EXPLORING HUMAN ERROR THROUGH THE SAFETY TALK OF UTILITIES DISTRIBUTION OPERATIVES

Mumtaz Patel[1] and Fred Sherratt[2] and Peter Farrell[2]

[1] *National Grid, Mersey Road North, Failsworth, Manchester, M35 9FF*

[2] *Faculty of Advanced Engineering and Sciences, University of Bolton, Deane Road, Bolton, BL3 5AB*

Cable strikes form a significant safety challenge for the construction industry's utilities sector. Such incidents can and do result in both death and injury for the workforce, as well as costing companies millions of pounds in associated damages and compensation costs. Despite specialised tools, processes and training programmes, cable strikes still occur on a regular basis. The majority of cable strikes are, like many incidents within the construction industry as a whole, attributed to human error. However, current thinking has suggested that human error is itself a symptom, rather than a cause, and theories have developed to position the incident-causing human error action as the final link in a much longer chain. This paper presents an exploratory study which sought to examine this theory within a specific context; the construction utilities sector and cable strike incidents. Seven interviews were undertaken with operatives within their work environments, which gathered talk around general safety and cable strike incidents. A thematic approach enabled patterns within the transcribed data to be extracted and contextualised within industry practice. Findings indicated that operatives assigned a variety of different causalities to their experiences of incident occurrence, which were then used to construct a taxonomy of the causal factors of cable strikes from the operatives' perspective. These factors were then analysed within the industry context to construct potential 'causal chains' which are able to link the site incidents to management policy. This study, although exploratory, suggests that application of the systems theory of human error is highly applicable to the construction industry, and that the focus of safety management and safety management research should look beyond operatives on the front line to seek further improvements in safety performance.

Keywords: accidents, human error, safety, utilities.

INTRODUCTION

The construction industry is one of the most dangerous in the UK; it accounted for 27% of all fatal workplace accidents in 2010/11, making it responsible for almost a third of all deaths at work (HSE 2011). Significant and inevitable hazards which affect

[2]F.Sherratt@Bolton.ac.uk

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construction companies and more specifically the utilities installation and maintenance companies, are underground services. Services within the ground include high/low voltage cables, street lighting cables, water, gas, telecoms, drains and sewers. However, for the purposes of this study, concern is focused on incidents involving the electricity network, subsequently termed 'cable strikes'. The hazards and risks associated with this specific type of service are extremely serious, both to the health and safety of the workers and approximate public, alongside the financial repercussions of a cable strike (Stancliffe 2008). Indeed considerable efforts are ongoing to examine the underlying causes of accidents and incidents within the construction industry as a whole (HSE 2009a), and the utilities industry has developed its own innovative solutions to mitigate these incidents, such as air shovels and vacuum excavators (ODA 2011; ADP 2012).

However, incidents still occur and utility safety training has recently focused on the human factor in terms of behaviours and attitudes to safety in the workplace (Industry Today 2011). Theories of human error have seen significant developments since Heinrich's (1980) study laid the majority of blame for incidents at the feet of operatives, and a systems approach now positions the human factor within the context of influential industry practices and processes. This study seeks to explore, from the site level upwards, the systems that potentially influence the behaviours and attitudes of the utilities installation and maintenance operatives as they carry out their works in this hazardous environment.

LITERATURE REVIEW

The Utility Context

An estimated 4 million holes are dug by utilities companies annually in the UK, a figure which does not include the many excavations carried out as part of ongoing construction projects (Stancliffe 2008). The precise number of cable strikes and subsequent injuries as a result of these excavations is more difficult to source due to parameters within the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (HSE 2012a) and the Electrical Safety, Quality and Continuity Regulations 2002 (as amended) (HSE 2012b). However the utility distribution industry does make its own estimations, for example Industry Today (2011) puts the figure at 60,000 strikes annually that are reported, whilst industry insurer Zurich (2007) claims an average of 12 deaths and 600 serious injuries per year are attributed to cable strikes.

Despite a lack of clarity in the figures, the potential severity of the consequences of cable strikes is not in dispute. Damage to underground services can cause fatal or severe injuries (HSE 2005) as well as the potential for fire or explosions, and these risks are not just to the workforce but also the general public. Even non-fatal shocks can cause severe and permanent injury (HSE 2010). Flash burns may occur as a result of arc formation; burns may be extensive and lower the resistance of the skin so that electric shock may add to the ill effects. Temporary blindness can also occur due to burning the retina of the eye (Hughes and Ferret 2007). Alongside the human costs, the financial repercussions can be severe. A recent case examined an accident in which an employee received life threatening 60% burns after striking a high voltage cable with a hydraulic breaker on London's Crossrail project in 2008. In addition to the disabling injuries received by the operative, the employing company was fined £55,000 with £30,000 costs (Prior 2012).

