ATTRIBUTING MANAGEMENT PROBLEMS ON CONSTRUCTION PROJECTS TO PROJECT INFORMATION

J Abukhder[1] and A K Munns[2]

[1]*Department of Architecture and Building Science, University of Strathclyde, 131 Rottenrow, Glasgow, G4 0NG, Scotland, UK*
[2]*Department of Civil Engineering, University of Dundee, Dundee, DD1 4HN, Scotland, UK*

The construction process generates a large quantity of information which is often not integrated, but is developed and owned by different individuals and organizations. This can create problems with keeping information up-to-date, and ensuring that all parties requiring access to the information have the most recent version. In this paper several case studies are examined in order to assess the integration problems that exist in construction projects. Five hypotheses will be tested to show the magnitude of effect on the management of the project, and to assess the impact of any failures in integration on the success of the project. The paper makes recommendations on the integration of project information to improve communication and reduce managerial problems on projects.

Keywords: communication, information management, management information systems, project management.

INTRODUCTION

Statistics show that the construction industry represents approximately 10% of the GNP for most nations (Harris *et al.*, 1998). Therefore, the productivity target of 30% real cost reduction suggested by Latham (1994) would have a dramatically positive effect on the nation as a whole. Both Latham (1994) and Egan (1998) in their reports highlighted problems that are encountered in the construction industry in UK. One of these is the fragmented nature of the construction industry which causes poor communication among all parties working on a construction project (Latham, 1994). As well as increased fragmentation the complexity in the construction industry has increased due to changes in technology and specialization of services. The present construction process generates large quantities of information which includes, for example, design information, construction information, and operation information. Any process can be defined as ‘a connected set of operations that are performed intentionally in order to reach a particular result’ (Longman, 1993). The process on a construction project should be described at a level of detail that will make it useful, because the more detailed the decomposition, the more accurate and reliable the description. Scheduling is an important aspect of process description and design, but describing only that aspect of a process through a PERT or Gantt diagram does not do justice to the complexity of a process. Issues like information flow, process management, feedback, and decision making need to be described in a different way

[1] Jamal.abukhder@strath.ac.uk
[2] a.k.munns@dundee.ac.uk

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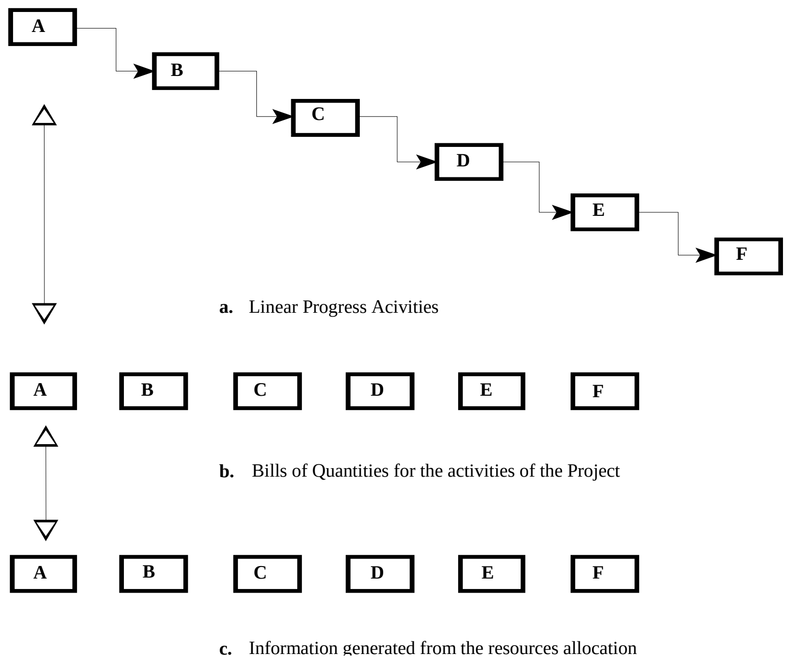

