction period. Quotes such as below from the JCT guidance notes show how this can be done;

"The Provider will assist the Employer and the other Project Participants in exploring ways in which the environmental performance and sustainability of the Tasks might be improved and environmental impact reduced. For instance, the selection of products and materials and/or the adoption of construction/engineering techniques and processes which result in or involve:

- *reductions in waste;*
- *reductions in energy consumption;*
- *reductions in mains water consumption;*
- *reductions in CO2 emissions;*
- *reductions in materials from non-renewable sources;*
- *reductions in commercial vehicle movements;*
- *maintenance or optimisation of biodiversity;*
- *maintenance or optimisation of ecologically valuable habitat; and*
- *improvements in whole life performance.*

The Contractor shall provide to the Employer all information that he reasonably requests regarding the environmental impact of the supply and use of materials and goods which the Contractor selects.

The Provider is encouraged to suggest changes to Tasks which, if implemented, would result in financial benefits to the Employer. Such benefits may arise in the form of:

- *a reduction in the capital cost of the project of which the Tasks form part;*
- *a reduction in the life cycle and/or operating costs associated with the project;*
- *This places burden on others to supply what the client required whilst waiting for legislation to be updated to assist future demands."*

JCT (2009, page 6-7)

Early Contractor Involvement (ECI) is concept that has been formalised in the literature over the past few years. There are several views on ECI, with that proposed by Nichols (2007) being widely accepted, "ECI is a form of partnering with the contractor appointed earlier than usual to help in planning, advise on 'buildability', and jointly develop a Target Price as the basis for a pain/gain share formula in the contract". Is it reasonable to propose that ECI should be the framework under which sustainable construction is undertaken? Rahman and

Alhassan (2012) collate the benefits (and drawbacks) of ECI presented in the wider literature. Amongst these are:

- "Improved buildability and reduced design errors"
- "Quality Improvements"
- "Potential for innovation / creativity"
- "Mutual learning and knowledge sharing"

These benefits could equally be applied to sustainability as any other aspect of the project.

ECI can be supported by a number of contractual approaches. In the past bespoke forms were often used (RICS, 2010), more recently JCT Pre-Construction Services Agreement has been produced to support the contractor being involved early in the project lifecycle. Indeed JCT state "*The Contractor's involvement and advice during the pre-construction period, as to (inter alia) programme, cost plans, buildability and specialist procurement as well as the final design and preparations for the construction phase, is generally valuable and often essential, particularly in Design and Build procurement. It is in the pre-construction period, not during the construction phase, that the Employer, assisted by the Contractor and relevant specialists, is able to derive the greatest benefits from value engineering exercises.*" (JCT, 2011). It is reasonable for this involvement and advice to also to address sustainability.

RESEARCH METHODOLY

The literature review identified that both clients and main contractors need to work closer together to ensure sustainable initiatives are applied. Main contractors are measuring sustainable performance using key performance indicators and achieving good BREEAM/Considerate contractor's scores, demonstrating their sustainable credentials throughout the construction process. The research went on to examine the main contractors view to improving sustainable projects, what progress seems to have been made from the literature review and any barriers they foresee.

The purpose of the quantitative research was to understand the broad current view of main contractors in relation sustainability literature and find any common trends that occurred to show what progress has been made. From this quantitative research the student then carried out qualitative research to have a better understanding of the reasons why these common trends had occurred, compare this to the literature review and review what should be taken forward from the research.

The quantitative research was carried out in the form of a questionnaire. The questionnaire was sent out to approximately 200 people in hope that at least 50 surveys would be completed. Table 1 shows the timing related questions asked by the research and where how they relate to concepts examined in the literature review.

	Why these Quantitative questions were asked	
	Question	Why Used?
5	Do you think there is a client demand for sustainable buildings?	CIOB (2007), stated no client demand and client is key barrier. Is this still the case?
6	Which one of the following in your opinion takes lead on assisting the client to achieving a sustainable build	Sodagar & Fieldson (2008) State it is the contractors and designers responsibility to support the client in sustainability, what is the main contractors view?
7	Who do you think is the main barrier to fully sustainable projects?	Hartenberger (2009), believe the funder is the main barrier, Sodagar & Fieldson (2008) believe the main barrier is the client. What is the current view? Has it changed since literature in order to progress?
9	Do you support clients to try and gain funding for sustainable materials from the funder?	Hartenberger (2009), Sodagar & Fieldson (2008) stated main contractors duty to support clients. Is this role being fulfilled?
12	Do you think more time in pre-construction and construction would ensure projects are sustainable?	DTI (2006) state more time is required in order to consider further sustainability options Have clients recognised this and released pressure on contractors?
13	Do you think main contractors should be procured earlier to discuss the project and look into sustainable design alongside the client?	Following from the DTI Report (2006) if more time is required does this mean contractors need to be procured earlier to fulfil duties. Williams and Dair (2006) states main contractor involved too late to have impact.
14	Is your supply chain procured as soon as you receive an order to provide early specialist input into the design?	Duty of main contractors requested in CIRIA (2004) and (2011), RIBA (2003).

Table 1 - Why the Quantitative questions were asked, Musson (2013)

The Qualitative research was undertaken using face to face interviews. There are two categories of Qualitative research; exploratory and attitudinal. The method adopted was attitudinal. Attitudinal is defined as;

"Used to subjectively evaluate the opinion, view or the perception of a person, towards a particular object." (Naoum 2007).

The reason why the research chose this method was because there is no right or wrong answer for how sustainability is driven forward. The solution is more complex than a yes or no answer. The type of information the student aimed to receive is personal to the individual but would also show how people within businesses are working to give opportunities to both the business they work in and clients/end users.

The resources utilised in the interviews were senior management personnel of construction companies. These individuals have worked for several main contractors and are highly experienced within the construction sector working on various different projects.

The research carried out four interviews with people who were employed by main contractors. The roles of these individuals ranged from Project Surveyors, Construction Managers and Projects Managers. Due to the individuals being in senior positions, these people are all regularly in communication with clients and design teams. These individuals also manage and have day to day contacts with the supply chain that assist in delivering construction projects. This provided the student with various opinions to interpret and analyse to concluding the findings.

FINDINGS

The quantitative research carried out received a total of 68 responses, 18 more than was expected; this showed a positive response to the survey. The finding presented in this paper focus on timing of contractor involvement.

Quantitative findings

Several of the quantitative questions related to the timing of sustainable contributions to the project. Question 5 examined the client demand for sustainable building from the contractors perspective, that is, it there a desire for a sustainable build initiated at the start of the project lifecycle by the client. **Error! Reference source not found.** shows the response to the question. Overwhelmingly contractors perceive that there is a client demand for sustainable buildings. This contrast to the view put forward by Williams and Dair (2006) where lack of client interest was stated as the most significant barrier.

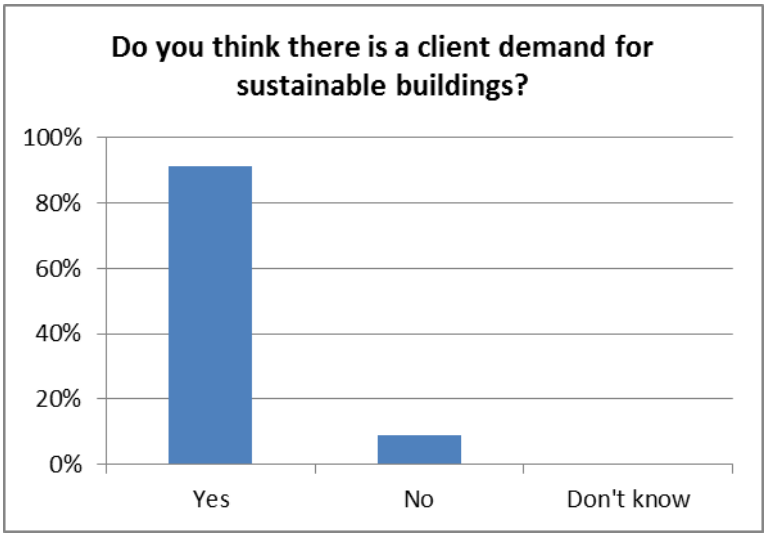

Figure 5 Examination of Client Demand

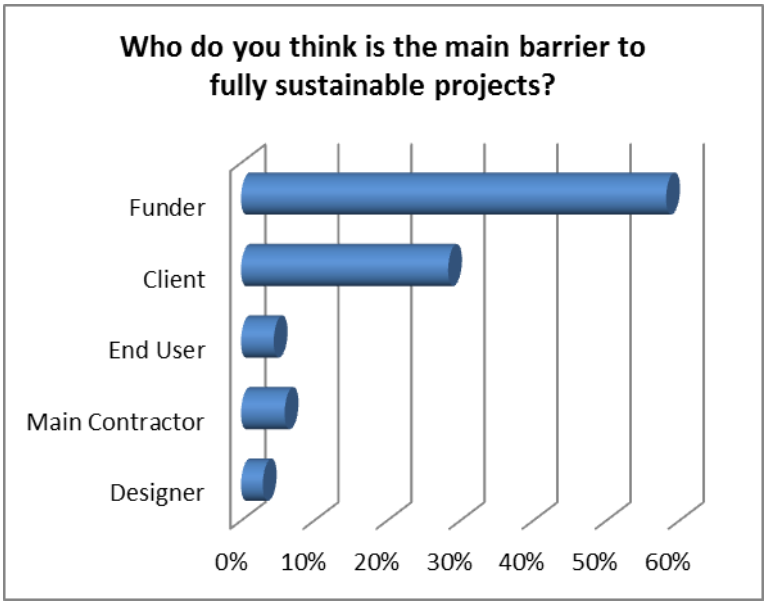

Figure 6 Barriers to Sustainable Projects

Question 7 explored the contractors view on funding for the project. From the experience and knowledge the main contractors had, as shown in Figure 6, 60% of the respondents said the barrier to obtaining sustainable projects is still with the funder, showing there has been little change since previous literature.

Although main contractors have responded to supporting clients in obtaining sustainable projects the responses indicate that main contractors believe it is the duty of the designer to support the client in achieving these results with 81% of the respondents stating this viewpoint in response to question 6 (see Figure 7). This means these main contractors views are slightly different to those reported in the literature of the CIOB who believe it is also the main contactors duty. Less than 10% of main contractors believe it is their duty to assist.