Such financial repercussions are commonplace within the industry, and insurer Zurich publish its own 'best practice guidelines for construction companies' to avoid underground cable strikes. Zurich (2007) warn that whilst insurance may cover the repair and legal costs for claims, it will not cover the costs of incident investigation, loss of contracts, insurance excesses, penalties and reduced bonuses. Indeed, the fines that can result from a utility service disruption often drive the total cost of the event even higher (Utiliquest 2010).

With regard to human safety, the HSE have published detailed guidance for best practice in the form of Guidance Booklet HSG47 'Avoiding Danger from Underground Services'. HSG47 outlines the dangers which can arise from work near underground services and gives advice on how to reduce the risk (HSE 2005). HSG47 requires detailed inspections prior to any excavation to ensure that all utilities are identified and safe systems of work employed to detect the presence of underground plant and services. Safe systems of work are a fundamental feature of HSG47 and include all aspects of the work; planning, utility drawings, cable locating devices and safe digging practice.

Flyn *et al.* (2000) note that in industries where significant hazards exist, there is considerable attention paid to safety assessment, and this is evident within the utilities industry. Safety management systems, as established by the HSE in its guidance documentation, 'Successful Health and Safety Management' (HSE 2006) can be found within larger contractors of the industry. Its implementation looks to provide structure to the legislative and other safety management requirements of organisations, and articulate their practical implementation on sites (Howarth and Watson 2009). For example, Enterprise (2012), one of the UK's largest utility installation and maintenance contractors promotes its own safety programme 'TargetZero', launched in 2003 '… with the belief that all accidents and incidents can be prevented …' as well as establishing a safety management team to ensure full employee training, personal ownership of health and safety in addition to meeting all legislative requirements.

However, cases brought to court reveal that the HSE Guidance and company procedures are not necessarily followed in practice. For example, HSE inspectors examining the Crossrail incident found that no effective lines of communication had been established, appropriate training in digging techniques had not been provided, key safety documentation showing the cable was not to hand at the work location, and although the site had been scanned no markings had been made to show the locations of buried cables. As this incident happened in a busy London street, the HSE inspectors felt it was '… completely foreseeable that cables would be present …' (Prior 2012). Following an incident in 2002, the HSE (2002) voiced a warning to the construction industry to ensure safe working practices are followed when working near buried electrical cables. This followed an incident where an employee suffered burns to the face and neck as a result of striking a live 11kV electricity cable and the employer fined £10,000, yet the investigation concluded that had the method statement actually been followed in practice '… this was a preventable accident.'

Theoretical explanations for these behavioural challenges to procedures can be found within the management structures and payment systems of the utilities sector. In keeping with the practices of the construction industry as a whole, a large proportion of utilities work is subcontracted both by the operating companies to contractors, and also from contractor to contractor due to the fluctuating workload (Lingard and Rowlinson 2005), resulting in potentially elongated supply chains and highly fragmented delivery systems (Loosemore *et al.* 2003). The utility industry subcontractors are paid on a price per metre basis as an incentive to increase productivity, facilitated by the ease with which outputs can be measured and rewarded (Harris *et al.* 2006). However, this practice has been found to encourage operatives, who are also paid on price, to work as fast as possible to make the most money in a day or shift. As speed often means cutting corners and taking risks, safety is often sacrificed (Spanswick 2007). In a work scenario where painstaking preparation through the use of Cable Avoidance Tools, followed by careful and precise excavation using hand tools or mini diggers is essential for cable avoidance, a payment structure based on speed of installation appears somewhat incongruous.

Indeed, recent developments in training have shifted in focus from technical to behavioural. The online 'cable avoidance evaluation' assessment for operatives has been developed by a utilities industry training provider, to establish knowledge, confidence and attitudes rather than just technical knowledge to enable evaluation of skills gaps and training needs (Industry Today 2011). Such an approach acknowledges the people in the process, and their influence and participation within cable strike incidents; indeed, a human influence can be identified in the case studies noted above. Consideration of the human element as a causal factor in accidents and incidents is not uncommon within the construction industry as a whole (HSE 2009a) and associated behaviours such as inaccurate assessments, bad decisions and poor judgements are often judged the root cause of incidents (Perrow 1999; Dekker 2006).

