

USE OF ICT-BASED SYSTEMS IN SITE SECURITY MANAGEMENT: A SOUTH AFRICAN STUDY

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ABSTRACT

Adoption of information and communications technology systems for the enhancement of security management on construction sites is presented in this paper. The site security situation, key influencing factors, use, and impact of ICT-based security systems are examined in the context of South Africa as an emerging economy. The paper uses a purposive sample of special informative literature on construction in developing countries, technology transfer, ICT in Construction, and site security management. Deductions from literature review are complimented with field work using a case study of construction sites. Limitations of access to data sources were placed on the study. Nevertheless the case study approach ensured richness of data collected. Findings suggest the occurrence of security lapses and an appreciable need for site security on local construction sites. While there is availability of ICT-based security systems, there is an apparent lack of expedient adoption considering the benefits, and threats to site security. There is also attestable difference in the impact of adoption amongst adopters and rate of theft on sites which depend on manual systems for security management. Major implications include the need for more adoption of such technologies in site security management, especially in remote areas. In addition there is need to seek ways of using ICT-based systems to enhance the performance of manual systems in site security management. Furthermore the need to adopt such ICT should reflect on tenders for contracts ab initio. Findings from the study add value to the local body of knowledge on ICT in Construction, with regard to possibilities for site security management.

Keywords: ICT, Security systems, site theft, site management, site security management

1. INTRODUCTION

The construction industry has experienced accelerated growth in the world, which is fuelled by population growth and the attendant need for physical development in all areas of economic life (Lepatner, 2007). Pierre (1991) noted that sector growth inevitably occasions the emergence of new construction procedures, equipment and materials. Nunnally (1998) also asserted that such changes place more responsibility and managerial demands on construction professionals. One of the areas where construction is faced with the challenge of efficiency, according to Lepatner (2007), is site management. Specifically, site security with regard to theft, is one of the challenges to efficient site management in many countries (Boba and Santos, 2008). For instance, by 1976 the UK Building Research Establishment (BRE), reported that between (10%) and (20%) of all materials delivered to site during the construction period either end up as waste or stolen, (Harris, 1989). The United States National Crime Bureau in 2002 estimated direct costs of about 1 billion dollars each year, resulting from theft of construction equipment and tools (Trunko, 2002). Another study put the loss due to theft of tools and equipment at about (20%) of the construction cost (Boba and Santos, 2008). While large construction contractors struggle with such costs, small contractor businesses could be totally paralysed (Charlett, 1992).

In the case of South Africa a recent study from South Africa suggests that a high percentage of local contractors in South Africa still use traditional manual security systems (Kelleger, 2007). This is regardless of the fact that site theft is considered a management issue. The type of traditional manual security systems referred to would include the use of fence barriers, site lighting and security guards (Barnet, 2003). Such manual systems have been judged inadequate to address the present scenario of site security against theft. Given the local environment of construction sites and the stated constraints, intruders know how to circumvent and essentially outsmart manual security systems (Kelleger, 2007). In response to the security situation on sites there are recent ICT-based security systems, which are available internationally and locally. Such systems are relatively cost effective and can be easily deployed in most site situations. Some of stated systems have capacity to monitor, or hinder theft remotely. They are also hardwearing enough to resist damage considerably. The ICT-based security systems referred to, have been implemented in various facilities with measurable benefits, including improved protection and time savings in management. However there is apparent inadequacy in existing knowledge about such systems. The apparent lack of awareness partly fuels resistance towards their adoption (Clark, 2007).

In the case of South Africa, relevant studies such as Azzar and Karam (2003) and Ozumba and Shakantu (2012), attest to some degree of awareness and adoption of ICT and automation technologies in the construction industry. However the adoption of ICT-based products has been shown to be generally sub-optimal, in addition to being considerably low in critical areas of site management (Ozumba and Shakantu, 2012). Furthermore there is limited research on the adoption of ICT in site management and specifically on site security management.

The current paper therefore presents a study, purposed to investigate construction site theft and the adoption of ICT-based security systems for improving security management on construction sites. The paper continues with further review of relevant literature. Deductions from literature were used as basis for field work, which involved the collection and analysis of primary data.