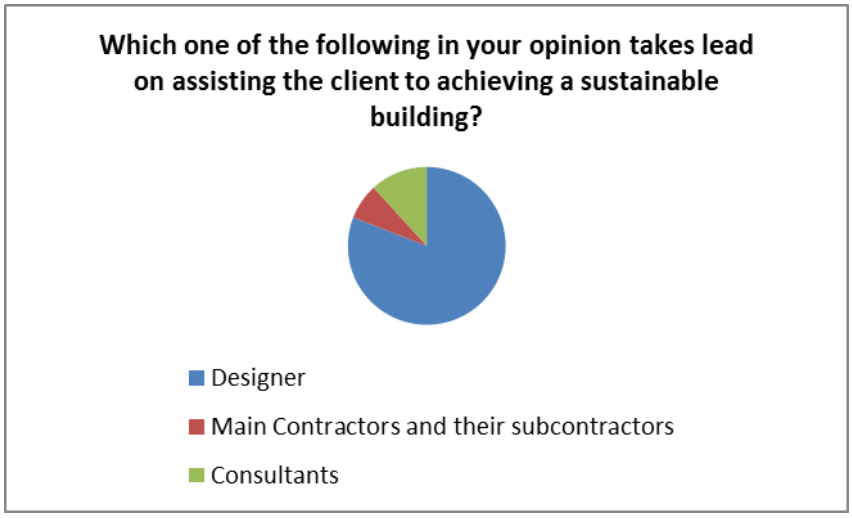

Figure 7 Assisting the Client

One of the duties introduced by the literature review was that contractors should support the client on releasing funding for sustainable projects this was proposed by both Hartenberger (2009), Sodagar & Fieldson (2008). The research shows that main contractors are recognising this, as over half of the respondents had advised that they carry out this role as shown in Figure 9. Although contractors are carrying out this role clients are still not interested, as they know they will not get the investment from their funder.

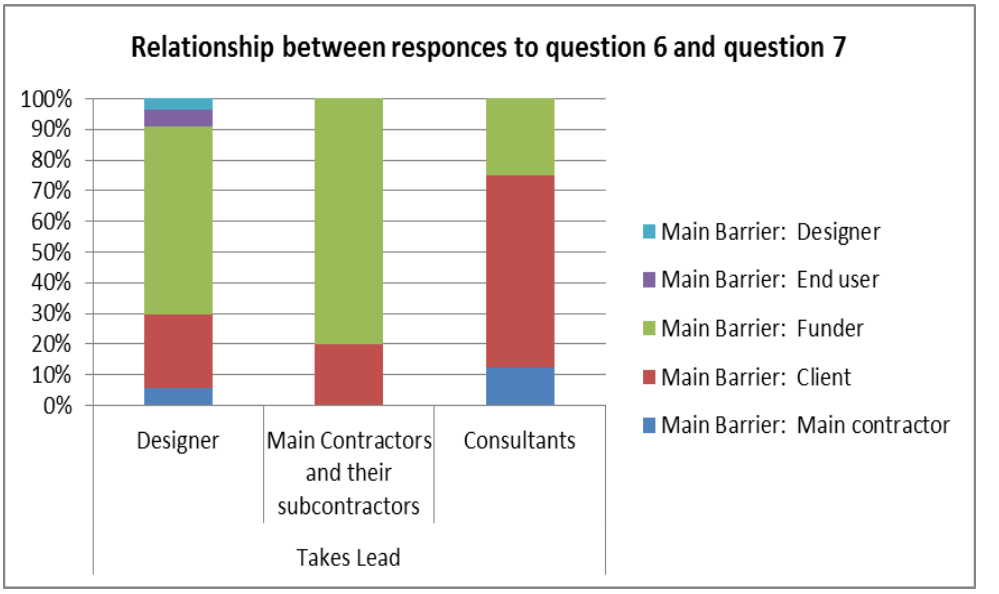

Figure 8 Assisting Clients and Barriers

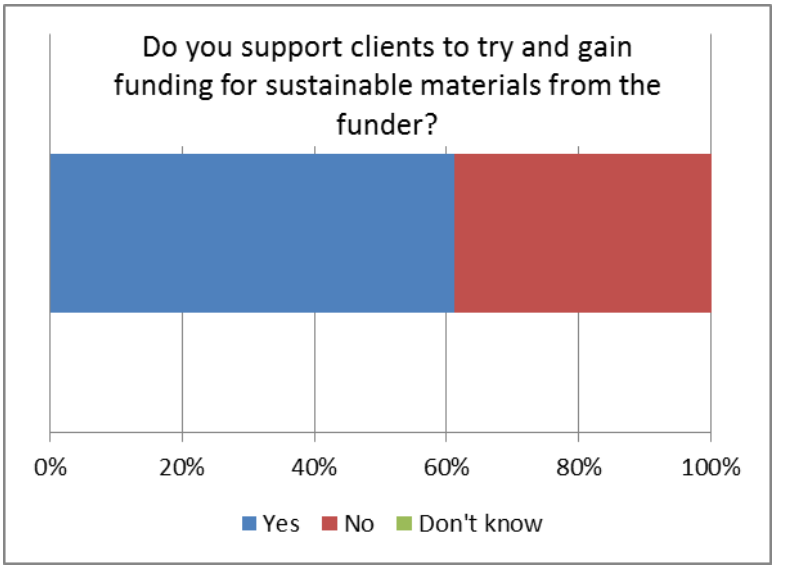

Figure 9 Supporting Clients

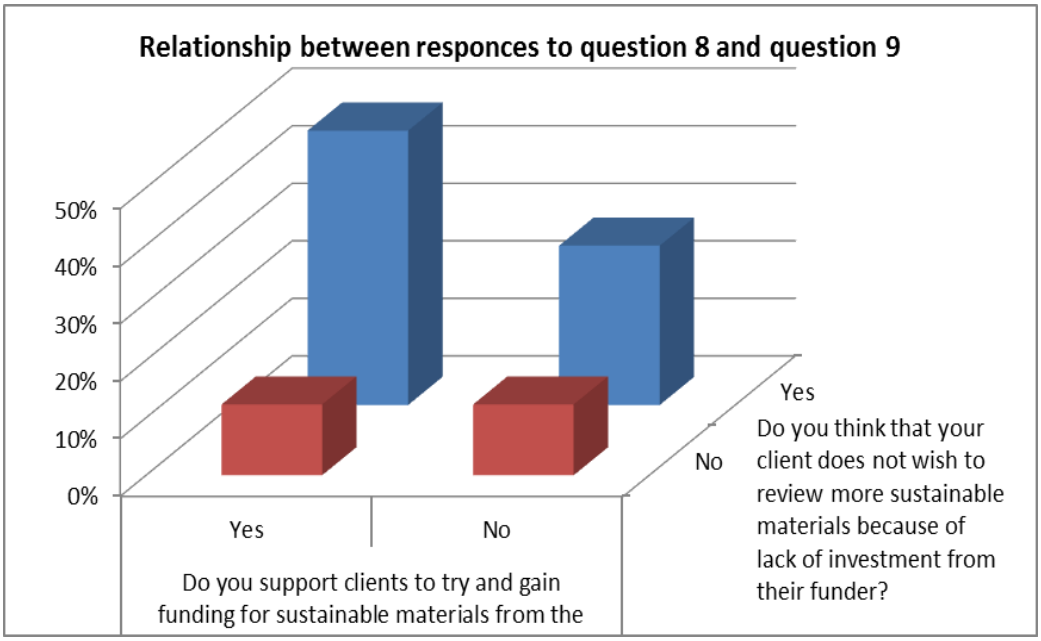

Figure 2 Supporting Clients and Funder Support

Figure 10 further illustrates the statement that main contractors are supporting their clients by relating the responses to questions 8 and 9. However there is still improvement to be done. Almost a third of clients and main contractors are not working together to gain funding and only a small majority of main contractors and clients are truly working as a team to the same aspirations.

The literature review showed that main contractors and their specialist subcontractors needed to be procured earlier allowing buildability and design concepts to be reviewed both practically and technically ensuring the best key contacts are in place and the correct concepts chosen. The responses to question 13 certainly appear to support this view with over 90% agreeing with the statement (see Figure 11).

However, thought the literature and the responses support the notion of early main contractor involvement this is not reflected in the procurement of the supply chain as explored in question 14. Figure 12 shows that the responders views are split with a small majority not procuring specialist input early.

The interaction to the responses to Questions 13 and 14 (see Figure 13) shows that most contractors feel they need to be procured earlier, however will not procure their subcontractors at the same time. There is recognition though that some main contractors also procure their subcontractors earlier when they themselves are procured early. This means though there is progress towards the

viewpoints expressed in the literature review and that the main contractors recognise this duty, this requirement still needs to be progressed.

