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The influence of communication structure upon crisis management efficiency

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A construction crisis stimulates a network of communications within its host organization, the structure of which influences crisis management efficiency. It does so by determining the effectiveness of information transfer between project participants, and thereby the level of uncertainty, misunderstanding and ultimately conflict which materializes. These conclusions arose from research which was concerned specifically with the patterns of communication and behaviour which emerge in response to construction crises. The methodology adopted a longitudinal, multiple case study approach and combined the complementary techniques of content analysis and social network analysis.

Keywords: Crisis management, efficiency, communication, structure, networks

Introduction

Linear models of communication such as Shannon and Weaver's (1949) and Minai's (1984) traditionally have dominated research within and outside a construction management context (Rogers and Kincaid, 1981; Bowen, 1993). Rogers and Kincaid (1981) criticize such models, arguing that their widespread adoption generally has resulted in simplistic explanations of sociological phenomena. The reason is that linear-based research focuses typically upon the receiver in isolation and at one point in time, meaning that the dynamic influence of people's wider social networks is ignored. Rogers and Kincaid argue that to produce more realistic explanations there is a need to move towards a perspective which reflects the dynamic, cyclical and mutually influential nature of the communication process. A mechanism for achieving this is the social network perspective, which has its origins in sociology (Simmel, 1950) and anthropology (Mitchell, 1969; Boissevain, 1974). The widely accepted definition of a social network is that proposed by Mitchell (1969, p. 2) which is 'a specific set of linkages among a defined set of persons, with the additional property that the characteristics of these linkages as a whole may

be used to interpret the social behaviour of the persons involved'. In essence, the social network perspective conceives the act of communication as a joint occurrence in which two or more people repeatedly share information in order to reach a mutual understanding. An organization is seen as a system of objects (people, groups, organizations) joined by a variety of relationships and there is a particular concern with the structure and patterning of those relationships over time and with their causes and consequences (Tichy *et al.*, 1979; Scott, 1991). Indeed, it is with the dynamic structuring of social relationships that this paper is concerned. The aim is to investigate the relationship between the structure of communication networks which specifically emerge in response to construction crises and the efficiency of crisis management efforts.

Defining a crisis

A definition of crisis has emerged gradually with the evolution of crisis management research. It is research which grew originally out of the potential for catastrophe from increasing technological complexity during the 1960s. Further momentum, from an inter-

national relations perspective, was added by worldwide political instability during the 1980s. More recently, interest from an organizational perspective has grown because of an increasingly hostile business environment (Shrivastava, 1994). While crisis management research from an organizational perspective is still in its infancy, it is generally accepted in the crisis management literature that a crisis is an unexpected event for which there are no contingency plans in place. A crisis represents a significant threat to high priority goals, demands a non-routine solution under extreme time-pressure, and stresses to the limit an organization's capacity to respond (Williams, 1957; Hermann, 1963; Brecher, 1977; Shrivastava, 1994). The fact that the specific attributes of a crisis have been identified but not in a precisely measurable way has implications for their study which have been discussed, with other problematical issues, in Loosemore (1996).

The concept of communication structure and its relationship with crisis management efficiency

Communication structure is defined as the 'differentiated elements that can be recognised in the patterned communication flows in a system' (Rogers and Kincaid, 1981, p. 146). The most convincing evidence to support a potential link between communication structure and crisis management efficiency has been provided by the pioneering work of Leavitt (1951) and Shaw (1954). They investigated experimentally the relationship between the problem solving efficiency of small groups and their communication structure. Leavitt artificially created small groups of people and gave them a simple problem to solve which required the pooling of information. The members of each group were separated physically and permitted to use only predetermined two-way communication channels. The group communication patterns which were investigated are illustrated in Fig. 1.