2. THE NEED FOR IMPROVED SITE SECURITY

The demand for physical development is among the challenges facing the construction industry, especially in developing countries (Ofori 2007). Demand for higher productivity also translates to increase in mechanization of construction works, which leads to the demand for construction machinery. The high cost of such machinery would equally make them attractive to criminally minded persons (Hinze, 2004). In addition it has been noted that sophisticated thieves are mostly interested in expensive equipment and large amounts of materials or components, for which there is ready market (Harris, 1989). Recent research also states that some construction materials are in high demand on the black market, thereby creating enabling environment for theft of such items towards financial gains (Hinze, 2004). Therefore it is arguable that increase in construction and the consequent higher demand for relevant materials and equipment, could increase the possibility of theft. Similarly such increase in site theft would demand improvements in site security management, especially in the area of site theft.

2.1 Site Security With Focus on Theft

Theft as referred to in the Oxford English dictionary is the act of stealing (Oxford University press, 2013). It is essentially the act a thief indulges in. Typically it describes the act of dishonest appropriation of property, with the intention of depriving the rightful owner (Oxford University press 2013). Literature on security identifies four key factors which influence site security. These are the physical, socio-political, loss history factors, and criminal activities in the area. Physical factors refer to the nature of the environment and of the neighbourhood.

Socio-political factors refer to the factors, which have impacted on ethnic groups and their economy. Loss history factors refer to the history and frequency of the loss of assets in the area (Healy, 1983). Trunko (2002) estimates that (70%) of stolen equipment reported were not moved outside the locality of the site where the theft occurred. The suggestion here is that construction site theft is mostly a local issue. In emerging economies such as South Africa, constraints to site security include location, prestige and project size. Such developing countries experience appreciable construction activities, which collectively present a challenge to site security management especially in crime prone areas (Trunko, 2002). It is then arguable that the bigger the size of the project, the more vulnerable, the equipment and materials could be.

The preceding assertions demonstrate that site theft and consequently site security are major issues of concern in projects and indeed for construction concerns. The amount of criminal activities on site is reported to have increased, following the recent global economic recession. In a recent UK study (92%) of respondents experienced theft in their businesses; (91%) experienced vandalism; (38%) stated that site security cost their business a minimum of (£10,000) each year; and (9%) reported that losses of (£100,000) were incurred each year due to the combined effects of theft, vandalism and H&S negligence. Organised crime has also been noted as a real and active enemy to the smooth flow of projects (Chartered Institute of Building (CIOB), 2009). Other authors such as Mittrup, Smarshy, Hartman, and Bettziecle (2003), have called for increased monitoring in construction, due to site security reasons. In modern construction an effective monitoring system must out-perform the works of criminals. Monitoring should be a step ahead of the criminal, and cover site management sphere of responsibility (Mittrup et al., 2003).

2.2 Site Theft

Site theft of both company and employees' property has been earlier grouped with non-accidental but malicious damage to company property, and grave breaches of safety regulations (Forster, 1989). Research shows that site theft is a constant and costly occurrence (Kelleger, 2007). In one instance UK contractors increased their cost to clients as a way of recovering such losses (Kelleger, 2007). In Japan, more than 1000 construction machines were reported stolen in a year. Furthermore in Canada, up to 46 million dollars loss to site theft has been reported in a study (Hinze, 2004). With regard to stolen items, the UK study identified trailers, excavators, site dumpers and tele-handlers, as the most commonly stolen equipment (Kelleger, 2007). Moreover existing research shows that large construction companies are more susceptible to site theft at project sites than smaller building companies (Sharma and Bausman, 2009).

It is arguable that larger construction concerns would occupy larger construction sites and also have a higher concentration of materials and equipment on site, in the absence of efficient logistics. As such the notion of rise in site theft correlating positively with increase in site activities, materials and equipment is supported.

