# ‘ROOT’ CAUSE ANALYSIS: A TOOL FOR CLOSER SUPPLY CHAIN INTEGRATION IN CONSTRUCTION

**Mark Hall**

*Agile construction Initiative, School of Management, University of Bath, BA2 7AY, UK*

Perhaps more than most industries, successful construction in the UK relies on effectively bringing together a diverse range of suppliers in what is often referred to as a ‘temporary-multi organization’. Relationships and integration between the organizations within this diverse and complex supply chain are difficult to form and maintain. Frequently, relationships degenerate and become acrimonious, with companies attempting to protect their own position to the detriment of the construction project. This paper outlines the root cause analysis tool and shows, using real-life case studies, how it can be used not only to identify and resolve problems but, at the same time engender better relationships and understanding between suppliers of services and products for a construction project.

Keywords: root cause analysis, supply chain, quality cycles

## INTRODUCTION

Difficulties besetting improvements in construction industry performance are many-fold. Among them are the problems associated with creating better integration and communication through the supply chain. The issue of better supply integration and closer partnership is beginning to be addressed within the construction industry. However, with cost continuing to be a major driver of project success, and with the main contractor best placed to configure the supply chain (Proverbs and Holt, 2000), the tendency is to scope the market for lowest cost rather than best value on each occasion. This is exacerbated by the well-documented ‘unique’ nature of the construction process and its often-bespoke product. Coupled with the finding that contractors (who are figurative in shaping supply relationships) are more oriented toward their clients than their suppliers (Akintoye *et al.*, 2000), supply chains are still, in the main, newly created and dissolved with each new project. Where this occurs, site-based staff are frequently required to reconfigure relationships afresh, entailing a rebuilding of mutual trust and understanding in each instance. This has implications for communications and managerial control and, hence, productivity.

This paper reports on the findings of root cause analysis (RCA) sessions, conducted within quality circles, on two different building projects. The RCA sessions were intended as a supplement to a series of cost of quality (COQ) exercises conducted on a number of construction projects. The COQ studies, and their associated methodology, are reported elsewhere (Hall and Tomkins, 2001; Barber *et al.*, 2000). The paper presents the direct findings of the RCA sessions but goes on to report on the unexpected benefits for supplier integration that were an outcome of conducting the RCA sessions themselves.

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## ROOT CAUSE ANALYSIS

Root cause analysis, (also referred to as root cause failure analysis or RCFA), is, essentially, a method or series of actions taken to determine why a particular failure or problem exists and to establish a means of correcting the causes. In RCA, a problem can be defined as a situation where the performance of a process does not meet the expectations or goals (Latino and Latino, 1999). RCA is a structured procedure that uncovers the physical, human, and latent causes of any undesirable event in the workplace. Armed with the knowledge arising from RCA, organizations can develop an understanding of why errors occur and implement measures to eliminate chronic errors from reoccurring.

Root cause analysis has been used extensively in various industries, such as medicine (Fernandes *et al.*, 1997; Motschman and Moore, 1999), the service industry environment generally (Dorsch *et al.*, 1997) and 'high-hazard' and process industries (Uth, 1999; Shen *et al.*, 1997). However, there are few reports of the approach being applied in construction, apart from the area of predictive construction plant maintenance (Edwards *et al.*, 1998). RCA is a relatively simple procedure of constantly questioning the causes for a particular event occurring. The starting point is the incident to be investigated, which is tracked back through continual enquiry until a single 'root' cause can be identified (Ammerman, 1998; Latino and Latino, 1999). Typical approaches include asking 'the five questions' (also known as 'why-why' analysis) and using cause-effect diagrams (also known as 'fishbone' or 'Ishikawa' diagrams) (Finlow-Bates, 1998; Slack *et al.*, 1995).

The term 'root cause' is, however, itself problematic (hence, the inverted commas in the title). The term 'root' implies some absolute position – that there can be only a single, underlying cause that must be uncovered before a solution can be proposed. Finlow-Bates (1998) challenges this view. He points out that the root cause is dependent on the problem owner, and on where in the supply chain they are located. He also notes that there can legitimately be more than one root cause and that the final choice of root cause can not be made until the economics of possible solutions have been considered. Finlow-Bates (p. 12) goes on to define the *real* root cause as "the step in the tangible cause-effect chain where the owner of the final, undesired effect can make an economically justified intervention to produce a long-term removal of the undesired effect". This definition introduces the supply chain relevance of RCA.