Figure 1: Lack of integration of systems planning, time, cost, people and information

(Mandel, 1990). In addition to these, there are additional characteristics such as iterations in a process and feedback. Iteration is one of the more important features of many processes. Many processes are not executed in one direction, from the start to the finish, without portions of the process being revisited. Iteration can be initiated inside or outside the process. Externally caused iteration is the result of changes outside the process boundaries, for example, the creation of new regulations. Internally caused iteration is triggered by a feedback message from an activity within the process (Mandel, 1990). The aim of this paper is to develop, describe and test hypothesis concerning the integration of construction that can be derived from studies of the existing planning systems and the systems which developed in the construction industry. Each hypothesis is explained and discussed with reference to the literature.

HYPOTHESIS

Traditional techniques for planning and control of projects are not harmonized or integrated (Egan, 1998). These techniques vary from planning the time on the project to costing and allocating the resources. Figure 1 shows the different tools used in a project. This figure explains that in the case of planning activity A, three processes are involved:

- Planning time that activity A may take. This is shown in (a) the process activities;
- Planning the cost. This is shown in (b) the quantities activities; and
- Allocating the resources required for this activity. This is shown in (c) the resources allocation.

In the event of any interruption in the progress of the project, caused, for example, by a delay or a need to up-date the programme of the project, all three separate processes need to be updated independently for each change. However, the lack of integration of the three systems can create difficulties in monitoring and controlling the project, for example, when information is not updated correctly and/or someone forgets to update one system. Technology can also create lack of integration. Technology brings

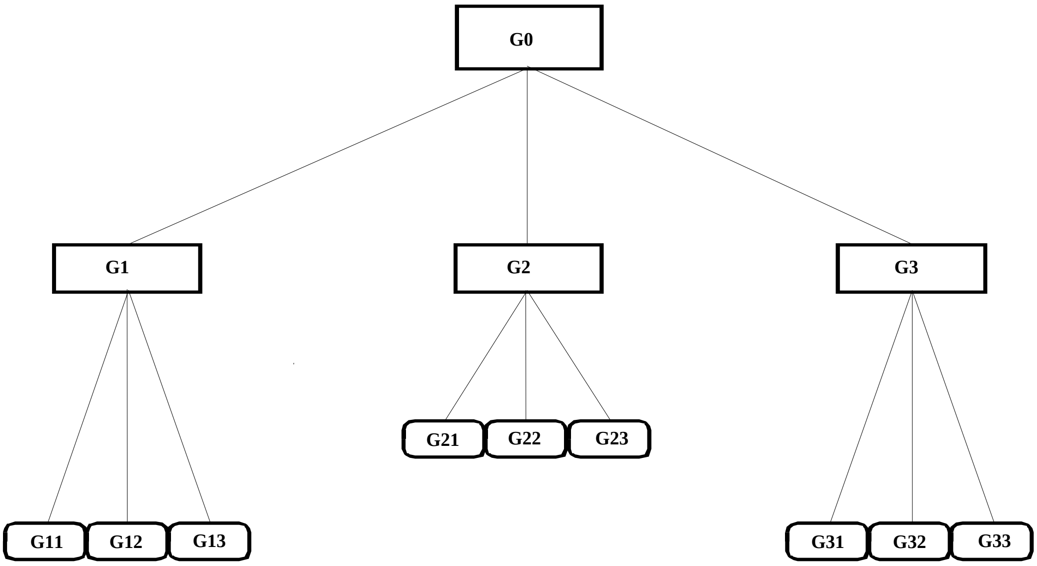

Figure 2: Hierarchical node structure of a project

different specialities to the industry, for example, the electrical consultant or structural engineer, and is the key variable in matching the complexity of the environment to the organizational structure (Woodward, 1965). The diversity of skill types required on a project is one demonstration of the extent of technological differentiation. Each of these disciplines produces their own information requiring high control and management of the project process in order to complete the project without any disruption or lack of information. Any change occurring in any of these disciplines results in the need to update the systems used elsewhere on the project. Thus, their needs to be integration of systems to link together the planning items, such as time, cost, information and people. In the first hypothesis, if a factor in one planning system changes but is not automatically changed in other related planning systems, then there is a failure in integration. This leads to the hypothesis (***Integration)***: **lack of integration between planning systems causes problems in the management of project processes.**