Construction site theft is viewed as an occurrence that requires the participation of certain parties. Existing research identifies the public, site workers, and site visitors as sources of site thieves. A considerable number of reported cases demonstrate the occurrence of assistance to site thieves emanating from site workers or people who are familiar with construction sites. However in other cases thieves are generally attracted by lack of adequate security measures (Barnet, 2003). Most site thefts occur at night and on weekends, when sites are essentially vacant. Existing research estimates that (75%) of thefts on site occur at such times (Clark, 2007). It has also been suggested that site workers engage in site theft alone. Two factors which could enable worker participation in site theft are knowledge of construction practices, and access to keys, tools and materials (Boba and Santos, 2008). From the foregoing site theft would present a challenge to management due to increased number of employees on typical construction sites. Since site workers stay both short term and long term, it is possible for some of them to be involved in site theft. When workers stay long on particular sites, they familiarise themselves with the environment, to an extent that they could plan and execute theft successfully. It is also possible to be involved in theft when staying short term, on the basis that identification and tracking of the thief may be difficult or impossible. Despite the realities mentioned thus far, lack of adequate precautions against site theft by contractors have been identified in existing research. Earnshaw (1984) states that insufficient funds due to lack of contractual provision is often the excuse advanced by contractors for lack of necessary precautions against site theft. The author advised that necessary security measures and their attendant costs should constitute major considerations when tendering for jobs.

With regard to the susceptibility of construction sites to theft, Kitchen and Schneider (2002) support the idea that physical environments influence human behaviour such as crime. Glaeser and Sacerdote (1999) also state that easy access, availability of victims, low cost of committing crime, and low probability of arrest, are among major reasons for crime. Firstly crime prone areas have a higher proportion of vacant land. Secondly developments in such areas lack homogeneity in addition to having more mixed land use. Thirdly there would be more multi-family units, which are usually clustered, while extended families could be living in one unit. The neighbourhoods would also be surrounded by areas of lower socio-economic status (Poyner, 1983). Likewise some of the conditions here stated could apply to inner cities.

Kitchen and Schneider (2002) also found that inner city residential and developing areas are highly prone to crime. It is arguable that descriptions by Poyner, and Kitchen and Schneider, are characteristic of highly populated parts of South Africa such as the cities and their surroundings. Findings from Louw (1999) support the argument that major South African cities have a higher level of crime than other parts of the country.

2.3 Use of traditional site security systems

As stated earlier in this paper, many local construction concerns still rely solely on manual security systems on sites. Such traditional site security systems employ a number of measures that can be taken to protect construction site from unauthorized access (Sales, 2006). Forms of deterrence differ, according to variables that are associated with construction site theft (Hinze, 2004). However the location, surrounding area, and type of work are important in determining the level of site security needed (Sales, 2006). From existing research, most commonly used security methods by contractors include Perimeter fencing with few entrances (Sharma and Bausman, 2009); Store sheds (Earnshaw, 1984); Warning signs and security lighting (Sales, 2006; Hinze, 2004); and watchmen or security guards (Earnshaw, 1984; Hinze, 2004). Manual Security devices for equipment such as immobilizing systems, Fuel shut off or ignition locks, and battery-disconnect switches are also utilised (Kelleger, 2007). Additional measures include patterned parking of equipment at close of work day; additional naming on equipment and machinery; use of unique colour marking for machinery and equipment; and modification of ignition or fuel lines (Hinze, 2004). Furthermore there is the application of zero tolerance rule to employees caught stealing equipment, material or tools on site (Sharma and Bausman, 2009). Moreover special storage is used in some cases, for materials such as timber, face bricks, frames, glass, and cement. Spaces adjacent to their workface are utilised in order to reduce the risk of theft (Earnshaw, 1984). Regardless of the measures applied, there are appreciable disadvantages to the use of manual security systems.

2.4 Weakness of traditional site security systems and the ICT potential

Although the use of perimeter fencing presents good physical security, it essentially delays intrusion (Clark, 2007). Night watchmen constitute a psychological deterrent but human limitations render such measures inadequate, especially in the case of armed intrusion (Wilson, 2009). Immobilizers could be used to secure site plant, but this measure will not deter a thief who is equipped to remove the plant by other means (Kelleger, 2007).