Within a predetermined communication structure each group was given a number of problems to solve enabling Leavitt to study the development of group efficiency in each pattern. Efficiency was measured by

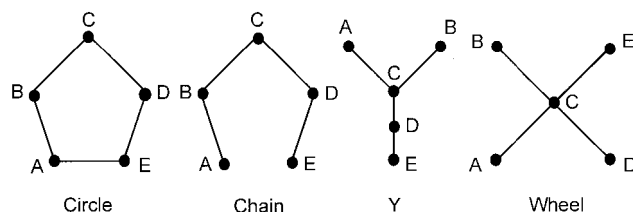


Figure 1 Leavitt's (1951:42) experimental patterns

the amount of time required for solution, the quality of solution being considered irrelevant because of problem simplicity. Through observations, interviews and analysis of communication, Leavitt found significant differences in problem solving efficiency between the patterns. He found that organizational efficiency developed most rapidly in the chain, followed by the Y, the wheel and finally the circle. In terms of leadership, the circle was seen as active, leaderless, unorganized and erratic, but yet enjoyed by its members. In complete contrast, the wheel was less active, had a distinct leader, was well and stably organized, was less erratic, and dissatisfying to its membership. Leavitt saw the concept of centrality as fundamental to an explanation of the results. In Leavitt's (1951, p. 38) view 'the most central position in a pattern is the position closest to all other positions', distance being measured by 'the number of communicative links which must be utilized to get, by the shortest route, from one position to another'. Leavitt concluded that where centrality and hence interdependence are evenly distributed, there will be no leader, high activity, slow problem solving, but high satisfaction.

Shaw (1954) refined Leavitt's work by investigating how task complexity affected relative group efficiencies. Strikingly, he found that as task complexity increased, the relative efficiency of various patterns reversed completely. The circle became the fastest and the wheel the slowest. By contrast, all other findings relating to satisfaction and leadership were in agreement with Leavitt's original conclusions. The explanation was that as problem complexity increased, the central person in the wheel became overloaded with information and peripheral people became less willing to accept solutions offered by the central person.

Research rationale

A logical extension of Leavitt's and Shaw's research led to the proposition that 'the structure of communications which emerges in response to a construction crisis is related to crisis management efficiency'. However, Leavitt's and Shaw's research was conducted when communication research was in its infancy, and since then a greater understanding of communication structure has developed. In this sense, their research now seems out-dated. A further limitation was the artificial environment in which their research was conducted. They stripped away all the complications of real life and placed people in a laboratory environment where there were no time pressures or barriers to communication. Furthermore, the problems posed were, even in Shaw's case, relatively simple, and people were permitted to communicate only through formally

prescribed routes. These artificial conditions make their detailed findings of little relevance to the reality of a construction project during a crisis. A crisis is likely to pose complex problems of major proportions, impose significant pressures, create substantial physical and emotional barriers to communication and encourage people to bypass formal prescribed procedures (Janowitz, 1959; Mintzberg, 1976; Bennett, 1991; Sagan, 1991). In this sense, there was considerable potential to extend Leavitt's and Shaw's work in a more realistic context. In particular, there was the opportunity to apply new techniques of indexing more complex dimensions of communication structure. Furthermore, there was the need to do this in the field rather than in a laboratory, and to develop methodologies to take account of personal pressures, communication barriers and the informal and dynamic aspects of interpersonal communications. This realization prompted research to investigate the relationship between the structure of communications which emerge in response to a construction crisis and the efficiency of crisis management efforts. Four case studies were analysed and the research took the client's perspective, focusing upon the construction stage of traditionally procured projects.

Research methodology

A multiple case study approach was used because it provided an opportunity to ascertain how the crisis was experienced by project participants, and to develop an understanding of why people behaved as they did. It also enabled the collection of relational data over the life of a crisis. Relational data about people's interactions was collected longitudinally by diaries which were distributed to the main project participants. Diaries were used on the basis of Bernard *et al*'s (1982) assessment of the accuracy of various methods of collecting relational data. When a crisis arose, project members were asked to start using their diaries to record all of their formal and informal communications in relation to that crisis. The collection of data from a wide range of respondents helped to avoid the problems of differing diligence in completing their diaries. When the crisis was resolved, the completed diaries were collected back and cross referenced to produce a chronological network of the social interactions which represented the crisis management process. A portion of a typical social network from one case study is shown in Fig. 2, where the bold vertical lines, placed along a time continuum, represent the transaction of information via a range of communications media. A key is provided at the top of the network to link each type of line to a specific medium. The arrows on the lines

indicate the direction of initiation of a communication, not the direction of information flow. This is an important distinction, because some media facilitate a two-way flow and others a one-way flow. The horizontal lines on the network represent reference points to different role players in a construction project. They are listed down the left hand side of the network and a key is provided to explain each abbreviation. The letters running along the base of the network are there to combine interactions into definable blocks to simplify analysis. Finally, the partly shaded bar in the top left hand corner of the network shows the total duration of the crisis management process and the portion represented by the depicted network. In this case, the crisis management process lasted 9 months in total.