Theories of Human Error

Traditionally, 'blame' was allocated to individual workers through their 'error' in terms of poor behaviour or inadequate risk perception. This approach is based on the work of Heinrich (1980) and his seminal examination of accidents at work, which drew the conclusion that 88% of workplace injuries were due to unsafe acts on the part of operators. Although this study has since been criticised for the choices made in data selection and classification that may have led to this high figure (Woodcock 2007), human error is still seen as a major cause of accidents within construction (Wilson 2007; HSE 2009a). Indeed one HSE report (2003a) found that worker actions and behaviours contributed to over 70% of the accidents investigated, and such high estimations are not uncommon within industry (Wilson 2007).

However there has been a paradigm shift in the overall positioning of human error within the accident context, and the view that work related accidents and injuries are a direct result of carelessness and unsafe behaviours has become outdated (HSE 2007). The systems theory of accident causation has challenged this approach. This theory, also known as the 'new view', states that 'Human error is the effect, or symptom of deeper trouble … that it is systematically connected to features of peoples' tools, tasks and operating environment.' (Dekker 2006: 15). It states that people make incorrect assessments or take incorrect action as a result of failures in the systems which have created situations which dictate a certain course of action (Perrow 1999; Dekker 2006). It is no longer accepted that the system will work correctly if not for the behaviour of some 'bad apples', rather there is a need for safety to be instilled at all levels of the organisation (Dekker 2006), including management, who may unwittingly create latent failures within the system through the choices they make in boardrooms (Reason 1990; Kletz 2001). Cultural influences have also been suggested to affect people working within complex systems, and therefore can influence safety in terms of acceptance of authority, need to conform to the social groups within organisations as well as organisational culture itself (Strauch 2004).

This systems approach has also been acknowledged within construction industry research. The HSE (2009b) commented that although inappropriate actions and behaviours did contribute to incidents on sites, they were in the majority founded on weakness inherent within site management processes. The report found indications that causal factors were operating from well beyond the physical location of construction sites. For example, contracting strategies commonly employed within industry and the levels of responsibility and accountability at higher levels of management were indicated as contributory factors to accidents on sites. The report clearly categorises these 'mezzo' factors, such as inappropriate procurement systems and supply chain arrangements, and also 'macro' factors, such as potentially immature corporate systems and inappropriate enforcement, as areas of latent influence that directly affect construction sites.

Awareness of these higher level factors was also demonstrated in the findings of the earlier HSE Study (2003a), which articulated the potential links between site based causal factors and underlying issues such as design or client influences. However, as Chaplin (2006) noted in his report for the Main Contractors Group examining organisational ‘safety stressors’ and the relationship to accidents within the UK construction industry, accident investigation findings will vary depending on the focus of the investigating team. A focus on human error will seek behavioural causes as opposed to a systems approach to safety. Chaplin identified time based pressure, lack of attention to procedures, and production pressures as the key systemic root causes of accidents on UK sites, whilst also suggesting that personal behaviour and competence were significant human factors, highlighting workplace culture as a key area of concern.

However, despite the use of a systems theory approach within construction safety research (HSE 2009a) to date there has not been in-depth application of the theory to accidents at site level. The HSE has called for research to improve understanding of the links, the systemic connections, between accidents on sites and project factors such as project stage, size of contractor and type of works in progress (HSE 2003b). More commonly, the potential causes of systemic failures with relation to safety are examined solely at the mezzo and macro level, with failures at site level labelled as active (Lingard and Rowlinson 2005) rather than latent, and which retains association with human error, rather than completing the theoretical chain.

METHODOLOGY

This study employed a qualitative and interpretivist approach (Creswell 2003; Flick 2009) in its desire to seek out the subjective experiences, understandings and attitudes of operatives. Semi-structured interviews were employed as the exploratory tool (Gillham 2005), and were undertaken with a sample of convenience consisting of seven members of a utilities distribution operational workforce. The interviews employed open questions to enable probing where appropriate (Fellows and Lui 2008) and facilitate development of talk around safety.

Whilst this small sample size and selection process does not allow for generalisation, it does provide insights as to the perspectives of operatives with regard to safety, cable strikes and the potential causes that lie behind them, and indeed reached a level of saturation within the data (Kumar 2005). These initial interviews were carried out to start to bring the picture into focus (Fellows 2008), rather than take the finished photograph, and the findings will be used to inform and develop further lines of inquiry and research in this area. It can also be argued that given the peripatetic nature of utilities distribution, the operatives' experiences, perceptions and attitudes are likely to be common within the industry as a whole.