Without special storage, materials such as cement and steel can be easily stolen once intruders gain access to a site (Earnshaw, 1984). On the basis of aforementioned limitations and with knowledge of traditional methods of securing sites, most criminals could overcome such systems. Therefore the potential in recent ICT becomes relevant to construction site security.

Recent ICT-based security solutions could be used to significantly curtail crime on construction sites (Wilson, 2009; Hampton, 2004). Research abounds with assertions of the appreciable potential in recent ICT to enhance all aspects of site management. There is evidence in existing literature of the pervasive capacity and tele-presence, which useful exploitation of potential in recent ICT could yield to site management (Ozumba and Shakantu, 2008). Security systems built on such ICT potential, assist contractors who use them in overcoming security gaps in site management (Wilson, 2009; Hampton, 2004). Nevertheless there is need for acceptance and adoption of such technologies in order to reap the benefits of enhancing site security management. Recent studies in South Africa strongly suggest sub-optimality in the adoption of ICT to improve effectiveness of site management (Koekemer and Smallwood, 2007; Ozumba and Shakantu, 2012; Ozumba and Shakantu, 2013). Since site security management is an aspect of the overall site management process, the limited transfer of such useful technologies extends to the area of security. By extrapolation it could be reasonably expected that local site management contends with issues of site theft. It is then possible that in response, site management would be stretching its capacity thinner, through the employment of more traditional approaches to security management on site. This would fly in the face of useful developments from the ICT sector, which could enhance the security situation on local construction sites. The paper therefore presents a study which investigates the site theft and the adoption of recent ICT to address the limitations of traditional site security.

Based on issues discussed in preceding sections, methodology for the field work is presented in the next section. The objectives were: To evaluate the general situation of theft on sites, including the patterns and methods employed by intruders; to identify construction site anti-theft security systems used locally; factors affecting the adoption of ICT systems for security; and to determine the benefits of adopting ICT-based security systems, from contractors' perspective.

3. RESEARCH METHODOLOGY

Mixed method approach was adopted for the methodology (Trochim and Donnelly, 2008; McMillan and Schumacher, 1993). A combination of non-experimental and survey research strategies was utilised. Surveys, interviews and field observations were used for data collection.

For field observation, an observation checklist was used, while an interview schedule was used for collecting data from verbal interviews. A questionnaire was used to collect data from the survey. The method of analysis utilized for qualitative data in the research is topology, which classifies findings by different types of individual or group experiences with the same phenomenon. Findings are also divided according to categories of perspective or actions of participants (McMillan and Schumacher, 1993). Results of data analysis are presented in text, numbers, narratives, a scatter plot diagram and a chart.

The primary data is based on a pilot study conducted in South Africa in 2010. The study was scoped to the greater Johannesburg area of the Gauteng Province of South Africa. The sample population was made up of construction companies and construction sites. Information was obtained from (11) construction companies, which were purposively selected. A total of (6) construction project sites which were managed by different companies, were physically visited. The construction manager for each site was interviewed and field observations were conducted, during the visits. In addition survey questionnaire was administered to construction managers who represented the management of an additional (5) construction companies. The (11) companies investigated were made up of large and small construction companies. Their construction activities ranged from civil construction works, housing, road works, and industrial development, to retail development. Most of the companies have also been in business up to 15 years.

In order to specifically check for the influence of site location on theft and the specific response of site management in each case, sites were chosen from different locations such as the inner city, urban area, township, and a gated location. Two sites were visited in the inner city (Johannesburg CBD and Hillbrow respectively); one site from a residential zone (Parktown), one site from a university campus; one site from an urban area (Rosebank); and another site located near a Township.

4. FINDINGS AND DISCUSSION

From observations, the main security measure against site theft was the use of guards. Perimeter fencing was also utilised, with limited access control, securing of storage on site, electronic alarms, warning signs, parking of equipment, marking of tools and the use of exterior lighting. There were some individual peculiarities according to sites visited. Only one site had an electronic alarm system for monitoring the secured site office and storage space. The site located in Johannesburg CBD had no fencing due to space constraints, but it employed the most guards, which were (10) in number. Conversely sites in low risk areas, such as the university campus and residential area, deployed minimal number of guards.