In producing the network from the diary data, the cross referencing process between the range of diaries returned helped to overcome the problems of missing entries. It did so by highlighting discrepancies which were then resolved during retrospective interviews with each respondent. Where necessary, documents also were inspected to resolve discrepancies. These measures overcame the main problem associated with the use of diaries to collect data. Although the retrospective interviews were useful for resolving discrepancies, their main purpose was to gather qualitative data about people's behaviour and their differing perceptions of the crisis management process. Behavioural data were collected through the semi-structured retrospective interviews and also during the reaction process itself. Non-participant observations were made of meetings where the crisis was discussed.

The above data collection strategy produced a variety of qualitative and quantitative data from a wide range of perceptions. The process of analysis in each case study involved three stages which became progressively more quantitative. The first stage of analysis was largely intuitive and based upon the reconciliation of often conflicting accounts of the crisis which emerged from diary, observational and interview data. This time consuming process resulted in a longitudinal descriptive account of the crisis management process from a wide range of perceptions. Although the impressions and intuitions which arose from such accounts were helpful in providing insights, their contribution was limited by their inherent subjectivity. In this sense they were used only to provide leads which were then followed up by more rigorous analysis. The second stage of analysis utilized the technique of content analysis, which has been developed to help researchers examine artefacts of social communication in order to derive some meaning from them (Berg, 1989). The use of the technique essentially involved categorizing the communication content of each network interaction into its components parts and