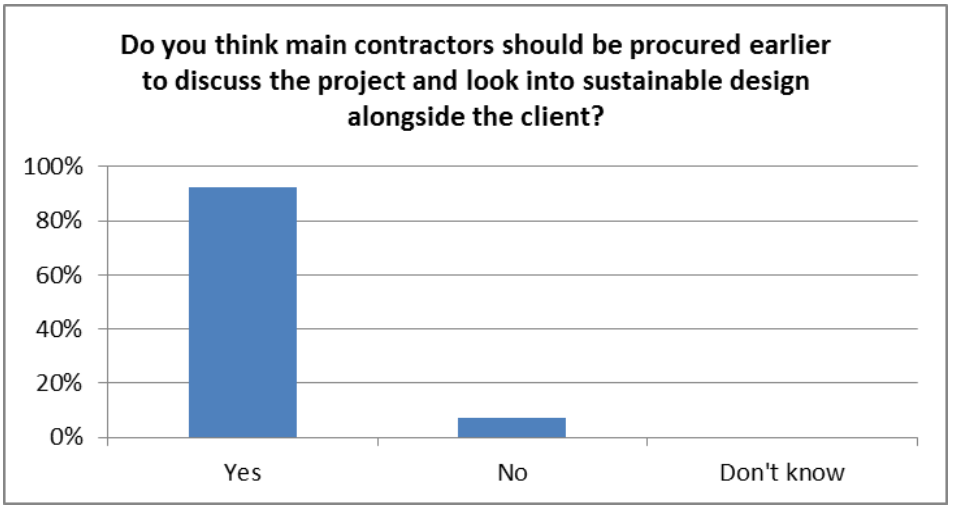

Figure 11 Early Procurement

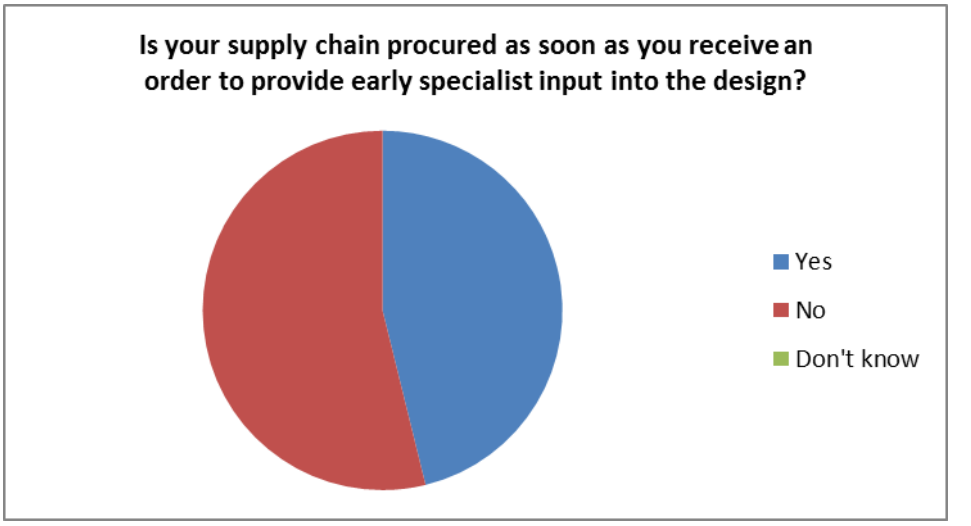

Figure 12 Procuring the Supply Chain

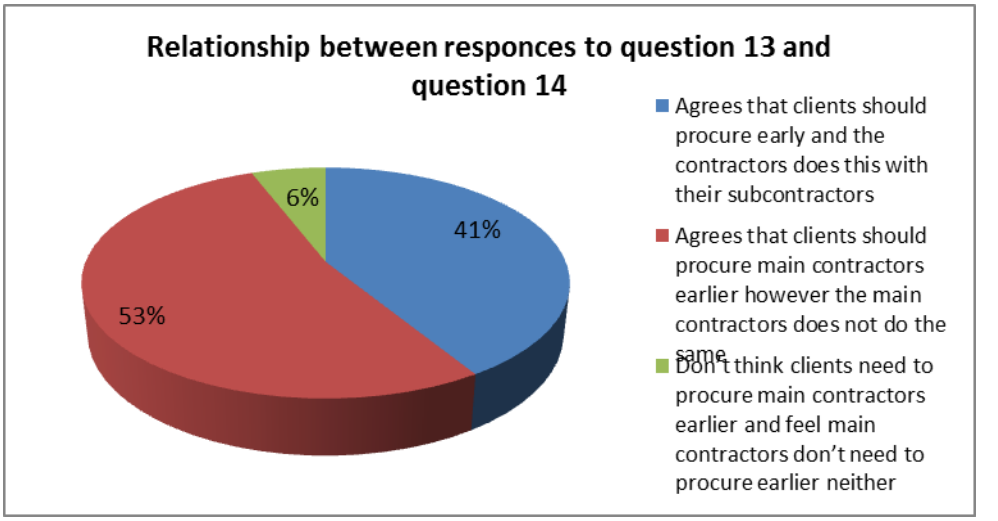

Figure 13 Early Main Contractor Procurement and Sub Contractor Procurement

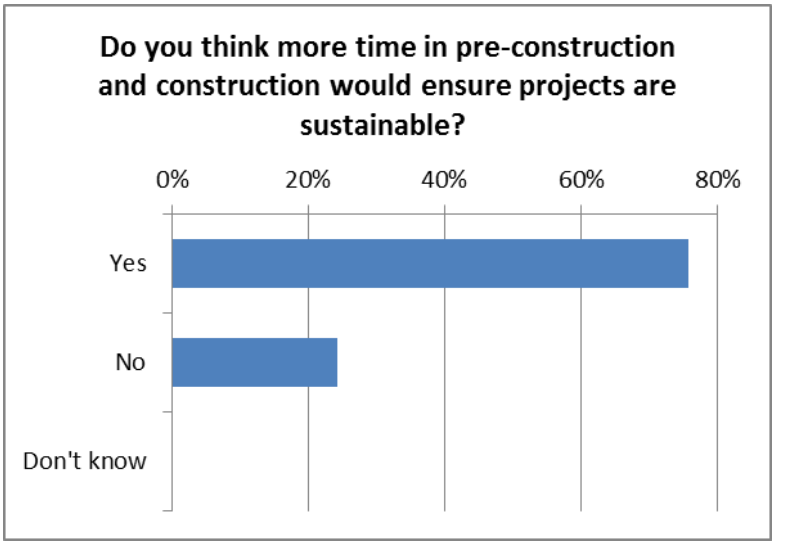

Figure 14 Time in Pre-Construction

Question 12 explored the need for more time in pre-construction and construction to ensure a more sustainable build, whilst the high level of positive response is not unexpected the significant negative response is worthy of note (see Figure 14).

Qualitative Findings

The starting questions to explore timing of appointment in the qualitative research were:

- Why do you feel like you need to be procured earlier and at what stage? Does this mean you procure sub contractors at the same time? This question prompts detail in relation to quantitative question 13 and 14, that is do the interviewees responses reflection the sample and why do they hold those views (Figure 12)
- If you had more time in pre-construction and construction how do you think this would help you? This question prompts detail in relation to quantitative question 12. It was hoped that the qualitative responses may help give some differentiation for example is there a difference between pre-construction and construction.
- What is your view on how we move forward as main contractors, what barriers do you foresee? A general question not specifically about timing. However, would timing be raised as a barrier?
- Why do main contractors believe it is the role of the designer to support the client in sustainability when most main contractors take lead and why? This question prompts detail in relation to quantitative question 8 and 9. Would the responses reflect different contracts and the point at which the main contractor is appointed within those contracts?

All of the interviewees agreed with the majority view that early procurement was key to better sustainable builds. Details highlighted included:

- Better supporting client needs
- Assisting the client in cost control
- Support design and buildability
- The interviewees feel that they need to be procured as early as RIBA stage A to assist the client's needs of sustainable projects.
- One interviewee stated Main contractors at the latest would want to be procured at Stage D, as at this point it is very difficult to influence sustainable design as contractors at this point need to ensure the project is buildable and that everything can fit within the floor areas, which takes time.

Within the qualitative interview there was a more support for the notion of early procurement of sub-contractors to assist the client in achieving a sustainable

build than in the quantitative data, the view here being contractors are willing to procure their specialist sub-contractors to assist this process as main contractors rely on them for evidence and practical solutions. However, the timeliness of this depended on when the main contractor is procured.

When asked about barriers, the interviewee's raised points such as cost and the funders willingness to support sustainable construction, the nature of the current construction procurement and current tendering market stress rather than explicitly the timing of, or the extent of, their involvement at early project statement. This contrasts in part with their views expressed against the other questions discussed here. However, in part the comments in regard to procurement and tendering reflect the current late appointment of the main contractor.

All four of the interviewees believe main contractors still require more time in preconstruction, however, are comfortable with the time they have at present. In the interviews main contractors could list lots of reasons why they needed to be procured earlier for instance; reducing waste; provide better environmental solutions; find more local contractors to produce materials rather than relying on other countries and increasing carbon footprints; protect clients cash flow; ensure build ability works for instance size of risers; save money and review whole life cycle. This clearly identifies that main contractors have lots of significant expertise to support clients. However, they need more time to plan and review elements of the project which is in the clients' interest.

The Main Contractors believes it is still the Designers role to take lead on supporting the client in sustainability as they are the first party involved on the project and start with a blank piece of paper. In contrast however, Main Contractors feel they are procured too late on in the project to support the client. Most interviewees stated though that it is still down to the client at first to specify their sustainability brief. At the current stage main contractors are procured, interviewees three and four stated it is only the main contractors requirement to ensure the clients and architects specification is achieved with interview four going on to say this is all they have time for. Interview 2 stated if they were procured earlier, they would probably take on this role.

DISCUSSION

Until relativity recently, the most significant issue facing sustainable build was the lack of client interest. This was evident from the literature, comments made in the qualitative research and indeed the modest number of sustainable builds that have been completed. Hence, to an extent in the past the timing of the contractors' involvement was moot, without client demand for a sustainable

project as a whole, the timing of contractor involvement is unlikely to have a significant impact on the uptake or success of a sustainable build. There is one possibility that is worthy of consideration, would earlier contractor involvement make the client more willing to undertake a sustainable build? Would clients be reassured by the early involvement of a contractor that a sustainable build could be achieved, for example, could the client be reassured that a sustainable build could be brought in on cost. However, overall the research has shown that for many projects the barrier of client interest has been removed, with only a small number of clients being unwilling to undertake a sustainable build. Given this is clearly the case the a key point of consideration is the issues of early contractor involvement.

The advantages of early contractor involvement outlined in the research are clear, specific examples have been given and many more similar benefits could be expected to arise. These benefit primarily arose from the literature. The primary research showed that contractors felt they should be involved and gave some indication of the benefits that could be achieved. However, these were more limited than those listed in the wider literature, this is to be expected, the situation is catch twenty two, clients perhaps do not wish to have contractors involved early as the benefits for a sustainable build have not been extensively demonstrated, contractors cannot demonstrate extensive examples of the benefits until they have been involved at an early stage in several projects. This is an area that is worthy of further research, as demonstrated in the literature there are many wider project benefits to early contractor involvement and further research could demonstrate their applicability to a sustainable build.

The research addressed the willingness of contractors to be involved early in a sustainable project. Certainly, the clear view in qualitative and quantitative research is that they are willing and are confident that this will lead to better sustainable projects. Against this clear view, some countervailing views where expressed. Firstly, a significant number of respondents did not support the client in gaining funding for sustainable materials and a similar proportion did not procure subcontractor early in the project.