The hierarchy approach unifies the whole project as a single system. The advantage of this approach is that it involves assessing each of the component parts of the system in terms of their relationships to each other, and in their relationships to the whole. A hierarchy is a specific type of structure. From the whole the hierarchical structure subsets into progressively smaller or less complex units until it reaches the lowest levels of subsystems and individual activities. Figure 2 shows the hierarchical node structure of a project. Figure 2 shows that the project is working as a unitary system and that it is possible to focus on one component of the project while not missing the whole. This hierarchical structure provides the opportunity to study each element of the project separately whilst also identifying its links to the other elements. For example, in the project the activity G0 may be decomposed into three elements: G1, G2 and G3. Each of these elements could be broken down into other elements till the required level of decomposition has been obtained. This top-down approach does not miss the links and relationships between elements in the project. Alternative planning programmes used in projects, for example, bar charts and networking, provide only linear progression. The hierarchy method represents a system at a high level of abstraction suitable for consideration at management level and also at a low, detailed level suitable for implementation by engineers and software developers. A problem

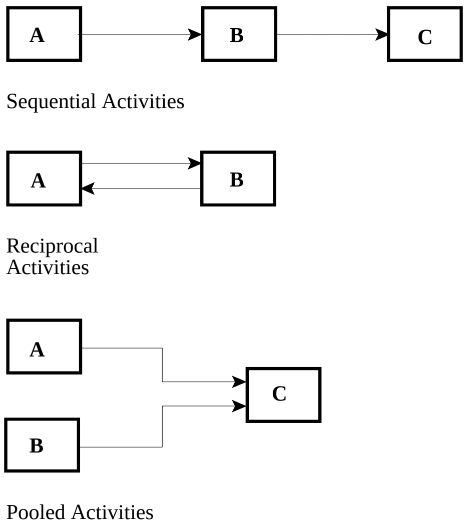

Figure 3: Patterns of interdependency

can occur on a project if there is insufficient detail in the breakdown of activities to identify the consequences of events. Its hypothesized (***Hierarchy***): **problems created by insufficient detail or associations in a project are caused by the lack of hierarchical approaches in planning**. Traditional techniques used in the construction industry, particular at the construction planning phase, deal with single direction mapping processes of the project, for example, bar charts and networks. Other information such as feedback and/or iterative issues in the design processes by their nature involve loops of activities. There are three basic ways in which structural components of a system may interact and be interdependent. Figure 3 shows the three types of these relationships of interdependency.