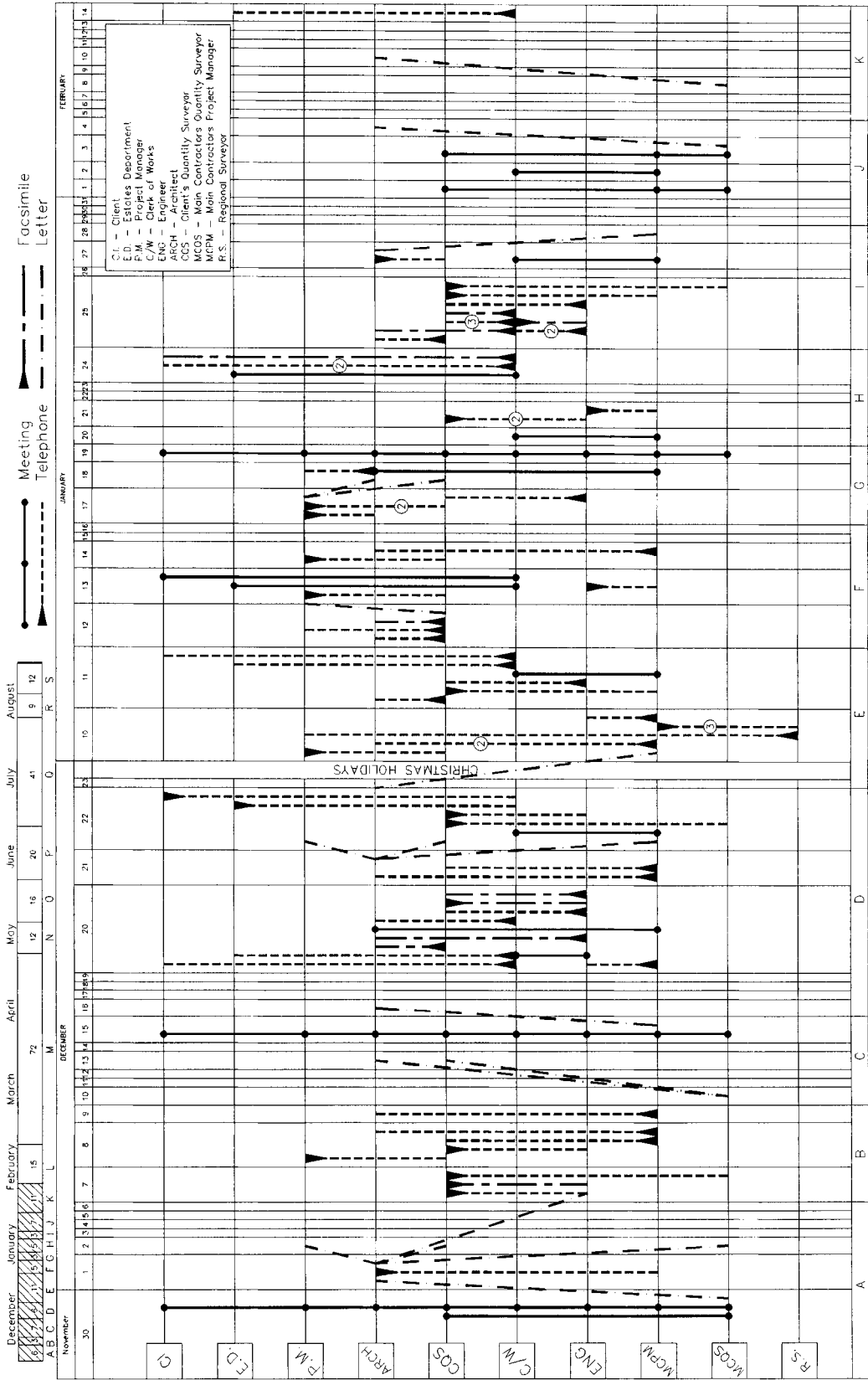


Figure 2 Portion of a typical social network

quantifying it. A framework proposed by Berelson (1971) was used for this purpose and it resulted in a longitudinal account of the crisis management process which helped in understanding how people's behaviour changed over time. The final element of the analytical strategy was purely quantitative, and involved indexing the communication structure of the crisis management networks. To do this, the techniques of social network analysis (SNA) were used through software called 'UCINET' Version 1.00 (Borgatti *et al.*, 1992). This package was used because it was designed for relatively small networks and the range of measures produced were meaningful to this research.

Dimensions of structure investigated

Many dimensions of communication structure and methods of measurement have been developed in the SNA literature since Leavitt's and Shaw's research (Rogers and Kincaid, 1981; Scott, 1991; Wasserman and Faust, 1994). It was important not to assume that every structural dimension was useful, and in this research a particular dimension was investigated only where there was evidence that it could be given a meaningful and useful interpretation in the context of construction crisis management. What follows is an explanation of the rationale which underpinned the choice of the structural dimensions investigated. Before embarking upon this rationale it is important to differentiate between two levels of communication structure, the 'socio-centric' structure of the network as a whole and the 'ego-centric' structure associated with the communication network of each individual within it.

Factions

A faction is a collection of people who communicate more frequently with each other than they do with others (Glover, 1989). They are based around people's informal social relations and have their own norms, values, orientations and sub-cultures (Weis and Jacobson, 1955; Tichy and Fombrun, 1978; Van de Ven and Ferry, 1980). Many studies have seen factionalism as central to explanations of social phenomena in that factions perform important social functions by providing a source of identity and sense of belonging. Scott (1991, p. 105) points out that the number and size of factions found in an organization is indicative of its internal obstacles to communication and resource transfers. The concept of the faction was considered important to this research because of the conflicts of interest that exist in the construction process. These ensure that distinct winners and losers emerge during a crisis and that people with similar interests will form groups to increase their power base in the pursuit

of their common interests (Snyder, 1962; Janis, 1988; George, 1991). The identification of factions was therefore considered to be indicative of division and tension during a crisis.

Structural and regular equivalence

A pair of people in a network are structurally equivalent if they have exactly the same pattern of contacts. It has been argued that such people play the same role in an organization and are interchangeable (Lorrain and White, 1971; Burt, 1976). However, this view has been discredited because people can be highly structurally equivalent by having the same patterns of connections with different people. Both Borgatti and Everett (1989) and Scott (1991) argue that this does not mean that they are playing the same social role and advocate the concept of 'regular equivalence', which takes account of both the pattern and the nature of people within that pattern. Two people are regularly equivalent only if they are connected to the same people in the same way.

In investigating the crisis reaction process, the concept of regular equivalence was important because it was reasonable to assume that communication would be better and thus the reaction process more efficient within highly equivalent groups. Members of highly equivalent groups would have common neighbours, meaning shorter communication routes and less distortion through filtering.

Centrality

Mackenzie (1966, p. 17) defined socio-centric centrality as 'the degree to which information flows are centred on one or a few organizational units'. Ego-centric centrality is defined as 'the degree to which information flows focus upon a target individual'.