The research explored the main contractor's desire for more time in pre-construction to ensure the design is correct and given the opportunity to offer alternative products. This was clearly demonstrated both in the qualitative and quantitative research. Main contractors have lots of activities that they want to do in the clients (and wider societies) interests to boost sustainability, however they are clear in their view that they don't have time to carry out any of these activities. For main contractors to fully engage in sustainability all participants of the survey requested they needed to be procured as early as RIBA Stage A.

Certainly, anything from Stage D onwards means contractors have little opportunity to support the design and clients' budgets as they need to review the projects build ability from this stage onwards.

CONCLUSIONS

The literature review recognised that the adoption of duties by main contractors in relation to sustainable construction continues to progress. The results of the quantitative and qualitative research show that main contractors still want and need to be procured earlier and currently believe when clients wish to procure main contractors it is too late in the project lifecycle. In order for main contractors to provide their best possible service and ensure all aspects have been covered they request to be procured as early as RIBA Stage A.

Main Contractors have recognised their duty of working with clients. However, based on when they are currently procured (normally stage D), main contractors only have time to ensure the designers design is buildable and that they can deliver what they are contracted to by the clients brief. To be seen as working more closely with client's main contractors need more time in pre-construction and procured earlier. If sustainable products, materials and specifications are not established by Stage D when contractors are currently procured it is very difficult to change the design to promote sustainability or indeed maintain sustainability in the light of the value engineering pressures.

The research has shown that there are many benefits to be gained from early contractor involvement in sustainably construction projects. Further, it is clear that main contractors are willing to adopt such responsibilities, including to an extent early procurement of sub- contractors. However, whilst contractual frameworks exist to support such early involvement the lack of experience of early involvement does mean that main contractors' familiarity with and confident in undertaking this role has yet to develop. The steps needed to give clients the confidence to appoint contractors early in order to access the benefits established in the research is an area worthy of further investigation.

REFERENCES

BSI 2010. BS 8903; Principles and framework for procuring sustainability - Guide, London, British Standards Institute.

CIOB (2007). The green perspective – A UK construction industry report on sustainability, [online], Ascot, CIOB. Last accessed 14th October 2012 at http://www.ciob.org.uk/sites/ciob.org.uk/files/WEBINF/files/documents/TheGreenPerspective.pdf

CIRIA 2004. Sustainable construction - Implementing targets and indicators. C633, London, CIRIA

CIRIA 2011 . Guide to sustainable procurement. C695, London CIRIA

DTI 2006. Review of Sustainable Construction [online]. London, Department of Trade and Industry, Last Accessed 3 November 2013 at: www.bis.gov.uklfiles/file34979.pdf

HARTENBERGER, Ursula 2008 . Breaking the viscous Circle of Blame - Making the Business Case for Sustainable Buildings, London, RICS

JCT. 2011 . JCT pre-construction services agreement - general contractor, London, Sweet and Maxwell

MUSSON, Steven, 2013. The duties and views of main contractors to endure future sustainable demands, BSc Hons Construction and Commercial Management, Department of the Built Environment, Sheffield Hallam University

NAOUM S.G 2007 . Dissertation research and writing for construction students, second edition, Oxford, Butterworth-Heinemann

NICHOLS, M. 2007 , Review of Highway Agency's Major Roads Programme, London, The Nichols Group.

RAHMAN, M & ALHASSAN, A 2012, A contractor's perception on early contractor involvement, Built Environment Project and Asset Management, Vol. 2 No. 2, 2012 pp. 217-233

RIBA 2003 . Sustainable Communities - RIBA response to the Egan review of skills in the Built Environment Professions. [online] RIBA, Last Accessed 3 November 2013 at: http://www.architecture.comlfiles/ribaholdings/policyandintemationalrelations/policy Ipublicaffairsiresponsetoeganreviewofskills.pdf

RICS 2010. Two-stage tendering / Early contractor involvement. [online]. Last accessed 3 November 2013 at: http://www.isurv.com/site/scripts/documents_info.aspx?documentID=2696&pageNumber=3

SODAGAR, B & FIELDS ON, R 2008 . Towards a sustainable construction practice. Construction Information Quarterly, 10 3, 10 1-108

WILLIAMS, K & DAIR, C 2006. What Is Stopping Sustainable Building in England? Barriers Experienced by Stakeholders in Delivering Sustainable Developments. Sustainable Development, 15 3, 135-146

WRAP No Date/a) . Designing out Waste: a design team guide for buildings, Banbury, WRAP

WRAP No Date(b). The efficient use of materials in regeneration projects: 6. Roles and responsibilities, Banbury, WRAP

WWF No Date. Building towards sustain ability - Performance and progress amongst the U.K's listed, house builders. [online]. Woking, WWF, Last Accessed 3 November 2013 at: http://www . wwf.org./uklfilelibrary/pdf/investinsustainability. pdf

THE EFFECTIVENESS OF SUSA BEHAVIOURAL SAFETY INITIATIVE IN A REGIONAL ORGANISATION

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The focus of this research was the effectiveness of a Behaviour Based Safety (BBS) initiative that has been operating for four years in a UK regional (construction) contracting organisation. UK statistics show that, year on year, the construction industry records high fatality and injury rates. This research was designed to evaluate the effectiveness of one particular approach to reducing accidents, and improving attitudes to safety. A comparison of company data and statistics with information collected from a structured interview, an unstructured discussion group and onsite survey questionnaires was made. This was evaluated in relation to issues identified in the literature and with data collected from another contracting organisation that does not operate a BBS initiative. The regional organisation's statistics show a marked decrease in accident rates over the relevant four year period. However, the findings suggest that this may be due to other factors as the initiative operates alongside other safety schemes and its accident figures had been falling for some years beforehand. The main conclusions drawn from this study are that while the initiative appears to have had a positive impact in reducing injuries, at this stage it is not as effective as it has the potential to be and it is not always producing the desired change in terms of safety behaviour and attitudes. The study recommends that there is a clearer, agreed focus on the behaviours to be targeted and the improvements that should be expected along with better training and feedback. Cost effectiveness should be recorded, site workers should have more input and the strategy could perhaps be adapted to increase subcontractor involvement.

Key words: behaviour based safety initiative; fatality and injury rates; regional contracting organisation; construction and effectiveness

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INTRODUCTION

The primary aim of this dissertation is to establish 'the effectiveness of the SUSA behavioural safety initiative in a regional contracting organisation.'

The key areas for analysis of the initiative are:

- Why it was adopted.
- Its management and organisation.
- Its effectiveness in practice.
- Its operation during periods of boom and recession.

The eventual aim was to provide the reader, and the regional contracting organisation, with enough information to determine whether the behavioural safety process is as effective as it could be. In this way, it is intended to support the company's commitment to improving the health and safety of all employees. The research examines the operation of the SafeUnsafeActs (SUSA) strategy at Kier Construction Northern (KCN) which employs 147 people. KCN was selected for the study as a representative example of Kier' s eight regional construction organisations, all of which operate the same safety systems and procedures alongside the SUSA strategy.

In 2012, at £2.,069m, the overall revenue for Kier plc was slightly down from 2011, and operating margins in the Construction division were 2.5%, down from 2.7% the previous year. In that same year, the Accident Incident Rate (AIR) for Kier (Kier Group, 2012) was 301 per 100,000, significantly lower than 389 in 2011 and the Health and Safety Executive (HSE) benchmark rate of 536. The Group received a total of 23 ROSPA awards and 12 British Safety Council Awards in 2012. Despite the challenging economic environment the company's stated health and safety focus remains firmly on to eliminating workplace injuries and raising awareness of occupational health issues (Kier Group, 2012).

In 2009, the SUSA behaviour based safety (BBS) initiative scheme was introduced at KCN and throughout the Kier construction division. It aims to reduce the number of injuries through peer observation of safe and unsafe actions followed by discussion and feedback. The programme involves all company personnel, and the supply chain, and is intended to change people's behaviour one discussion at a time. It is based on the traditional peer review process (Malallah, 2010), developed in the 1980s. This involves:

- Worksite observations carried out by peers or supervisors, recorded against checklists.
- Individual feedback and discussion.
- Information collated on an electronic database.

- Reports to steering committees identifying areas of concern.
- Steering committee of senior influential managers/directors analyses reports findings and produces recommendations.
- Feedback to site workers.

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The researcher joined KCN in 2008 as a trainee engineer/manager, and so has had first-hand experience of delivering SUSA discussions and observing the strategy in action since that time. Based on this experience, the author recognises that company data indicates that the initiative has led to improvements in safety. However, the author believes these figures alone may 'pot provide a complete picture. Consequently, as the strategy has now been fully implemented, this seemed to be a suitable point to conduct a study into its effectiveness.

RATIONALE

The research focuses on Kier Construction Northern with particular reference to the site where the author was employed. Secondary data including company documents and training materials from both Kier and KCN have been analysed. Throughout the study, where reference is made to Kier, the related information and data also applies to KCN. The main problem for the study is the difficulty of separating the effect of the SUSA initiative as it operates as one element of a larger safety system. Therefore, as well evaluating overall statistics, primary data has been collected using from interviews, focus groups and a survey will examine SUSA specific issues.

Both quantitative and qualitative methodologies were used to gain as detailed a picture as possible of the SUSA initiative, which was examined in relation to issues identified from the literature review. Quantitative research involved analysing a questionnaire completed by site-workers, A smaller-scale study relating to Company B, which follows similar safety procedures but does not include a BBS process, provided a comparison. Methodologies also involved evaluating secondary data obtained from KCN and Company B, as well as site-survey questionnaires. Qualitative methods included an interview and a focus

group. Quantitative studies are intended to identify the organisational features that affected the SUSA initiative and how, in turn, the initiative has affected the organisation. They also examined why, and how, Kier implemented the programme and measured its effectiveness. A recently retired KCN Director, responsible for health and safety, was interviewed to gather background information and to discuss KCN AIR statistics and comparison graphs. A cross-sectional case study and a semi-structured discussion were included to provide a fuller picture and pick up on the systems and procedures that were not addressed by the surveyor interview. In addition, reference was made to previous research studies including that of Melia (2012) and the author will also draw on his own experience of operating the SUS A initiative as a site engineer/manager. Using a closed format and five-point attitudinal scale, the questionnaires are designed to investigate employees' views about site safety and to check their awareness and knowledge of, and opinions on, the SUSA initiative (illustrated in Figure 1). In the case of Company B Questions 1 and 4 were adapted to relate to awareness of the need

for Health & Safety (H&S) and the effectiveness of the company's safety strategy, replacing the two questions about the SUSA strategy. Strongly agreeing/agreeing with Questions 1,2,4, 7, 8, 9, 10 and 12 (Group A) was interpreted as indicating that SUSA initiative was effective. Whereas strongly disagreeing/disagreeing with Questions 3, 5, 6, 9, 11, 13 and 14 (Group B) was interpreted in the same way.