## QUALITY CIRCLES

One forum in which RCA sessions are frequently conducted is that of quality circles. Quality circles are small groups that meet on a voluntary, regular basis to discuss problems and improvement in work processes. Their original development and use, in Japan, is frequently attributed to Kaoru Ishikawa (as is the introduction and use of the cause-effect diagram mentioned previously). Quality circles were seen as providing a simple and flexible tool to tackle and resolve problems in quality performance (Slack *et al.*, 1995). Their success in Japan led to their introduction in North America and, subsequently, to Europe and other parts of the world. However, Hill (1991), in his review of the quality circle 'movement' in the UK found that, for various reasons, they have fallen into disfavour. One problem, for example, was associated with the requirement that they be established outside the established lines of command and be unaccountable to managers, while top management was indifferent to how managers dealt with quality circles. This lead to middle management expressing little interest in

making the circles work. The consequence was that quality circle programmes in British industry faded away (Field and Swift, 1996). Even Nissan, in the UK, does not use the term 'quality circle', preferring the Japanese term *kaizen* teams. Although *kaizen* goes beyond RCA, in seeking to improve the process even where things have not gone wrong, their format is, essentially, the same as quality circles (Wickens, 1988). Despite their disrepute, quality circles have spawned variants and, through these, their use continues. To the *kaizen* teams at Nissan can be added Quality Action Teams (QAT) and Quality Improvement Teams (QIT) which involve management more fully and are related more closely to corporate strategy (Kerfoot and Knights, 1995).

Reports of the use of formal quality circles in the construction industry are rare. Hendrickson and Au (1989) note instances of their use in the Japanese construction industry while, more recently, McCabe *et al.* (1998) reported on their implementation in the UK.

## RESEARCH ACTIVITY AND METHODOLOGY

RCA sessions were conducted on two construction sites. On the first site (Project A), two sessions were conducted whilst, on the second (Project B), three sessions were conducted. The construction projects were similar in nature, both being small design and build office buildings, each of less than 12 months duration, located in the Southeast of England. The RCA sessions were conducted in the forum of quality circles with the subject being instances of non-conformance (i.e. quality failures) that had been identified in cost of quality studies. Thus, the RCA quality circles were supplementary to the main, COQ study. Quality failures were selected for discussion in the RCA quality circles using some or all of the following criteria for each incident:

- the magnitude of the failure cost,
- frequency of the failure type,
- to ensure that failures from all parts of the construction process were considered,
- and for the dynamics of the quality circle itself, by selecting sufficient incidents to ensure the full engagement of RCA participants in productive and beneficial dialogue.

Pareto analysis was applied across the first three criteria in order to identify the 'significant few' failures on which to concentrate (Latino and Latino, 1999). In this way, the RCA quality circles were provided with focus.

The principal research participant was a medium-sized general construction contractor based in the South of England. This company was committing the majority of the resources for collection of data and was hoping to gain commercial benefit from the findings. However, the importance of one aspect was recognized at an early stage: that there was involvement of key suppliers and subcontractors in the RCA quality circles. This was important because it was these organizations that were contributing the majority of the value and, in the main, their employees who were responsible for carrying out the work on the ground. In the event, and as these were design and build projects, that also meant the involvement of the majority of the design consultants. The supply chain focus of the study became, unexpectedly and without intention, a major aspect of the research and forms the subject of this paper.

Aware of some of the reasons for the failure of RCA sessions elsewhere, the following measures were taken to limit the possibility of failure on this occasion.

- Top level commitment was guaranteed with a director present at the initial meetings for each project.
- All management were involved and their commitment was encouraged.
- A facilitator (the researcher) was used to ensure focus for the sessions and record the findings for later analysis and feedback to the participants.
- The purpose of conducting RCA and some ground rules were discussed prior to commencing each session. This included the following aims:
    - to track causes back to their 'root' cause,
    - to find the real problem without going through a 'witch hunt',
    - to get away from the old, trouble-shooting (reactive) culture,
    - to enter into frank discussion in a spirit of openness and a blame-free environment,
    - to engage everyone attending the meeting in discourse,
    - to attempt to understand and 'manage out' quality failures.