The concept of centrality was important to this research because of its potential influence upon problem solving efficiency and behaviour. Evidence to this effect was first provided by Leavitt (1951) who, in a problem solving context, concluded that where centrality was evenly distributed there would be less leadership, many errors, high activity, slow problem solving but high satisfaction. Shaw (1954) refined Leavitt's work, arguing that the influence of centrality was dependent upon the nature of the task. More complex problems demanded less centralized structures. McGregor (1960) and Burns and Stalker (1961) also argued that the influence of centrality was dependent upon the nature of the task, the nature of the people who were performing the task, and the stability of the environment in which they operated. Decentralized structures were more suitable for unstable, changing tasks and for people of professional status. In contrast, centralized structures were suitable for stable environ-

ments where the nature of the task was more predictable and professional judgement less important. Mintzberg (1976) and Gibb (1984) point to a conflict which emerges between centralized control structures and the need for creativity and flexibility. They found that if an inappropriate degree of centralized control is applied in a situation which demands flexibility, then the behavioural response will be a defensive one. In a similar vein, Stacey (1992) has poignantly observed that, if inappropriately applied, centrally imposed order can lead to chaos where chaos eventually and naturally would have led to order.

A considerable interest in centrality has confused the literature in this area and Freeman (1979) is credited with clarifying it. He differentiated between degree centrality, closeness centrality and betweenness centrality.

Degree centrality. The simplest measure of ego-centric centrality is the 'degree' of a point, that is, the extent to which a person is connected to its immediate environment or neighbours. A person's in-degree and out-degree centralities represent the degree to which it is a receiver or sender of information from or to its neighbours, respectively. The former indicates a person's popularity in a network and their accessibility to information. The latter indicates a person's control or leadership over a network and the dependence of the network upon them. A person with a high in-degree can be classified as a sink and one with a high out-degree as a source.

At a socio-centric level, the in-degree index reflects the extent to which one or a few people are the focus of information supply in the whole network and the out-degree index reflects the extent to which information supply is controlled by one or a few people.

Closeness centrality. At an ego-centric level, closeness centrality measures the 'distance' of a person from every other person in a network. Distance is defined as the number of intermediaries through which two people have to go to communicate. Freeman (1979) argued that it is a good indication of a person's independence because a person who is close to many others finds it difficult to act independently without others knowing. However, conversely they have the capacity to monitor and control more people directly and to disseminate decisions and ideas quickly to a wider range of people.

At a socio-centric level, closeness centrality reflects the extent to which the whole network is close to one or a few people, i.e. tightly knit around one or a few points.

Betweenness centrality. At an ego-centric level, the concept of betweenness centrality measures the extent to which a particular person lies between other people

in a network. That is, it reflects the extent to which a person is a gatekeeper between or coordinator of different groups. Freeman (1979) argued that people with high betweenness centrality are powerful people, acting as the valves within a network. They occupy a critical position in maintaining free and open information flow. Cohn and Marriott (1958) pointed out that these people act as the glue that holds a system's parts together, and weaknesses at these critical points can lead to disintegration.

At a socio-centric level, betweenness centrality is a good indication of a network's vulnerability. This is because it measures the extent to which information flow within the network is channelled through a few people of high betweenness. The network is vulnerable because these people can manipulate and filter information flow to serve their own interests.

Measuring reaction efficiency

The distinction between effectiveness and efficiency in a crisis management context is an important one because it is possible to have an effective but inefficient crisis management process. Pijenburg and Menno (1990) argue that crisis management effectiveness should be measured by the extent to which the potential impact of a crisis upon organizational goals is mitigated. By contrast, efficiency measures 'the ratio of useful work performed to the total energy expended' (Allen, 1990), i.e. the best use of time, money and resources in the crisis management process. It can be measured by comparing the time and resources invested in a crisis management process with progress made towards a solution. However, measures of efficiency were made difficult by three complications.

The first complication was the possibility that the crisis management process may be punctuated by different phases of behaviour which contribute different amounts to reaction efficiency. Many models of crisis behaviour suggest that this would be the case (Fink *et al.*, 1971; Cisin and Clarke, 1962; Sipika and Smith, 1993). In this sense, holistic measures of efficiency were considered overly simplistic, and it was considered more appropriate to study reaction efficiency in relation to each behavioural phase identified during a crisis. These were identified using content analysis to highlight prolonged changes in communication content within a communication network.

The second complication arose from potential difficulties in measuring the resources invested in a crisis. A pilot study indicated that this information could be highly sensitive and that respondents may be reluctant to divulge it.