Most of the traditional techniques record sequential relationships. However, the reciprocal relationship, which deals with the interaction, occurs when a process flows in two or more directions simultaneously. Pooled interactions occur when two or more interactions come together at the same place and time. Reciprocal and pooled interactions are not always recorded in traditional planning techniques. Smith (1982) stated that communications and co-ordination demands increase as there is a move from sequential to reciprocal to pooled interdependencies. An example of this problem would be when there is more than one alternative to choose from. For example, in a sample test where there are two options on the result of the test, there are two possibilities. If the result is negative then reject the work; if the result is positive then proceed with the work. The result will have an impact on the next activity. Therefore, it hypothesized (***Iteration***): **problems are created by the lack of adequate iterative loops when traditional techniques are used**. Projects are described using pyramid organization charts. The charts show who has authority over whom, but they do not show the extent of that authority or the duties each person in the organization is expected to perform. Thus, the traditional organization chart shows only authority relationships. This follows the graphical portrayal of the traditional school of organization theory (Cleland and King, 1983). The drawback with this type of organizational chart is the vast amount of traditional text needed to describe an organization's structure fully. Most organizational charts deal only with status and authority (Hughes, 1989). By using a flexible organization in the model, the structure would be more adaptable and dynamic to the environment in which it is to operate. Thus, a flexible organization model could minimize the duplication of decisions and information because the roles and responsibilities would be clearly assigned to the participants in the project. A lack of linear responsibility analysis (LRA) could lead to failure in control and projects being developed or disrupted due to tasks not being completed correctly. Latham (1994) call, for more effective practices to improve construction and this could be achieved with improved control. The way to explain this hypothesis is that, when an activity is affected by a missing management function, then it is a linear responsibility analysis problem. The hypothesis (***LRA***): **where identification of the roles and responsibilities of each contributor to an activity are omitted this causes problems in the project processes**. Methodologies have been adopted from manufacturing industry to define and model the system on construction projects, to improve the efficiency of the project. One such model is IDEF, which has been described by Le Clair (1992). These mapping techniques are not adequate to map all the information needed to complete an activity. For example, the roles and responsibilities of the participants are not shown in the IDEF technique although individuals we assigned to the activity in control roles, there is no explicit allocation of their responsibilities as defined in LRA. This could lead to confusing of individual's tasks, and control not being completed. In bar charts there is only one direction for relationships, that is, a sequential relationship. Yet it has been shown that there are three basic ways in which structural components of a system may interact and be interdependent (Figure-3). When the relationships between activities are affected by missing information from another activity this is called a mapping problem. For example, delay in the delivery of material or detail drawing to site prevents the related activities from progressing. Thus, we hypothesize (***Mapping***): **the lack of an effective mapping tool in the project causes problems in the management of information relationships**. The complexity of the project is affected by: rapid change and development in technology; unexpected changes in consumer demand; design changes; personnel changes; late completion of tasks; and unexpected events, such as bad weather. All of these factors have an effect on the project processes which causes interruption and delay. These changes require responsiveness in planning. This responsiveness in planning the project processes requires both responsive process mapping and process control techniques. In IDEF the technique is too rigid and is not responsive to change. When there is a delay in the planning systems responding to change and this delay results in time extensions on the project then it is a responsiveness problem. Thus, hypothesis (***Responsiveness***): **problems can occur in projects where there is a lack of a responsive process mapping and control technique**. Traditional programmes such as CPM and PERT are linear progress programmes, both are dynamic tools and this because they can be changed and updated easily to reflect changes in the project. Network analysis and bar charts are ideally suited to deterministic processes such as construction where activities are predefined. Although both techniques are traditionally used to programme the design phase of a building project, however, they are not good in mapping the project process. They can map the time process, but not the information needed for each activity or the management function. IDEF can map the information required to transform the function, but this is a static technique because it cannot map the time process. Although network techniques are functioning in time as noted, they have some drawbacks. Other mapping techniques, such as IDEF are not dynamic techniques. Thus, there is a need to have dynamic mapping systems that can overcome these drawbacks. The hypothesis is that (***Dynamics***): **problems can arise in projects due to lack of use of dynamic mapping systems**.