The approach, then, was to conduct a simple 'why-why' analysis of each issue up for discussion (Slack *et al.*, 1995) and construct causal 'trees', diagnosing each event. 'Why-why' analysis (a term preferable to 'the five questions' as there may be more or less than five questions in order to get to the root cause) is not a set of pre-determined questions. Rather, it requires the facilitator and participants to simply query the cause, or causes, of any effect until the causal chain is exhausted. Causal trees are an adaptation of Ishikawa diagrams. Rather than attempting to sub-divide the causes into pre-determined categories, the aim in this case was to establish a root cause that could be tackled. The causal tree arising from each enquiry could be either very complex or, conversely, very simple. The causal trees, together with an accompanying commentary, were to be fed back to the participants as an initial means of providing learning.

The methodology was interpretative in nature, seeking to convey an understanding of the points of view of the people participating in the study to create understanding that was not necessarily causal in form but was concerned with the investigation and explication of meaning. With this in mind, the participants were encouraged to speak widely across each topic, giving their opinions about the issues from their own, separate perspectives. With their permission, the RCA quality circles were recorded and the researcher ensured the anonymity of the participants and their respective organizations. The recordings were transcribed and analysed using a proprietary qualitative analysis computer programme.

## FINDINGS

### Causal analysis

The goal of the analysis approach was to identify common 'root' causes and establish a regime of measures that might be implemented to mitigate them in future projects. Through the analysis process, it emerged that the following categories were recurrent.

- Communications e.g. poor information control, misunderstandings.

- Plant e.g. breakdowns, punctures.
- Personnel e.g. carelessness, lack of training, poor workmanship, sickness.
- Design e.g. mistakes that 'get on to' the construction site.
- Management e.g. lack of planning, errors, poor organization.
- Suppliers (including subcontractors) e.g. poor selection, errors and mistakes.
- *Force majeure* e.g. third parties, weather, ground conditions.
- Client changes.

Table 1 illustrates the frequency with which the quality incidents being discussed for each project could be categorized into these different causes. These patterns of causes for quality failures arising during the projects should be viewed with caution. It was found that Finlow-Bates' (1998) warning of multiple causes and other complexity was borne out through analysis. The categories simplified a more involved picture. For example, mistakes by specific individuals could be attributable to the main contractor's or suppliers' employees and their 'root' cause was diverse, including lack of training and inexperience. Similarly, the 'root' cause of suppliers' errors could, in fact, be poor selection of specific suppliers in the first instance, or poor co-ordination of different trades. This was an important finding, as the initial tendency, when viewing the figures, was to seek to attribute blame. However, the purpose was to provide an overview of the issues and indicate the direction for corrective measures and change management.

**Table 1**: Frequency of causes for case study projects

| Cause | Percentage distribution | |
|---|---|---|
| | Project A | Project B |
| Communication | 9 | 12 |
| Plant | 13 | 3 |
| Personnel | 22 | 17 |
| Design | 11 | 14 |
| Management | 16 | 20 |
| Suppliers | 27 | 30 |
| *Force majuere* | 2 | 2 |
| Client change | 0 | 1 |

While the focus of this analysis was to identify causes and seek means of reducing future failures, a number of additional themes emerged during the analysis of the sessions. The unexpected findings related to the RCA process itself. What emerged was a general impression of closer integration throughout the supply chain. Representatives of the client, main contractor, principle consultants, key subcontractors and major suppliers, had all come together in a joint, facilitated forum, in a spirit of openness and participation. In the ensuing dialogue, the selected incidents were discussed from the multiple perspectives of the different participants, which led to a shared understanding of the complex series of events that gave rise to many of the incidents up for consideration. Thus, participation in the root cause analysis process itself gave rise to a change in attitude among the individuals working on site. There was a realization that problems were rarely the consequence of any specific individual but the result of a wide range of root causes, that organizations and their employees

worked within constraints often beyond their control and that sharing problems and working together to find solutions would not only benefit the client in delivery of a final product (the building) of greater integrity but also benefit themselves in improved margins, reduced stress and aggravation and enhanced reputations.