The interviews were digitally recorded, transcribed verbatim and subsequently coded, to highlight themes, consistencies, inconsistencies, patterns and irregularities (Silverman 2001; Langdridge 2005) when the data was viewed through the lens of the literature. Attention was given to the causal factors as developed through the operatives' talk, and the connections and interactions described between them. These factors were further analysed to enable the development of causal chains, sparked by the initial thematic associations from the data, and developed within the context and understanding of industry practices.

FINDINGS

A prominent and overarching finding was that all the operatives were aware of the safety risks and hazards associated with their work and the safety procedures in place to manage and prevent them. However, all but one of the operatives interviewed had struck a cable in the course of their work. Interestingly, the majority could not articulate why the cable strike had occurred, and were reluctant or unable to speculate as to any underlying or contributory causes. Indeed, this was further associated with the proverb 'accidents will happen'; that accidents cannot be avoided, all risk cannot be removed, and cable strikes are an inevitable part of the work.

Therefore, in order to explore potential causal factors further through a systemic lens, the operatives talk was analysed as a whole to draw out the most prominent themes that developed through indirect discussions of the causal factors of cable strikes, rather than seeking direct explanations for incidents the operatives had been involved with. These findings are illustrated in Figure 1 below:

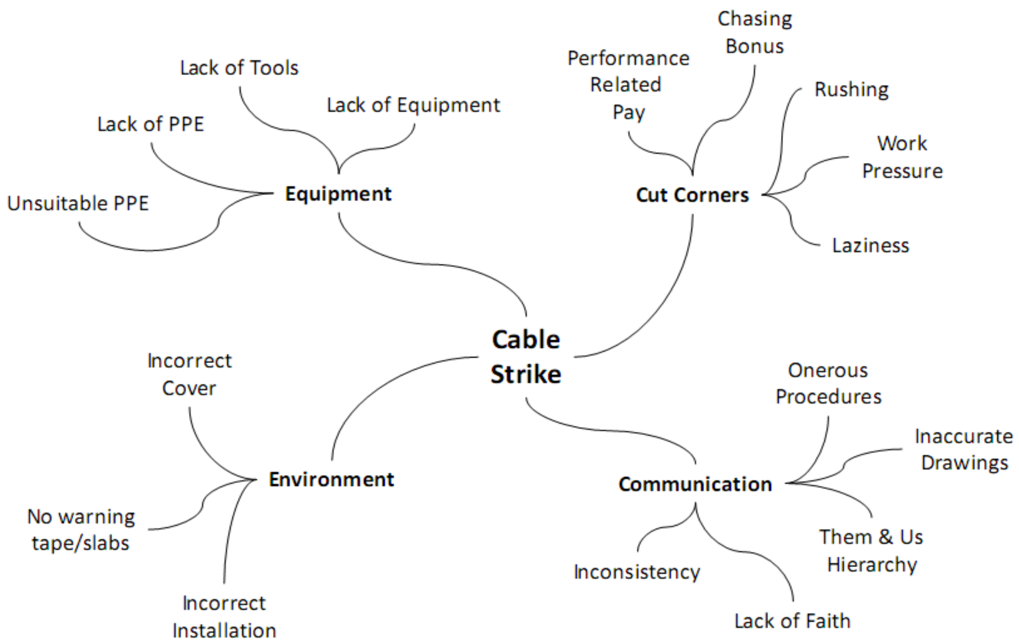

Figure 1: Causal factors of cable strikes

Analysis of the data enabled the identification of four distinct causal factor 'categories'; equipment, environment, cut corners and communication. Both 'equipment' and 'cut corners' were closely associated by operatives with money, and more specifically the management's money. Lack of expenditure for the correct provision of work equipment was a common criticism and the availability of tools and equipment was directly associated with an increase in risk within work practices. Methods of payment, either by rate per metre laid or the provision of a bonus for work completed within a specific timescale, were also associated by the operatives with an increase in risk and the potential for incidents. Although the hazards of the work were clearly articulated and understood, the operatives positioned these two factors directly in competition with safe working practices, including simply taking the time to follow procedures. It was argued that there was no motivation to work in the correct manner when incentives encouraged another route.