The third complication arose from potential difficulties in measuring the amount of time invested in a crisis. Although a communication network could indicate how long a crisis took to resolve, it could not indicate the amount of time invested. For these reasons it was considered most sensible to develop an indicative rather than an accurate measure of efficiency.

In attempting to develop an indicative measure of crisis management efficiency, the pilot study relied upon the perceptions of those involved in the crisis management process. However, the concepts of efficiency and effectiveness were confused by respondents because they tended to judge efficiency by their degree of personal satisfaction with the crisis outcome. In response to this feedback, the method of measuring efficiency was changed and eventually based upon content analysis data. Its value was its ability to quantify and explain crisis management efficiency. In the content analysis, the communication content in each communication network interaction was classified into nine categories according to Berelson's (1971) framework. The most useful category for measuring efficiency was one which was referred to as 'direction' by Berelson. In Berelson's terms, direction refers to the supportive or critical treatment of a communication content's subject matter. In the research, communications were classed as either positive or negative. Those communications classified as positive indicated an element of cooperation and concurrence and in this sense contributed to the forward momentum of the reaction process. In contrast, those communications classed as negative had an element of obstruction and opposition and in this sense contributed inertia to the reaction process. Some interactions were classed as both negative and positive, but degrees of positiveness or negativeness could not be measured. A good indicative measure of the efficiency of any behavioural phase within a reaction process is the average value of all the positive and negative interactions in that phase. For example, if there are 100 communications during a phase of behaviour and 70% were classed as positive and 30% as negative, then the efficiency index of that phase would be +40% ($+70\% - 30\% = +40\%$). If 50% of the interactions were positive and 50% negative then the efficiency index would be zero ($+50\% - 50\% = 0\%$). In this sense, the efficiency index could range between +100% and -100% and provided a quantity which reflected the progress (forward momentum) made in relation to the total energy invested.

Discussion of research results

Since crisis management efficiency was measured for each behavioural phase discovered during a crisis, communication structure also had to be measured at behavioural phase level. To measure the communication structure of a whole network would be to ignore the different phases of efficiency which exist during a crisis, and thereby to oversimplify any investigations of relationships between communication structure and efficiency. Consequently, before structural analysis via UCINET the communication network associated with each case study crisis was split along the lines of the behavioural phases discovered. The structural and efficiency indices relating to each behavioural phase in each case study were then correlated. The results of a bivariate Pearson Product-Moment correlational analysis between each structural variable and efficiency are presented in Table 1. The Pearson correlation coefficient was used because of the continuous nature of the structural and efficiency indexes. If the data were ranked then it would have been more appropriate to have used Kendall's tau or the Spearman rho correlation coefficients. Correlation coefficients indicate the strength and direction of any linear association that may exist between each structural variable and reaction efficiency within the sample. The significance values shown in Table 1 indicate the probability that an association has occurred by sampling error, that is, by chance. In this paper, the term association is used in place of relationship because, as Jackson (1982) points out, assuming causation from correlation is unreliable. At best, correlations can indicate only association.

Before interpreting the results it is important to place them in context because, in social science research, correlation coefficients demand different interpretations from those in the physical sciences (De Vaus, 1990). While a correlation coefficient of 0.35 might be interpreted as a weak correlation in the physical sciences it would be interpreted as a moderate one in the social sciences. This is because of the inherent difficulties associated with measuring accurately the variables used typically in social science research. Furthermore, Cozby (1985) pointed out that even with significance values of 0.05 or less the typically small sample sizes associated with case study research makes claims of representatives to the wider population

Table 1 Results of Pearson Product-Moment correlation analysis between communication structure and reaction efficiency

	Fit	Out-degree centrality	In-degree centrality	Closeness centrality	Betweenness centrality	Regular equivalence
Correlation	0.5750	0.3620	-0.2163	0.4478	-0.2406	0.4974
Significance	0.041	0.152	0.274	0.097	0.252	0.072

unreliable. It is for the above reasons that no claims to statistical rigour and causal relationships are made in this paper. The correlation analysis and significance tests are used merely to aid discussions about trends that emerged from the data. Further research clearly is needed to draw firm conclusions, and the results should, for the time being, be treated as a basis for further investigative work.

Fit-efficiency

The correlation coefficient indicates a strong positive association, and the high level of significance indicates that it is also likely to hold in the wider population. However, it is important to accept this statement in the context of the small sample size.