This theme was given additional weight, as it appeared to occur on each occasion. After an initial period of caution and, on occasion, anxiety, the participants began to discuss the issues freely and with animation. The theme was subjected to further analysis to uncover the features of the phenomenon. This revealed two inter-related characteristics:

- The 'no-blame' culture.
- The development of mutual understanding.

**'No-blame' culture**

Involving the suppliers and subcontractors in the study transpired to be a very delicate exercise and, for the contractor's staff, a very difficult proposition. The COQ methodology has, at its heart, the recording and costing of incidences of failure. The manner in which the methodology was interpreted for the projects under investigation meant that any procedure that failed to proceed as planned was included within the analysis. This led to the inclusion of, for example, missed and late deliveries, accidents and plant breakdowns (i.e. things that did not necessarily require rework) as well as more recognisable failures where rework was required. The problem in involving other members of the supply chain was that the majority of the incidents being considered would traditionally have formed part of a claim for delay and disruption. With this as the backdrop, discussion of such issues in a spirit of learning and quality improvement was likely to prove to be very difficult. The temptation would be to use the COQ exercise as a form of surveillance and as part of a claim. The danger then would be that people would be unwilling to participate beyond blaming each other for failures.

This concern was recognized and it became beholden of the staff on site to set an example of what was meant by openness. The study was introduced to each supplier and subcontractor at the start of the project, with the involvement of the researcher emphasized. The researcher was portrayed as an 'honest broker', able to take an unbiased, academic view of events with the aim of gaining knowledge and understanding. It was stressed that all data would be retained by the researcher and all participants would benefit from the findings.

While this allayed some initial concerns, there was still scepticism among the suppliers and subcontractors of the main contractor's motives. The RCA quality circles became watersheds in dissipating this scepticism. While focussing on specific quality failures on each project, the quality circles were held away from the sites in question in a more 'neutral' environment. Cost was not discussed and the participants were assured that the findings would be held by the researcher rather than the main contractor's quantity surveyor. Finally, main contractor site staff demonstrated their openness by being prepared to accept blame where the fault lay with them. For example, on Project A it was found that the steelwork supplier had failed to apply fire protection in the factory at manufacturing stage, leading to substantial additional costs in applying the protection materials after erection. The following discussion occurred.

> Architect: That was a strange one because we talked about it, how the fire regs could be achieved and, at one point, it was going to be fixed by [the main contractor] on site but

> we thought about it and came to the conclusion that it would be better if you [the supplier] manufactured the steelwork with the fire protection already applied because we were concerned about the exposure on site. As far as I'm concerned, it was down to you [the supplier] to deal with… oh, there's someone putting up his hand now.
>
> Project Manager: I recall this quite clearly, really. I'm going to be quite honest with you all. We got the note from [the architect] and, I don't know why, but I didn't pass it on to yourselves [the supplier] to incorporate into your package, for whatever reason. But, I remember thinking along the lines that because we had the discussions with Building Control about the fire regs being a requirement, the discussion went along the lines that it would be best placed in the factory by [the supplier] by which time, the drawings were issued with the comment "fire protection by others" and I didn't pass that comment on. So I think that it was a mistake by me.

In fact, the term, 'no-blame' is something of a misnomer. The reality was that people were, frequently to blame but that, rather than being a single person, it was a number of people or management responsible for putting certain systems or policies in place. What was encouraged was an environment where people were not frightened to admit fault on the basis that that fault was to be learned from and that collective responsibility for problems was an overarching ethos – not so much a 'no-blame' culture as an 'all-blame' culture. After a number of examples similar to the one illustrated above, the participants began to contradict each other, showing that fault rarely lay with a single organization or individual but was a failure on the part of several.

**Mutual understanding**

The main reason for engaging the supply chain in the RCA quality circles was to develop a multiple perspective of each event. From previous experience (Barber *et al.*, 2000), it was found that taking one perspective on events could be misleading as the tendency was to blame others whose voices were not represented. However, through this engagement of multiple perspectives, it was found that what developed was a mutual understanding of the constraints and influences acting on the different supply chain members. For example, on Project B, a design change to the lift beam was not adequately communicated to the supplier of the lift for the building. This led to additional costs in rework and project delays while the beam was altered prior to installation of the lift. The following discussion was recorded.