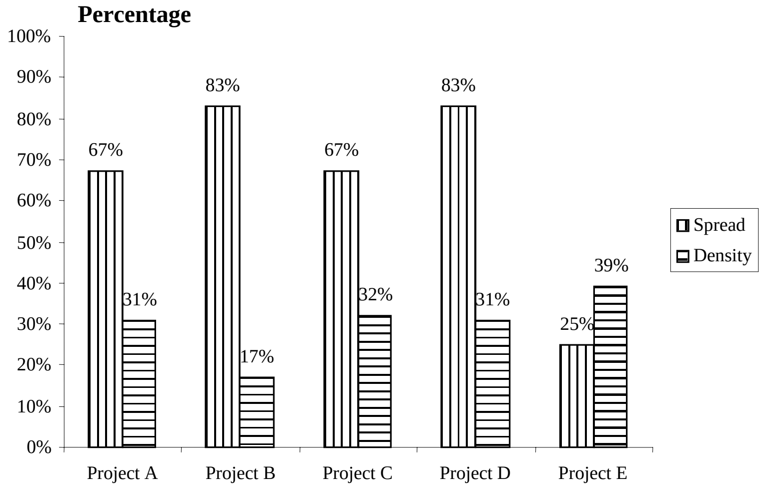

Figure 4: Integration results by case study

METHOD

Best practice guidelines advocate the use of a protocol in case study research (Yin, 1989). This is required to scope the investigation and as a strategy for data collection and analysis. Five case studies were used in this research. In each study data on problems occurring on the project, their cause and impact was collected through a triangulation process. The first element involved interviewing some of the project personnel such as the site manager, the clerk of works and others involved in the project. To verify the information from this source contract documents were used to check whether the information was realistic or not. In the second element, information was obtained through visiting the site and observing the activities, the workers and the supply of the materials. The third element comprised a review of the documents of the project such as minutes of meeting, diary of the contractor, and the drawings of the projects. Problems were then categorized as unique events and then attributed to activities on the project. An activity could be the source of the problem, or be affected by a problem arising from another related activity.

DISCUSSION

Two scales were used to weigh the problems identified in the data gathering process. The first was Density which was used to show the impact of the problem on the project's activities. The second was the Spread which was used to show the impact of the problem on the elements in the project. Density and Spread scales were used to assess and compare the case study values and were calculated on different bases. The Density was calculated according to the effect of the problem on the activities of the project. To measure the Density the number of activities affected by a problem was divided by the total number of the project activities. The Spread was calculated regarding the effect of the problems in one element of the project compared to the remaining elements of the same project. For measurement of Spread, the number of elements affected by a problem was divided by the total number of the project elements. Different results in Density and Spread will mean, for example, high Spread value will mean many elements of the project have been affected, but this does not mean many activities were affected. The Density reading will show that many

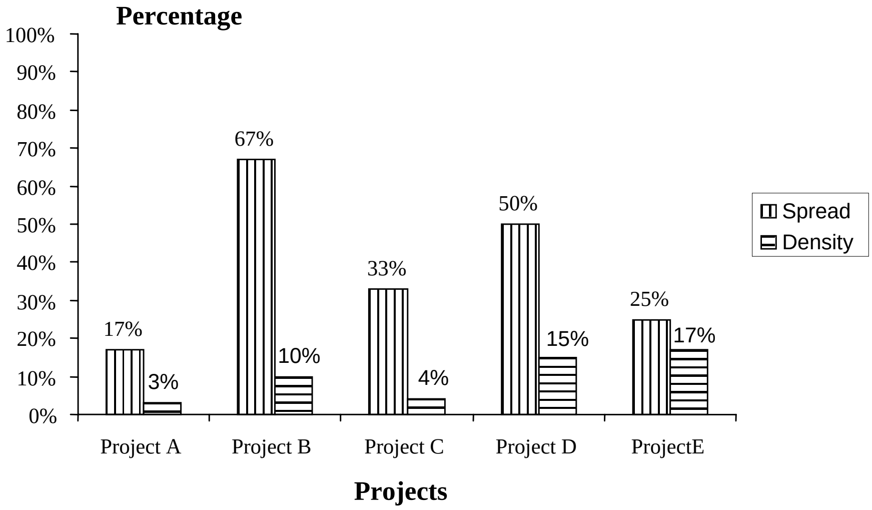

Figure 5: Hierarchy results by case study

activities have been affected. In such circumstances, this can mean poor across the project activities, because many activities had been affected instead of a few activities.