Questionnaires were completed on-site and there was no obligation to participate in the study. To protect employees' privacy, responses were anonymous but it is recognised that the employer has the right to be informed if the research identifies any serious safety issues. Consequently, although not the preferred option in terms of clarity but to avoid any possible repercussions, participants were asked what they thought the majority of site operatives would do - rather than what they personally would do. The author also obtained permission to conduct the research and draw on company data from both organisations.

LITERATURE REVIEW

A review of current literature shows that there are conflicting opinions on the effectiveness of the behavioural approach in achieving compliance with safety procedures. Some writers believe it can have a range of benefits (Hidley, 1998, Marsh, 1999 and Geller, 2012). There is also evidence that in the first four years a behaviour safety process reduced accident rates by 34%, 44%, 61 % and 71 % (Krause, 1997 cited in Marsh, 1999).

Cooper (2009) suggested that BBS is only half as effective in dynamic organisational settings, as in static ones which have a stable workforce and/or stable environment. However, apart from Cooper's study, there does not appear to have been any extensive examination of the approach in different types of settings, such as construction, or in more recent organisational models using mainly subcontracted workers.

The literature identifies the elements considered necessary for an effective behavioural safety process and also the many problems associated with it. There should be a systematic, scheduled and focused programme of intervention targeting specific behaviours (Sulzer-Azeroff and Lischeid, 1999, cited in Stranks, 2007 p28). The scheme must obtain the commitment of the workforce, which should be significantly involved in its operation. There should also be visible and ongoing support from management and supervisors.

Hidley (1998) also included a process blueprint, well-trained and competent observers, effective communication and feedback and the provision of technical resources to ensure continuous improvement. McSween (2013) argued that a never- ending BBS process should operate alongside fixed-length safety programmes and strategies to address the areas of concern identified, and provide the novelty that keeps behavioural safety fresh.

DePasquale and Geller (1999) emphasised that belief in management abilities, rather than their intentions, is the crucial factor in gaining employee confidence in a BBS programme. McSween (2013) proposed that lack of strong, visible leadership support is one of the greatest problems associated with the BBS process.

Reinforcement of safe behaviour often takes the form of tangible safety awards but research suggests that leadership's interest and interaction is actually a more important factor (Komaki, 2010 cited in McSween, 2013). Throughout the organisation attention should be focused on behaviours related to the target issue by reviewing relevant activities in personal discussions and at senior management level (McSween,2013).

Most BBS observations make comparisons with specified safe and unsafe behaviour. However, Smith (1999) opined that this assumes there is just one safe way to perform a job; and the meaning of 'safe' will vary with the organisation or with the source used, and may differ from the employees own definition. The focus can be on rule violation instead of good rules (RSE, 2012).

Observation is at the centre of the behaviour based safety approach, but the literature shows that this is also where problems can occur. Being observed can create anxiety, confusion and resentment and the long-term consequences are

usually negative (Smith, 1999). Observation often misses what actually happens because people act differently when being watched (TUC, 2010) and when unannounced may be misunderstood as spying (Galloway, 2011). Quotas can lead to the belief that people are forced to be involved and that the number of observations is the main focus of the BBS strategy (Galloway, 2011).

The assessment of people cannot eliminate errors such as inadequate observation or subjective judgement (Lopez-Mena, 1993). Focusing on the individual and ignoring the upstream factors will not reveal why the unsafe action was taken and will lead to failure (Smith, 1999). It does not address the issue of how management decisions, about productivity for example, relate to safety (TUC, 2010).

Mathis (2005) comments that where BBS is operated by amateurs with minimal training this often leads to significant problems: behavioural targets are not expertly identified, feedback is not given effectively and observation strategies ignore good sampling techniques. The data collected often contains strong indicators of upcoming accidents and their underlying causes, but may not be expertly analysed and utilized. Consequently, problems remain unidentified, or are not shared with those who can resolve them, and organizations miss countless opportunities to prevent future accidents.

There is no such thing as universal best practice; much depends on how well BBS is delivered, what it is used for and how it is integrated (Marsh, 1999). BBS can tend to focus on easy intuitive issues and have a bias towards measureable success, ignoring low- probability, high consequence risks and drawing attention away from process safety (RSE, 2012). It requires real commitment and discipline from everyone involved, and must be linked to other goals such as team-working if it is to be effective (HSE, 2012).

BBS programmes may be incompatible with other areas (HSE, 2012), for example the link between observations and disciplinary procedures is often unclear (Galloway, 2011). Unless operated as part of a broader system they can lead to a lack of focus on the overall safety culture and environment (Smith, 2007).

Traditional BBS programmes require high levels of employee involvement and resource-intensive techniques (Mathis, 2013). Return on investment (Cooper, 2010) and cost effectiveness must be considered, especially at a time when organisations have fewer resources and may have difficulty financing such schemes (Eckenfelder, 2003, Mathis, 2005 and Smith, 2007). Cooper (2010) observed that the greatest benefits were achieved in static settings, conducting daily observations of entire workgroups and with multiple feedback channels.

The most significant losses were in organisations using weekly one-on-one observations, with only one or two feedback channels.

Galloway (2011) argued that employing lengthy checklists to shape behaviour uses the most expensive and unsustainable resource available. Mathis (2005) proposed a leaner, more efficient process using only selected parts of BBS technology, especially where organisations have specialised needs. He suggested the focus should be on using fewer, better-trained observers with the right skills, reducing the number of observations and length of checklists and targeting only those areas where BBS can make a difference; and that data analysis should be carried out by experts rather than steering committees or leadership teams.

The main concerns about BBS included poor quality information, low participation, poor or no discussion, low frequency of observations and no action plans (McSween, 2013). Feedback and comments on observation checklists were often of poor quality, probably due to lack of effort, failure to recognise hazards, lack of training and practice in pinpointing skills, lack of confidence or fear of getting co-workers into trouble (Geller, 2012).

McSween (2013) observed that competing production pressures are seen as a barrier to conducting safety observations. In the worst cases, observers lack motivation and the process lacks any meaning, making no contribution to safety. Senior management need to make it clear that the data reported by observers is acted upon to improve safety. If individuals are not kept informed about successes resulting from the BBS process it will be seen as ineffective, or forgotten about (Galloway, 2012).

The way the BBS process is analysed and measured is another factor. Geller (2012) argued that using the total recordable injury rate as the bottom-line measure of success tells the organisation nothing about why a BBS process is succeeding or failing. Mathis (2013) suggests that these lagging indicators may be due to luck or normal variation, they may be achieved by suppressing negative information or manipulated by the use of categories such as zero recordables and zero lost-time accidents. Rankings and/or financial incentives based on injury rates may act as reinforcement, motivating employees to cover-up accidents and stifling the communication needed to prevent injuries (O'Brien, 2000, cited in Geller, 2012).

Geller (2012) suggested it would be more effective to keep score on the various proactive things individuals and groups do to promote safety. Hidley (1998) argues that when BBS initiatives have few, or no, critical success factors they lack impact; they may wither away or become so costly and unwieldy that they are simply abandoned.

RESULTS AND DISCUSSION

1. Qualitative Research

The case study (Kier Group 2010a; Kier Group 201Ob; Kier Group, 2012a; Kier Group 2012b; Kier Group 2012c; Kier Construction Southern [KSN] 2012), and Interview (Interviewee A, 2013) and the unstructured focus group show that the SUSA strategy is designed to strengthen Kier's existing safety culture - not to replace it - and that it includes most of the elements necessary for BBS to be successful identified in several sources within the literature (Hidley, 1998, Sulzer-Azeroff and Lischeid (1999, cited in Stranks, 2007.) and McSween, 2013). Even so, it appears that nearly all of the problems identified in the literature review are impacting on the effectiveness of the programme.

The strategy at KCN does include most of the elements considered necessary for effectiveness. Nevertheless, the delivery of the programme and the information collected vary in quality depending on individual ability and time constraints. At company level data is collected and analysed for the limited purpose of monitoring quotas, although it is used to identify safety issues at individual site level. Importantly, the focus for observations is left to each individual and the programme may not be targeting the most risky behaviours and hazardous situations as identified by the HSE (2012).

The continuing recession has put more pressure on resources; while this has not altered the strategy it has affected the implementation of it (Interviewee A). People are more concerned about losing their jobs so they are more safety compliant, but as money is tighter and suppliers are paid less safety can be impaired.

2) Quantitative Research

Company statistics (Kier Construction Northern [KCN] 2013a; Kier Construction Northern [KCN] 2013b; Kier Construction Southern [KSN] ,2012a) do not always provide all the necessary evidence to fully establish the effectiveness of the strategy. There has been an impressive drop in the rate of reported RIDDOR incidents (i.e. major accidents and over 3-day injuries) (see Figure 1). However, the downward trend in Accident Incident Rates (AIR) was happening before the SUSA programme started, and also in the first year (2009) when it would have had only a limited effect. On the other hand the AIR figure at KCN is now 130, the lowest in the whole of the UK construction industry, and the overall trend shows that as SUSA conversations increase the accident rate falls (Kier Group, 2012).