Money also constructed a barrier between the site and managements teams, which further developed through the talk within the category of 'communication'. The operatives felt there was a lack of communication and management knowledge and understanding of the site environment and actual requirements needed to follow the policies and procedures they had set down. Management were criticised for making poor decisions regarding work practice when alternatives were available, as well as developing 'onerous' procedures. The operatives also felt that when they raised problems or concerns they did not appear to be addressed, such as near miss data requested by management but not revisited either through feedback or demonstrable changes in practice.

The final categorisation of 'environment' laid the blame for incidents on the previous workforce who had not followed their own procedures in installing or maintaining their utilities, however these operatives were operating within the context of all the other potential causal factors which could have resulted in their own poor work performance.

Reference to the literature and the wider discussions around safety as experienced by the operatives in their daily work enabled the mapping of these site level causal factors, connecting the site incident to the macro and mezzo factors higher up the causal chain. An example of one such chain can be seen in Figure 2 below:

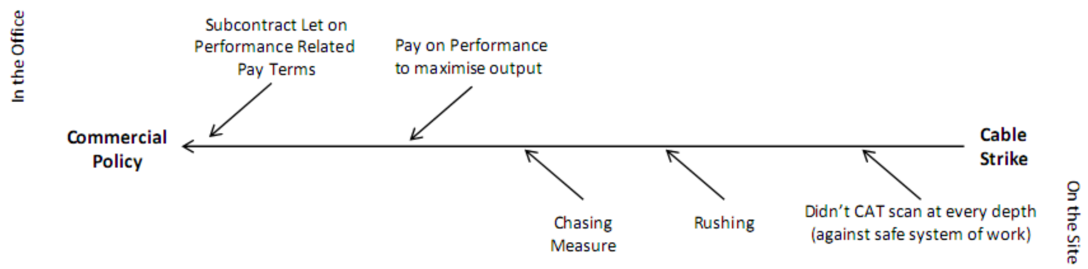

Figure 2: Causal Chain Example

Although highly simplistic in structure, this illustration demonstrates the chain of factors that connect commercial policy directly to a cable strike within just five links of the chain. The flow of influence from site to office, or rather office to site, can be clearly identified from the data provided by the operatives and the associated management practices. The contributory links in the chain, represented as arrows, are shown on contrasting sides to reflect the fragmented nature of the communication between the site and the office, as articulated by the operatives. Overall, the development of the causal chains through the analysis inevitably led to the commercial policy of the company as the key causal factor at the final link. In reality, this policy will be the product of many other factors, however it has been employed here as a symbol of management practice and as a direct challenge to the health and safety policy that will inevitably sit beside it.

DISCUSSION AND CONCLUSIONS

When the utility operatives' talk around safety was analysed, the 'system' with relation to human error and accident causation became immediately apparent. The categorisations of the data demonstrated the close association between safety and the management system under which the operatives were working, as evidenced through the provision, or rather lack of provision, of equipment, the lack of communication through comprehensive information or the implementation of onerous procedures, and payment structures that fundamentally contradict safety processes in practice. This reference to management and the hierarchy in which the operatives are working can be seen as a manifestation of the system, in which operatives on site form the very last link in the chain. Indeed, a strong critique of the communication between operatives and management was that raising issues '… up the chain …' did not bring any action or feedback.

The resignation of the operatives that cable strikes are an inevitable part of their work could be considered to be the result of a lack of understanding of the systemic causal factors operating within their daily lives. Alternatively, this resignation can be seen as a clear comprehension of their current situation; should the system continue to operate as it does, the inevitability of cable strikes as a daily occurrence will indeed remain inherent within it. The latter is further supported by the repeated emphasis of communication, money and management as prominent causal factors, the operatives demonstrating the system in practice, and constructing their own causal chains behind the safety incidents they witness on a regular basis.

However, one prominent anomaly within the data as a whole was the consideration of laziness or apathy as a causal factor. Whether this was a misconception on the part of the operatives who voiced this causal factor, or indeed the manifestation of an unavoidable 'human factor' could not be further explored within the scope of this study. Its presence within the data was an interesting challenge to the systemic theory of human error, suggesting a fundamental human characteristic, uninfluenced by the systems in which it was operating, and itself worthy of further research.

This study, although exploratory, suggests that the systems theory of human error is highly applicable to the utilities sector, and indeed the construction industry on a wider scale. The focus of safety management and safety management research should look beyond operatives on the front line to seek further improvements in safety performance higher up the causal chain. More extensive research is recommended to develop the application of the systems theory of human error within this context.

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