> Contracts Manager: Normally you would have a lift beam, but we changed it later on.
> Researcher: So, was it a change in design?
>
> CM: Yes, but I think it is as simple as lack of checking because we were at an early stage. When we changed the type of lift, it was at an early stage where it should have been picked up.
>
> R: Yes. This drawing discrepancy though. What was that about?
>
> Lift Supplier: It's about different perceptions, different positions, different assumptions, I suppose.
>
> CM: No, I think it was as simple as a lack of checking. It was correct on their [the supplier] drawing and they're the specialists – it had to be right on their drawings. It was but it wasn't picked up by our structural engineer. And, it wasn't picked up by us because we should have checked both drawings.
>
> LS: Something else I would add is that, in the past, because the lift industry has gone through a change in its regulations, certain things now are mandatory whereas before, they were just recommendations. Now, before, there was a possibility that our design

> could have been modified to accommodate that beam in a different position. But since July of last year, you couldn't have that change anymore. So it makes the change critical…
>
> CM: We did look at leaving it in that position but we couldn't do that.
>
> R: So, the lesson is that with any building with a lift, this is quite critical.
>
> LS: One other thing is that I'm not sure how much other subcontractors get involved but we don't get involved at the earliest stages but, as you can see, changing something relatively simple can have a big impact later on but we could warn you if we had input at a certain time. At an early stage, that has no cost impact at all.

Remaining with the subject of the lift on Project B, the supplier insisted on what the main contractor considered to be an exceptional lead-time and installation programme. It transpired that the lift installation was completed far more quickly than anticipated, allowing the contractor to recover programme slippage. Although this was not a failure, as such (the opposite, in fact) it became a topic of conversation. In a discussion (too lengthy to reproduce here), it emerged that the supplier had, in the past, experienced many problems with other contractors where linking trades had failed to finish on time, thus impacting the supplier's installation programme. It had built this experience into its programming. However, the supplier admitted that it had never experienced such problems with the contractor participating in the research and that, were they to be involved at an early stage, they would be able to offer a shorter installation programme.

The development of multiple perspectives and mutual understanding was found to lead to that most elusive of characteristics – trust. As the participants came to understand each other better and appreciate the constraints each was under and how their own actions impacted, often unknowingly, on others, there seemed to be a commitment to communicate more fully and focus on the needs of the project rather than being too self-serving. It was seen that, in this manner, they could trust each other to operate in an inclusive, rather than exclusive manner and that all would benefit.

## CONCLUSIONS

From the RCA quality circles, the following points summarize the main learning the occurred.

- More careful selection of suppliers and subcontractors – selection on a basis of best out-turn value rather than lowest initial cost.
- In design and build contracts, a closer and earlier involvement of the main contractor in the design process with more consideration of buildability issues.
- Consideration of ways in which information from the planning stage could be transferred to the design and construction stages more effectively.
- More involvement of key suppliers and subcontractors in the design stage of the project which would mean an earlier commitment to those suppliers and subcontractors by the main contractor. This would suggest that, for certain trades and services, strategic partnering arrangements should be established.
- Identification of common and recurring mistakes and errors that could be considered at the beginning of future projects and where effort by site staff could be directed.

- Better consideration of the training needs of suppliers' and subcontractors' employees and a co-ordinated, joint approach to setting training targets and seeing that these are achieved.
- A long-term strategic approach to tackling a culture of complacency that was identified to exist among suppliers of, for example, plant and certain products.

In short, the over-riding learning theme was for the main contractor, consultants and suppliers and subcontractors to work more closely together, both within and between projects and at both the project and organizational level. RCA quality circles were found to be an effective means of facilitating this. Indeed, for the main contractor, the quality circles became the dominant benefit from the research in enabling them to operate in a more effective manner with their suppliers.

It must be stressed, however, that RCA quality circles are not easy to conduct, particularly when involving supply chain participants. Achieving the results outlined in this paper required enormous commitment and enthusiasm, both on the part of top management and, in particular, among site staff. They were taking a risk in exposing themselves to criticism and blame. Furthermore, both projects could be regarded as being successful in terms of the key indicators of cost, time and quality. It remains to be seen whether it is possible to achieve similar results where the project is going seriously awry.

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