The positive association can be explained by reference to the qualitative data of each case study. This indicated that the boundaries created as an inevitable consequence of factions represented serious barriers to communication and resulted in a disjointed organization, with different groups pulling in different directions and progressing with a different understanding of the crisis. In explaining why the correlation is not perfect, it is helpful to refer to one behavioural phase which had a relatively low level of fit in relation to its efficiency. A possible explanation lay in its centrality data which also indicated a relatively high level of centrality in relation to its efficiency. Assuming the fit-efficiency association to be true, this has important implications in suggesting that a low level of fit may be compensated for by a high level of centrality. In managerial terms, the suggestion is that division is not a problem if attention is paid to a focused supply of information and opportunities are provided for people to communicate more directly. An opposite distortion occurred in another behavioural phase where the level of fit was relatively high in relation to the low level of efficiency. Here, a relatively low level of centrality may have had a negative effect in worsening the level of efficiency that would have been expected at that level of fit. This suggests that the level of centrality may be both counteractive or exaggerative of the positive or negative effects of various levels of fit. If this were true, then managers should aim for high levels of fit and centrality. However, the data suggested that the association between efficiency, centrality and fit may be more complex than this. In three behavioural phases there were found to be relatively high levels of both fit and centrality but relatively low levels of efficiency. The qualitative data in relation to these phases provided an explanation by indicating that although there was a high level of communication between those involved, the effectiveness of that communication was very low. This was a direct consequence of a dispute over financial responsibilities which induced a sense of defensiveness and acrimony between

all involved. In this sense, it appears that crisis management efficiency is not related entirely to patterns of information exchange but also to the manner in which it is exchanged.

Degree centrality-efficiency

The correlation coefficient indicates a moderate positive association between out-degree centrality and efficiency, and a weak negative association between in-degree centrality and efficiency. In both cases, the low level of significance makes statements of representativeness to the wider population unreliable.

The above associations can be explained by reference to the qualitative data of each case study. The advantages of high out-degree centrality and low in-degree centrality were most evident during a crisis which demanded a considerable amount of redesign. A characteristic of this crisis was that the architect, as the main source of design information, was highly efficient in its distribution. That is, there was a restricted source and widespread supply of information, a pattern which had the effect of reducing uncertainty and maintaining a forward momentum in the crisis management process. In contrast, during another similar crisis, information did not emanate from a strong source and its distribution was restricted, resulting in confusion, ignorance, uncertainty and misunderstanding. The out-degree correlation coefficient would have been weakened by a number of behavioural phases in other crises, which were characterized by a relatively high out-degree centrality but relatively low efficiency. These divergent results can be explained by reference to the qualitative data relating to these phases. For example, in one phase, the network was centralized around the site manager and engineer. However, rather than being a positive sign, it was merely a reflection of the problems of communication between them. In order to resolve continual errors in the engineer's drawings, the site manager forced the engineer into a central position by constantly pressurising him for information.

The in-degree correlation coefficient would have been weakened by other phases which were characterized by relatively high in-degree centralities and high efficiencies. The qualitative data relating to these phases illustrates that widespread information distribution is not always necessary to ensure efficiency. A simple example was one phase where information supply was restricted to the site manager and engineer, because at that stage the crisis was essentially technical in nature and needed to be resolved at site level.

Closeness centrality-efficiency

The correlation coefficient indicates a strong positive association, and the relatively high level of significance

indicates that this is also highly likely to hold in the wider population. However, this statement needs to be taken within the context of the small sample size.

The strong positive association can be explained by reference to the qualitative data of each case study. In particular, high closeness proved to be important during the initial behavioural phase of one crisis where the pressure of the situation forced people to throw away the bonds of hierarchy and communicate directly with one another. As a result of not having to follow predefined procedures of communication, information was transmitted rapidly between those involved. Furthermore, because of minimal distortions and blockages from potentially biased intermediaries, a common understanding of the crisis developed. While the correlation would have been strengthened by the initial phase of the above crisis, it was weakened by its latter phases. During these phases, people continued to experience a high level of closeness centrality but reducing levels of efficiency. The qualitative data provide an explanation by indicating that although those involved in the crisis management process continued to make a high level of direct contact, the nature of the information transacted became increasingly negative because of an accumulating dispute over the ownership of financial responsibility.

Betweenness centrality–efficiency

The correlation coefficient indicates a weak negative association, and the low level of significance makes statements of representatives to the wider population unreliable.