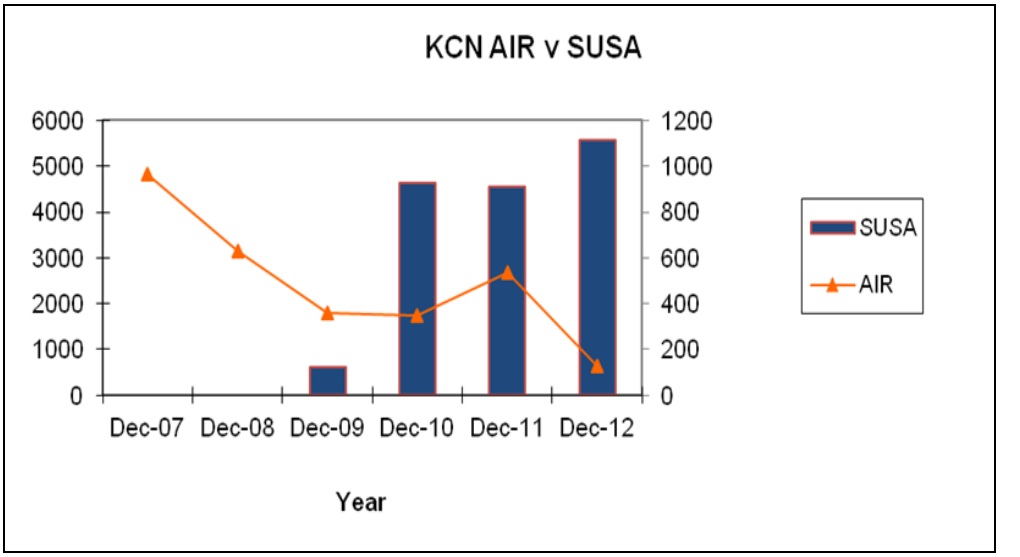

Figure 1 Graph showing reported R1DDOR incidents since 2007

The questionnaire was aimed at operatives in order to study the effect of the strategy on-site and to examine it from a different perspective. In total, there were 92 (75 and 17) respondents at the two KCN sites, and 95% of people asked completed the questionnaire did so.

Overall, the data (see Figure 2) indicated that around 70% of respondents believed most people understood the SUSA strategy (Q 1) and they received plenty of feedback and information about the accident rates initiative (Q 2). This was more or less in line with positive responses to the questions about maintaining plant (Q7), wearing PPE (Q8) and following the method statement (Q12). By contrast, only 54% thought that most people are open and honest in SUSA discussions (Q 4) and only 44% agreed that most people use dust suppression when they should (Q 10).

Responses to Q3 suggested that around 70% of respondents see site safety as their responsibility. In spite of this, only 40% of respondents disagreed that people would ignore someone working unsafely (Q5) cut corners (Q9) or use shortcuts instead of safe routes (Q11). Just 30% of respondents disagreed with the statement that people would not take time to report an unsafe area (Q6), and only 25% disagreed that people mostly don't bother to segregate work areas from other trades (Q13). Finally only 22% of respondents disagreed with the claim that most people will take a chance if they think they can get away with it (Q14).

SUMMARY SHEET Main Summary					
Age of Participants	20-30	31-40	41-50	51-60	61+
	38	25	15	8	6
Number of years participants have worked in Construction Industry	0-5	6-10	11-15	16-20	21-25
	15	24	19	7	6
	26-30	31-35	36-40	41+	
	9	5	2	5	
Current Trade of Participants in Construction	Joiner	Bricklayer	Painter	Plasterer	Ground worker
	7	0	7	2	2
	Steel Erector	Steel Fixer	Mechanical	Electrical	Plumber
	0	3	4	19	7
	Cladders	Dryliner	Admin	Manager	Scaffolder
	0	10	1	9	1
	Labourer	Floor Layer	Window Fitter	Crane Operator	Roofers
	9	1	2	3	5
Number of Participants SUSA Trained	Yes	No			
	23	69			

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Most people think it is important to have regular reminders about health and safety.	10	52	13	17	0
2. Everyone would agree they are given plenty of information about near misses and accident rates.	9	54	13	14	2
3. Most people think site safety is management's responsibility, not theirs.	3	16	11	48	14
4. Most people would answer truthfully if a supervisor asks why they are not working safely.	6	43	29	13	1
5. If they saw someone who was not working safely, most people would just ignore it.	4	42	10	30	6
6. Most people would not take time from their job to go and report an unsafe area.	6	42	16	27	1
7. People generally use and maintain plant correctly.	7	61	15	8	1
8. Most people wear the correct PPE for every task.	16	48	12	16	0
9. Nearly everyone would cut safety corners to get a job finished on time.	7	33	14	34	4
10. Nearly everyone uses dust suppression when they should.	3	38	15	31	5
11. People mostly use short-cuts instead of safe access routes.	8	29	20	32	3
12. Most people follow the method statement for the task.	12	53	15	12	0
13. Very often people don't bother to segregate their work area from other trades.	6	48	15	20	3
14. A lot of times people will take a chance that they can 'get away' with unsafe acts without injuring themselves.	3	50	19	17	3
Total	100	609	217	319	43

Fig. 2 Summary sheet of KCN Questionnaires

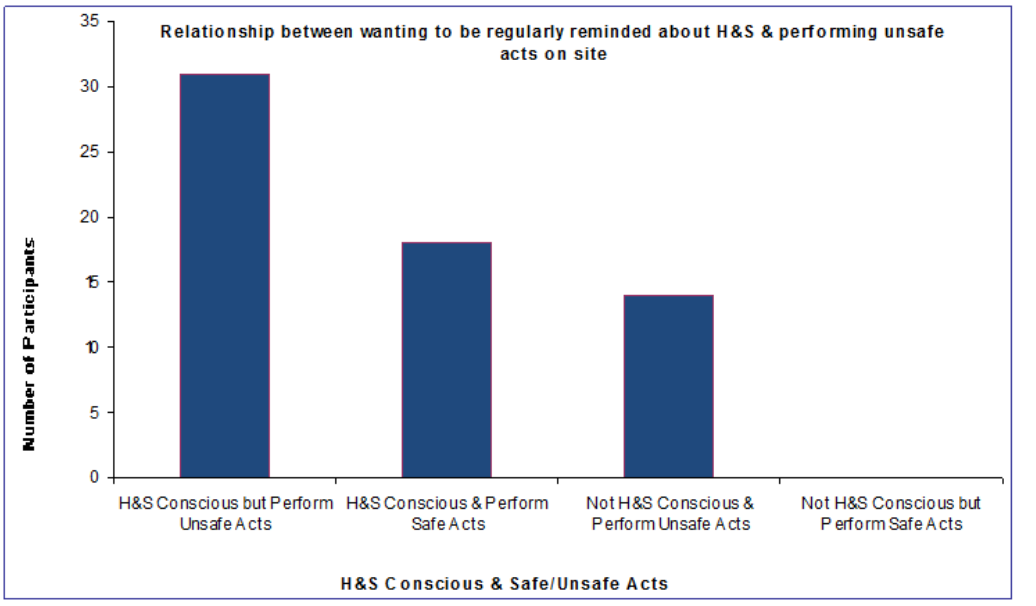

Figure 3 Relationship between wanting to be regularly reminded about H &S and performing unsafe acts on site - KCN

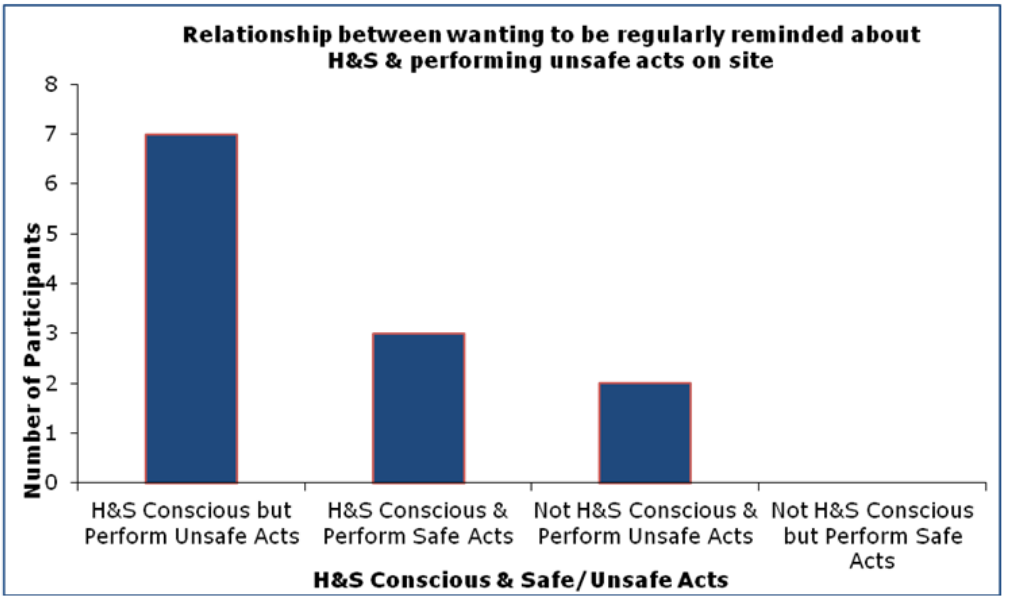

Figure 4 Relationship between wanting to be regularly reminded about H &5 and performing unsafe acts on site -Company B

As Company B did not operate a behavioural safety programme it was expected that the workforce there would be far less safety conscious. Twenty workers there completed a very similar questionnaire. In general, the results do indicate that SUSA training had produced better attitudes to health and safety in the KCN sites, in comparison with Company B sites. However, they also showed that the SUSA initiative not yet been fully effective in relation to a number of BBS issues and while the SUSA strategy had made a 14% difference overall this is much less than was expected.

Figures 3 and 4 show to the relationship between Q1 (understanding SUSA at KCN or the need for H&S reinforcement at Company B) and Q14 (taking a chance with unsafe acts on site). If the SUSA initiative was working effectively it was expected that most people would understand what it is about, and consequently this group would generally act more safely. Company B results were expected to show a higher proportion of people who were not so health and safety conscious. In fact, not counting those who were neutral, 78% of respondents at KCN agreed that most people understood SUSA. Of these, only 36% thought that people who understood SUSA would not chance acting unsafely. Company B results showed that 83% believed that people understood the need to reinforce safe working. Of that group, only 30% believed that people who understood this would generally act safely.

The graphs appear to show that in both companies the majority of the workforce understood the need to reinforce safe working, and so could be described as health and safety conscious. Unexpectedly, Company B results were slightly better than those at KCN. However, both also indicate that a considerable number of respondents believe people continue to perform unsafe acts even if they are safety conscious.

A possible reason for this could be that the workforce wished to, and received, more health and safety information. This is being used to calculate the risks of an unsafe act and decide whether to take a chance, as observed by McSween (2003), or possibly because of complacency and risk homeostasis as suggested by Wilde (2003. cited in Shranks, 2007). The more likely reason is that the workforce is not making the connection between safety information and the way they act on site, or they may simply forget about it.