Integration

Figure 4 shows the results of all case studies for integration problems. Project E had the highest of Integration problems but the lowest spread among the elements of this project. Projects B, C and E were managed using the same type of management but the three phases differed in the size of the project and the number of activities. All case studies were affected, and this suggests that the lack of Integration was not because of the type of procurement method used to manage and control the projects, which were different between the case studies. All projects utilized similar techniques to manage and plan activities and these techniques were used separately not in one framework. In the five case studies all had a spread of Integration problems and density factor. Therefore, Integration was a significant problem for the activities of the project.

Hierarchy

Figure 5 summarizes the results of all five projects. The Project A has the lowest results for both scales of Spread and Density with regard to the Hierarchy problem, because few problems occurred during the construction of this project and most of the conflicts happened due to the changes in the project. No special technique was used to plan this project other than a bar chart. However, this project had very simple activities with clear division and it was easier to group the activities. This view was supported by the personnel involved in this project. This explains why this project was the lowest among other projects in relation to the Hierarchy problem The higher spread of the Hierarchy problem occurred in the Project B. this could be attributed to the fixed time that was given to complete this project. This resulted in greater attention to the relationships between the activities which reduced the ability to breakdown activities to identify the consequence of events. In addition to this, the Project B was more complex compared to the other projects and consisted of a large number of activities which, in turn, made this project harder to plan compared with Project A.

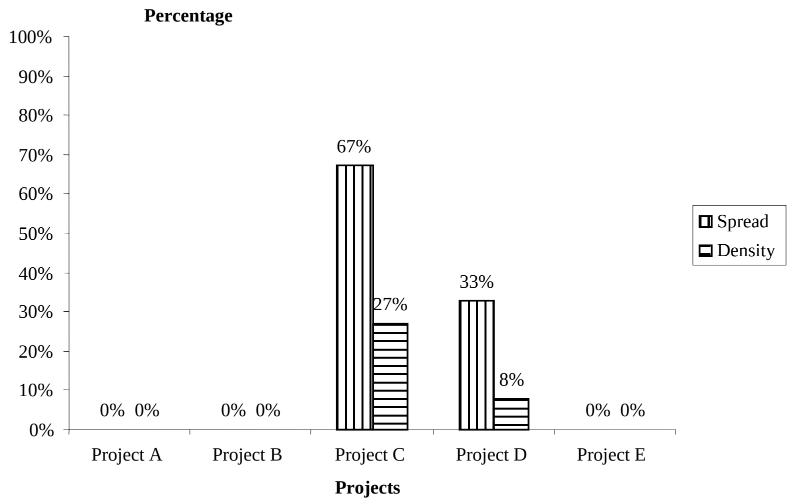

Figure 6: Iteration results by case study

All five projects were affected by the impact of the Hierarchy problem. The differences in the scale of the Hierarchy problems could be interpreted as a result of the complexity of each project. The results support the hypothesis and link the best project in terms of the impact of the problem to the complexity of the project.

Iteration

Figure 6 summarizes the results among all case studies. Only two projects were affected by this problem. The reason for this problem in the two cases was the lack of an iterative loop in the tool used to schedule the project activities. In the other three projects no Iteration problem appeared and this could be attributed to the fact that no significant changes occurred requiring iterative loops to complete the work.

The differences in the instances of the Iterative problem were evident in that the impact of changes was on more activities and elements on Project C compared with Project D. the reason for the Iteration problem was change during the construction stage requiring iterative loops. This problem occurred only on two projects, Iteration is only a problem when this sort of condition applies, and thus creates a major change in projects which require feedback and major changes in design works.

Linear Responsibility Analysis

The summary of the results for this given in Figure 7. This shows a wide range of results, some of which are very low. However, the Project D had the worst incidence of this problem when both Density and Spread of this problem were considered. This could be attributed to the way that this project was managed. The omission of identification of the roles and responsibilities of each contributor in this project, wrong delivery of materials; and delay in delivery of details significant problems resulted. Examples of these problems are delay in delivery;.