The weak association can be explained by reference to the qualitative data which highlight both the beneficial and damaging effects of high betweenness. The case analyses showed that high betweenness was damaging when occupants of high betweenness positions manipulated information flow to suit their own interests. Furthermore, the case analyses also showed that there were greater possibilities for information overload and bottlenecks to occur at those positions. In this sense, as the level of betweenness in a communication network increased, the reaction process became increasingly vulnerable to the attitudes, perceptions, abilities, interests and managerial styles of fewer people occupying those high betweenness positions. The dangers of high betweenness in presenting opportunities for the manipulation of information were seen most vividly in a case study where an architect placed himself between his fellow consultants and the contractor, allowing him to filter information and thereby keep them ignorant of a continuing dispute in which he was directly implicated. The result of this action, over time, was increasing

frustration on the contractor's part and eventually an escalation of the situation. The dangers of high betweenness in creating information bottlenecks and potential blockages was most vividly illustrated during two crises which demanded a considerable amount of redesign. A similarity of both crises was that a restricted number of people became the focus for information demand and supply, thereby placing them in high betweenness positions. During both crises, these key people experienced great difficulties in managing the large flows of information which were generated to bring about the necessary change. Furthermore, the resultant stress led them into a self-perpetuating cycle of errors, further pressure and further stress, which became increasingly difficult to break.

However, the negative correlation of betweenness with efficiency would have been weakened by several behavioural phases in other case studies which were characterized by relatively high levels of betweenness and efficiency. An explanation was to be found in the qualitative data which supported these phases, the common theme being that the people who occupied high betweenness positions had particularly valuable personal qualities and a very positive attitude towards their project. Consequently, rather than having a destructive impact, the high betweenness centrality had a positive impact upon the reaction process. Thus, in conclusion, the negative association of betweenness with efficiency is weakened by its dependence upon the personal characteristics of the parties who hold the high betweenness positions.

Regular equivalence–efficiency

The correlation coefficient indicates a strong positive association, and the low level of significance indicates that this is also likely to hold in the wider population. However, this statement must be taken within the context of the small sample size.

The explanation which emerges from the qualitative data is that high regular equivalence enables ideas to spread rapidly through an organization because people have access to the same information from the same sources. This enables a common understanding of the crisis, and of the coping strategies required to deal with it, to emerge. In contrast, a low structural equivalence leads to different people operating on the basis of different information which in turn produces a disjointed organization characterized by its members pulling in different directions.

A good example of the positive effect of high regular equivalence was provided by the first phase of one case study crisis where the high level of overlap in people's personal social networks led to a rapid and widespread mutual understanding of the nature of the crisis and

of the responsibility and leadership structure required to deal with it. However, the association between regular equivalence and efficiency would have been weakened by several phases of other case studies which were characterized by relatively high equivalence but low efficiency levels. These anomalies can be explained by reference to the qualitative data relating to those phases which indicated that although mutual understanding was good the quality of what was exchanged was poor in that it was exchanged in an acrimonious manner.

Conclusion

The research results indicated that it would be too simplistic to make one generalized statement about an association between efficiency and communication structure. This is because different strength associations of differing reliability emerged in relation to different structural attributes. For example, strong associations emerged between fit, regular equivalence, closeness centrality and efficiency. However, only in the case of fit was the significance of the association high enough to merit confident statements to be made about representativeness. In contrast to these strong associations, moderate associations emerged between degree centrality and efficiency and weak associations between betweenness centrality and efficiency. Furthermore, the low significance of these associations prevented any confident statements being made about them existing in the wider population.

Despite the above, it is possible, within the statistical constraints of case study research, to conclude that the issue of communication structure is a factor in determining the efficiency of crisis management in construction. The communication structure which emerges in response to a crisis influences reaction efficiency by determining the efficiency of information flow in terms of its speed of transfer and its distortion and reduction through filtering. Efficient information flow is important to the reduction of uncertainty which, in turn, is important to the reduction of misunderstanding, disjointedness, disagreement, frustration, tension and ultimately conflict. Efficient information flow also is important to the speed and appropriateness of response to a crisis. However, the influence of communication structure upon crisis management efficiency is complicated by the nature of transactional content and the interests and abilities of people operating within the structural framework. These factors can reinforce, weaken or even reverse the influence of communications structure upon efficiency.

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