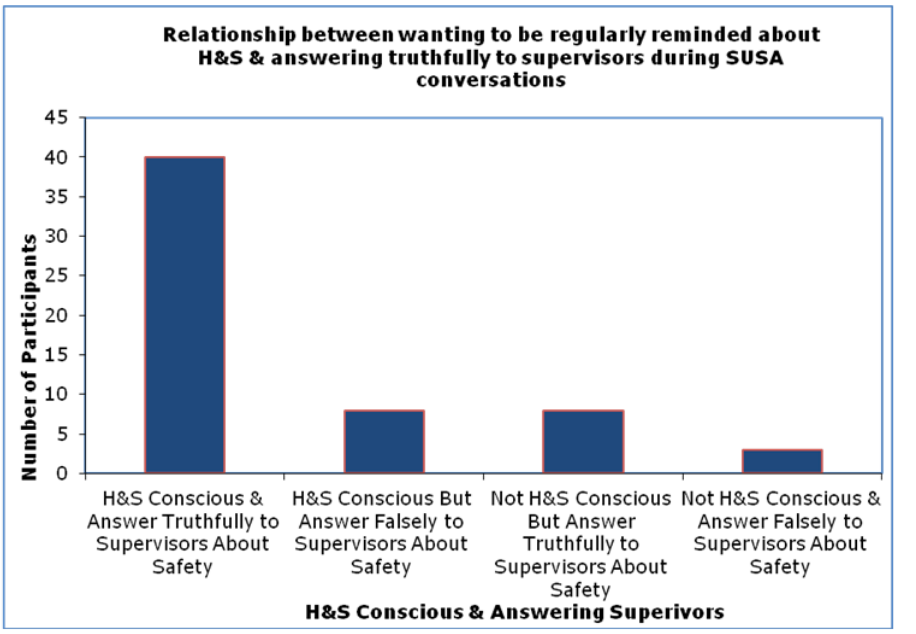

Figure 5 Relationship between wanting to be regularly reminded about H&S and answering truthfully to supervisors during SUSA conversations - KCN

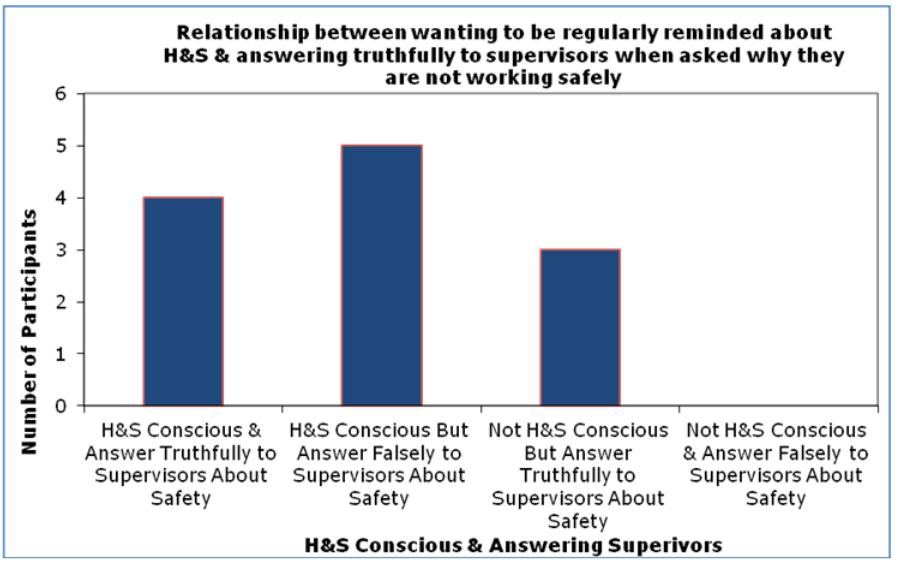

Figure 6 Relationship between wanting to be regularly reminded about H&S and answering truthfully to supervisors during SUSA conversations -Company B

Both the Kier and Company B graphs showed similar results, so this would suggest that not all the operatives on the Kier site were relating the health and safety information given through SUSAs to their working practices. Figures 5 and 6 compare the relationship between understanding SUSA (KCN, Q1) or being H&S conscious (Company B, Q1) and answering truthfully to supervisors during SUSA conversations (Q3).

It was expected that results would show that everybody on the KCN sites who knows what SUSA is about would answer truthfully during a SUSA discussion. This would be in line with the company's aspirational target of 100% appreciation of and commitment to health and safety on site. At Company B the same pattern would possibly be expected, but with a weaker positive trend because the SUSA initiative is not in place.

The KCN graph shows that the majority of operatives surveyed agreed that most people were aware of the health and safety initiatives and would speak to a supervisor honestly. This could be because if people are aware of SUSA and behavioural safety initiatives they realised that being honest would help improve the safety conditions on site and their own welfare.

The health and safety conscious people who answer untruthfully form just a small minority. It appears that these people may not be relating their SUSA understanding to the supervisor's questions; or they may not fully understand what the BBS initiative is about. It could also be, as McSween (2013) suggests, they are not motivated to reply truthfully because of lack of feedback or because they incorrectly link SUSA with disciplinary proceedings.

Company B graph (Figure 6) is completely different from that of KCN. The first category is comparatively much smaller, while the numbers who are H&S conscious but would still answer untruthfully is much higher. Unlike at Kier, however, no operative at Company B identified themselves as both not health and safety conscious and untruthful, perhaps due to the smaller sample pool used.

Comparing the two graphs appears to show that the SUSA initiative is, to some extent, having an effect in changing people's behaviour as the majority of operatives on Kier sites are truthful and that is not so at Company B.

Figures 7 and 8 show the relationship between workers believing safety on site is the manager's responsibility (Q3) and taking time to report unsafe areas (Q6).

The KCN graph showed 83% of operatives believed safety was everybody's responsibility, and 55% of the Company B workforce agreed with this. This is a very large difference and could be attributable to the SUSA initiative.

The operatives thinking safety is everybody's concern but not reporting unsafe areas contains the highest population on both KCN's and Company B's graphs. This should not be the case if people believe health and safety is everyone's responsibility. The most likely reason for this is that people are not linking their health and safety training to the reporting of unsafe areas, or again they are not motivated to do so. It may also be that those who are of the opinion that H&S is everyone's responsibility take this to mean that it is up to the person concerned to deal with an unsafe area. As noted by McSween (2013) time pressure could be another factor as construction operatives are on priced work and time lost from the job equals money lost.

In relation to SUSA, these findings raise the question of the extent to which employees have really taken on ownership of the BBS imitative. This is very relevant to its effectiveness and the importance of this aspect has been emphasised by (Sulzer-Azeroff and Lischeid (1999, cited in Stranks, 2007 p28). While it might not take much training to convert operatives to reporting unsafe areas, it could need more specific action to encourage them take wider ownership of health and safety.

There should not be an individual on KCN sites who sees health and safety solely as management's responsibility and who would not report unsafe areas on site. After an extensive training programme and four years of SUSA conversations, this way of thinking should have been eradicated by now. Worryingly 15% of those on the KCN graph above still think this way. Company B's graph shows a more uneven distribution of attitudes and is exactly what KCN is striving to move away from. The difference can probably be attributed to the effect of the SUSA strategy at KCN.

Figures 9 And 10 show the relationship between workers believing safety on site is the manager's responsibility (Q3) and whether they would ignore other people's unsafe acts (Q5). The graph shows 75% of the operatives surveyed on the KCN sites believed safety was not solely the manager's responsibility, and 53% of the Company B workforce also agreed with this. This is a very large difference and again could be attributed to the SUSA initiative. However it also shows that after four years the SUSA vision - everyone being responsible for their own safety and for that of others (Kier, 2012 06a) - is still a long way off.

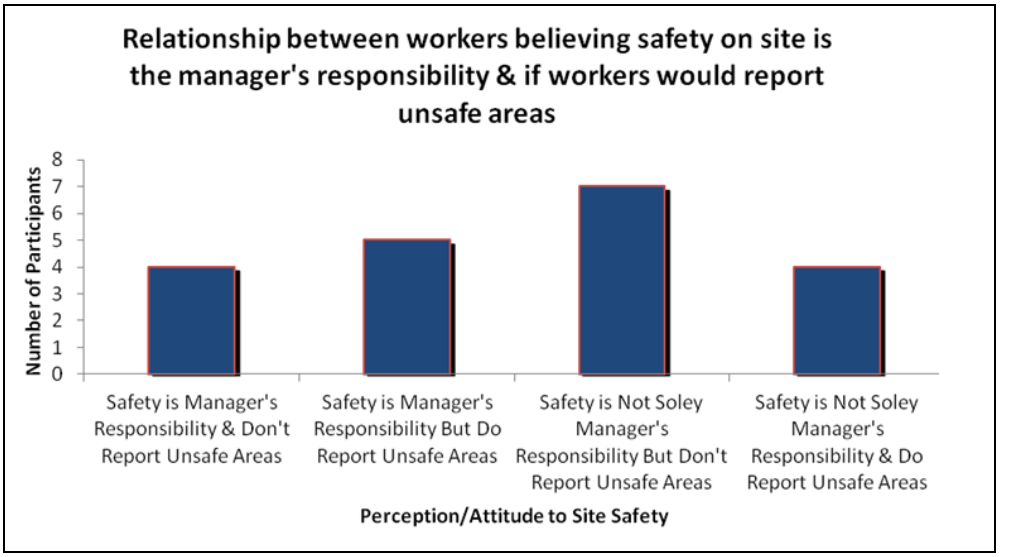

Figure 7 Relationship between workers believing safety on site is the manager's responsibility & if workers would report unsafe areas - KCN

Figure 8 Relationship between workers believing safety on site is the manager's responsibility & if workers would report unsafe areas - Company B

Figure 9 Relationship between workers believing safety on site is the manager's responsibility and if workers would report an unsafe act - KCN

Figure 10 Relationship between workers believing safety on site is the manager's responsibility and if workers would report an unsafe act - Company B

The category of operatives thinking safety is everybody's concern but not reporting unsafe areas/acts is the highest in both of the KCN graphs. This may be due to lack of training or understanding; it may possibly reflect the fact that

operative and observer have different perceptions of what is safe or unsafe. However, there is still a wider issue suggesting that the SUSA initiative is addressing some issues more effectively than others.