In addition the number of entrances, which are site requirements, essentially increased the risk of theft by providing multiple channels of access to thieves. Furthermore the guards were not very effective on some of the sites visited. In some cases the guards seemed not to be alert, as people accessed the site without reaction from them. Guards were notably distracted or suffered blind spots when busy with other security issues. In other cases they were not certain of those who had authorisation to access the site. For example an incident was narrated on one site, where thieves deceived site guards and carted materials away from the site. Possible issues of reliability, literacy levels, and adequacy of the education of guards about general activities on construction sites were also highlighted.

From questionnaires and interviews, it was established that all participating companies experienced site theft. Respondents' estimates rated (70%) of site theft as petty theft, while (10%) was allocated to armed robbery and (20%) was said to occur through misrepresentation or breaking and entering when security guards are absent. With regard to the source of theft, respondents rated the public as generating (45%) of the theft incidence on site. This is followed by a (33%) of the theft incidents ascribed to workers on site and (22%) due to members of the public and site employees working together. The (33%) of theft associated with site workers was described as daily petty theft of tools and small steel cables, which they re-sell on the black market. Major incidences of construction sites theft involved the loss of materials, as indicated by all respondents. With regard to type of materials stolen, about (89%) was said to be electrical goods such as copper, electrical wires, and air conditioning units. This is followed by tools, drilling machines and computer equipment.

About 40% of the contractors perceived that intruders are normally assisted by persons who know the site in each case, such as site workers. Another (20%) of the contractors refer to intruders as trespassers on to the facility, who gain access through the perimeter fence. About (10%) of participants alleged that security guards assisted criminals in site theft. However (30%) of the contractors surveyed could not explain how incidences of theft occurred on their sites. It was also determined from analysis that responsibility for losses accruing from such occurrences depend on the nature of the contract. From respondents' experiences, four scenarios of responsibility were common:

- The main contractor being responsible;
- The sub-contractor being responsible;
- The main and sub-contractor being jointly responsible; and
- The client being responsible.

The questionnaire and interviews were also specifically used to investigate the link, if any, between site location and site theft, in the local context. Based on literature reviewed in the study, participants had to indicate areas where their companies experienced high theft rates. Townships had the highest indication of (72%) of respondents, followed by (70%) Urban areas ranked (70%), (67%) for the inner city, while (11%) of respondents indicated high theft rates for remote and rural areas. With regard to this particular result, most of the companies surveyed are based in Gauteng and had done minimal work in rural and remote locations at the time. It is possible that the demographics affected the low percentage of indications for crime in remote and rural areas.

Data analysis further highlighted a pattern which supports deductions from literature, when considering site location, site theft rating, and the number of security guards at night. A correlation between the number of guards at night on each site, and the site location was performed, in relation to the high site theft rating of each location. The analysis for number of night security guards and site location returned an essentially positive correlation, as shown in Figure 1.