Overall, in relation to the problem of Linear Responsibility Analysis all five projects were affected. This happened because the traditional tools were used to plan these projects which omitted the roles and responsibilities of the contributors in these projects and thus resulted in the Linear Responsibility Analysis problem

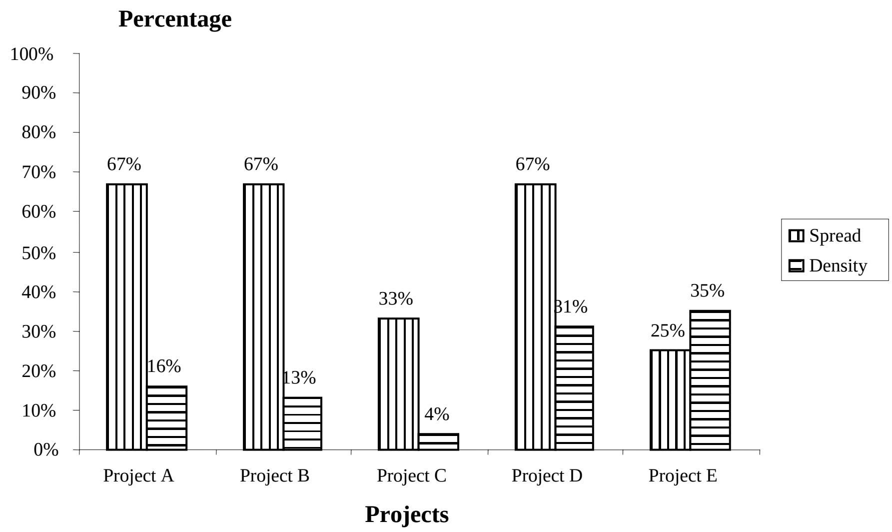

Figure 7: LRA results by case study

Mapping

Overall, in relation to problem of Mapping all five projects were affected. This occurred because all projects used a bar chart, but they were different in the level of detail. For example, projects B, C and E used two-weekly detailed programmes, which were able to respond to problems, whereas the monthly programme was not able to respond to problems

Responsiveness

Two projects were affected by this problem, and this could be attributed to the way that these projects were planned and managed. All project used a bar chart but different in the level of detail. For example, the three projects B, C and E used two-weekly programmes which were able to response to problems where the monthly programme were not able to respond to problems, but the others used a general schedule to plan the activities.. This created a Responsiveness problem in both projects. However, the detailed programme used to plan the activities in the other projects could help to prevent this problem. The projects suffered from the interruption and delay which caused a Responsiveness problem, and this was due to a major change during the construction stage. The Responsiveness problem occurs when there are major changes in projects activities.

Dynamics

In projects problems may arise because of the lack of use of dynamic mapping systems. There is a need for a system to cope with any changes in the project, for example, in Project C there was a change in the size of the basement. An example which showed how the bar chart can cope with a dynamic problem was the project D. This project had a dynamic problem because of the addition of another floor during the construction stage, but the bar chart coped with this change. All five projects were tested against this hypothesis and it has been suggested in this research that no dynamics problems were monitored. However, this does not mean that this hypothesis will not appear on other projects which use traditional planning techniques.

CONCLUSION

This paper has explored the management issues involved with the control of information on construction projects. The paper has identified six areas where problems could occur, and shown that four of these were shown to affect five projects to varying degrees. The most significant problems lay in the areas of integration, hierarchy, mapping and linear responsibility analysis. This would suggest that to reduce problems arising from management issues on construction projects there should be improved systems to manage information in the following areas:

Integration – to provide a single coherent system to link information on time, cost, responsibility, and dependency could reduce confusion between different systems.

Hierarchy – a structured breakdown of activities on projects could better identify the relationships between individual activities.

Mapping – a system to show information relationships and responsibilities could reduce confusion between activities.

Linear Responsibility Analysis – mapping individual responsibilities on activities could help reduce disruption by missing management functions.

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