In the KCN graphs those not reporting unsafe areas/acts form the highest category. This may be due to lack of training or understanding; it may possibly reflect the fact that operative and observer have different perceptions of what is safe or unsafe. However, there is still a wider issue suggesting that the SUSA initiative is addressing some issues more effectively than others. However, there should not be an individual on KCN sites who see health and safety solely as management's responsibility and would not report unsafe acts on site. Alarmingly, 17% of those on the KCN graph (Figure 9) think this way, and these would be the individuals most likely to be red- carded. The Company B graph (Figure 10) shows a fairly even distribution of attitudes. In view of the SUSA initiative, the author was surprised that a higher percentage of Company B employees who believe that everyone is responsible for health and safety would also report an unsafe act.

There is also a discrepancy in the KCN graphs between the perceived reporting of unsafe acts and unsafe areas. It was expected this would be equal as people who feel they have a responsibility to report unsafe acts would act accordingly in respect of unsafe areas. This relates to HSE (2012) comments on targeted BBS training and observation. It may also be that SUSA discussions focus on unsafe acts as they are more task specific and possibly more obvious to people than unsafe areas. Again, individuals may respond to a primary incident such as an individual committing an unsafe act, but possibly miss the secondary effect of how an unsafe area could lead to an accident. If people are not looking at the larger picture it may be that the SUSA training and/or observation checklists leads to a focus on easily identifiable issues.

CONCLUSION

In relation to the primary aim, this research has not revealed a clear picture of the overall effectiveness of the SUS A initiative. It appears that the strategy has had a positive impact in reducing injuries, but at this stage it is not as effective as it has the potential to be. Company statistics show that, since the SUSA initiative was introduced, accidents rates have dropped significantly and this could indicate that after four years KCN is starting to see the real effect of the SUSA initiative. Even so, these figures have not fallen to the extent that Krause (1997 cited in Marsh, 1999) observed that BBS programmes can achieve over a four-year period, and they remain well above the organisation's ultimate aim of zero injury. Comparison with Company B shows a marked difference, with the

latter's accident rate remaining static while those of Kier and KCN have fallen dramatically. However, the data also shows that these rates had already dropped considerably in the years before SUSA started, suggesting that other KCN safety systems and strategies may also be responsible for improvements. Again, the case study, interview and questionnaires did not provide a consistent picture of the impact of the initiative, identifying both the positive and negative features that had been noted in the literature review. Overall it appears that while the SUSA programme is effective to some extent it is not always producing the desired change in terms of site workers safety behaviour and attitudes.

Limitations and Recommendations

The main limitations of the research were the number of KCN sites participating in the SUSA survey questionnaire, the number of operatives surveyed at Company B and the number of people interviewed. Also, it is may be that some people did not wish to give their honest opinion when asked about safety issues in the questionnaire for fear of possible repercussions. The comparative financial costs of operating SUSA against savings made on the costs of poor safety were not available to provide an alternative measure of effectiveness, as these figures are not recorded by the company. The deep and ongoing recession, affecting the construction industry throughout the relevant period, also meant that it was not possible for this research to examine the effectiveness of the strategy in times of boom and recession.

Even though the overall research findings do not provide a consistent picture, they do indicate a number of measures which could increase the effectiveness of the SUSA strategy, such as:

- Identifying agreed target areas for the focus of observations..
- Reducing the number of items on checklists and revising them as necessary.
- Having fewer, but better-trained, observers.
- Improving feedback and two-way communication with onsite employees.
- Observing workgroups and work areas as well as individuals.
- Considering how to make priced work and project deadlines more compatible with safety improvements.
- Adapting the strategy to encourage subcontractor involvement.

Further research

The findings of this study also indicate that further research might usefully focus on:

- Operatives views on SUSA and the effectiveness of behavioural safety.
- Low take-up by the supply chain.
- Comparison of the KCN initiative with similar BBS strategies operated by other major contracting organisations.
- The effectiveness of group and self-observation in comparison with peer observation.

REFERENCES

Cooper, M.D. 2009. B-Safe Management Solutions Inc.[online]. Available from: <http://www.behavioural-safety.com/articles/behavioral_safety_interventions_a_review_of_process_design_factors.pdf>. [Accessed 27 January 2013].

Cooper, M.D. 2010. B-Safe Management Solutions Inc. [online]. Available from: <http://www.behavioral-safety.com/articles/Return_on_Investment_of_behavior_based_safety.pdf>. [Accessed 27 January 2013].

DePasquale, J. and Geller 1999. Critical Success Factors for Behavior-Based Safety. Journal of Safety Research [online]. 30 4, p.237 - 249. Available from: <https://www.safetyperformance.com/CriticalSuccessFactorsforBehavior-BasedSafety-ANIOSHStudyof20Industry-WideApplications.pdf>. [Accessed 09 March 2013].

Eckenfelder, D. J. 2003. occupationalhazards.com [online]. Available from: <http://culturethesos.com/downloads/OccHaz_09_01_03_Antidote_for_BBS.pdf>. [Accessed 10 January].

Galloway, S.M. 2011. Proactsafety [online]. Available from: <http://proactsafety.com/articles/contributing-factors-of-bbs-failures>. [Accessed 05 January 2013].

Galloway, S.M. 2012. Proactsafety [online]. Available from: <http://proactsafety.com/articles/avoiding-the-10-common-pitfalls-of-bbs>. [Accessed 05 January 2013].

Geller, E. S. 2012. Cambridge Centre for Behavioural Studies [online]. Available from: <http://www.behavior.org/resources/332.pdf>. [Accessed 09 February 2013].

Health and Safety Executive [online]. 2012. Available from: <http://www.hse.gov.uk/statistics/industry/construction/index.htm>. [Accessed 10 November, 2012].

Health and Safety Executive [online]. 2012. Available from: <http://www.hse.gov.uk>. [Accessed 10 December 2012].

Hidley J.H. 1998. CRITICAL SUCCESS FACTORS FOR BEHAVIOR-BASED SAFETY Avoiding Common Pitfalls and Achieving Real Gains. Professional Safety [online]. 43 7, p.30. Available from: <http://web.ebscohost.com.lcproxy.shu.ac.uk/ehost/detail?sid=0a5b34c6-a4b0-4767-99e8-c119d36e4902@sessionmgr4>. [Accessed 10 December 2012].

Kier Construction Northern KCN 2013>. Safe League Table 01/01/2009 - 31/12/2013. Kier Construction Northern KCN: Kier Intranet.

Kier Construction Northern KCN 2103>. Unsafe League Table 01/01/2009 - 31/12/2013. Kier Construction Northern KCN: Kier Intranet.

Kier Construction Southern KSN 2012 01>. Construction Southern Bulletin PSL Toolbox Talk. Kier Construction Southern KSN: Kier Intranet.

Kier Group 2010 05>. Employee CBS Workshop. Kier Group: Kier Intranet

Kier Group 2010>. GUIDANCE FOR DIRECTORS/SENIOR MANAGERS OPENING MANAGEMENT AND WORK TEAM POSITIVE SAFETY LEADERSHIP TRAINING. Kier Group: Kier Intranet

Kier Group 2012 01>. BULLETIN 2012/001 PSL TOOL BOX TALK. Kier group: Kier Intranet

Kier Group 2012 03>. POSITIVE SAFETY LEADERSHIP Behavioural safety Programme Communication Strategy. Kier Group: Kier Intranet

Kier Group 2012 06a>. Our Vision. Kier group: Kier Intranet

Kier Group 2012 06b>. POSITIVE SAFETY LEADERSHIP Behavioural safety Programme FREQUENTLY ASKED QUESTIONS. Kier Group: Kier Intranet

Kier Group plc http://www.kier.co.uk/ar2012/our-business/health-and-safety.aspx Workplace: Health and Safety Our Performance Commentary

Lopez-Mena, L. 1993. persist.cl [online]. Available from: <http://www.persist.cl/links/ingles.html website>. [Accessed 10 January 2013].

Malallah, S. 2012. Behavior-base Safety Model. Diagram. At: San Francisco: Wikipedia Foundation, Inc., Creative commons. http://creativecommons.org/licenses/by-sa/3.0], via Wikimedia Commons.

Marsh, T 1999. Behavioural Safety - The Current Position. Training Solutions [online]. 9, p.1-4 Article 9. Available from: <http://www.rydermarsh.co.uk/pdfs/article_9.pdf>. [Accessed 20 November 2012].

Mathis, T.L. 2013. Proactsafety [online]. Available from: Available from: <http://proactsafety.com/articles/zero-accidents-does-not-equal-safety-excellence>. [Accessed 19 February 2013].

McSween, T. 2003. VALUE_BASED SAFETY PROCESS Improving Your Safety Culture with Behaviour-Based Safety 2nd ed.. Hoboken: John Wiley. Available from: <http://www.dawsonera.com/depp/reader/protected/direct/SearchResults,buttons.eBookView.sdirect?sp=S9780471449973>. [Accessed 09 January 2013].

McSween, T. 2012. QualitySafetyEdge [online]. Available from: <http://www.qualitysafetyedge.com/index.php/en/en/component/content/article/124-newsletter/safety-edge-summer-2012/183-common-problems-part-2-low-participation>. [Accessed 05 March 2013].

McSween, T. 2013. Cambridge Centre for Behavioural Studies [online]. Available from: <http://www.behavior.org/resource.php?id=707>. [Accessed 05 March 2013].

Melia, J 2012. Has The Implementation Of Behavioural Safety Strategies By Main Contractors In The UK Construction Industry Improved Safety Performance And Attitudes Of Their

Smith, S. 2007. Behavior-Based Safety: Myth or Magic?. Occupational Hazards [online]. 69 10, p.45. Available from: <http://search.proquest.com.lcproxy.shu.ac.uk/docview/213694567>. [Accessed 05 December 2012].

Smith, T.A. 1999. Mocalinc [online]. Available from: <http:/mocalinc.com/id14.html>. [Accessed 09 March 2013].

Stranks, J. 2007. Human Factors in Behavioural Safety. Oxford: Butterworth-Heinemann. Available from: <http://www.dawsonera.com/depp/reader/protected/direct/SearchResults,buttons.eBookView.sdirect?sp=S9780080489001>. [Accessed 10 December 2102].

TUC [online]. (2010). Available from: <http://www.tuc.org.uk/workplace/tuc-17940-f0.cfm>. [Accessed 09 April 2013]