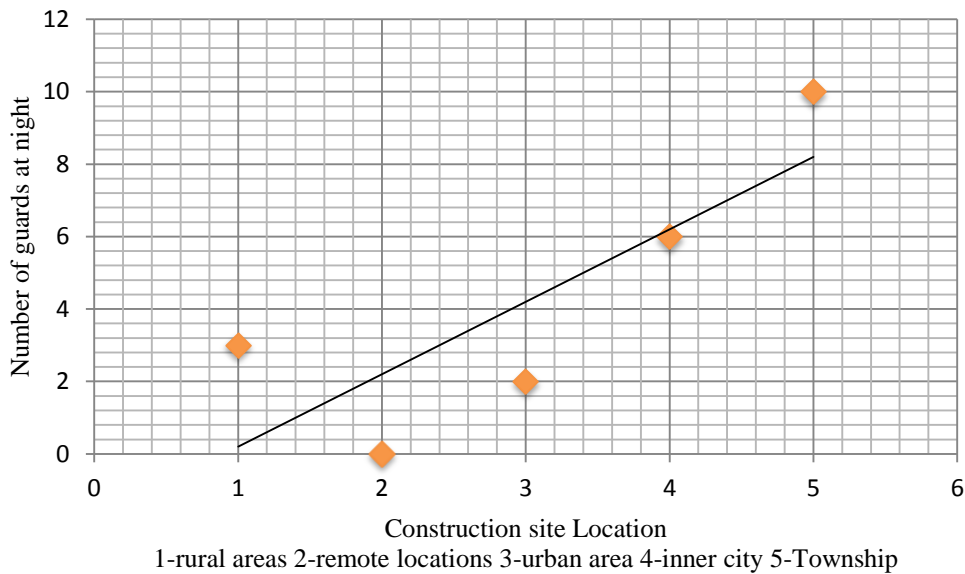


Figure 1. Scatter plot correlation of site location and number of guards at night.

Considering the trend line in the scatter plot, the number guards at night generally increased with the site theft rate. Townships ranked highest with (10) security guards deployed at night, followed by the inner city sites with (6) night guards. The urban area site had (2) night guards, controlled or gated location had no night guards, and rural areas had (3) night guards.

In light of the above results, the adoption of ICT for site security management on local construction sites was allegedly low. According to the experience of participating companies and the estimates of their representatives who responded to questions, up to (95%) of South African construction companies rely on manual security systems. Similarly (73%) of the participating companies used traditional and manual security systems. A low (27%) of respondents deployed ICT-based security systems on site. Out of this (27%) who deployed security technology systems on site, (75%) used access control systems, (25%) used surveillance systems, (50%) used electronic alarm systems, while (25%) used tracking systems. Appreciable benefits have also been realised from utilisation of such systems. About (65%) of respondents who used ICT-based site security systems, attested to the fact that such systems reduced unauthorized entry on site. They also experienced improvements in the general site management efficiency. Especially with access control, they were able to achieve detailed inventory of people on site.

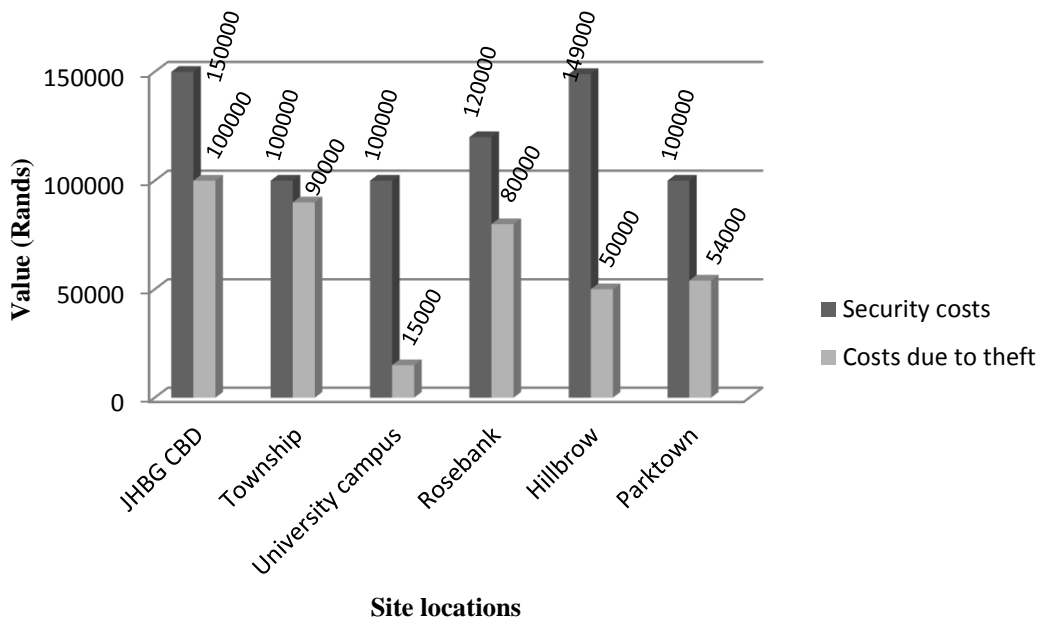


Figure 2. Comparison of estimated costs of site theft and implementation of ICT-based site security systems.

Further to the extensive use of manual systems on site, it was also determined that labour for security guard services in South Africa is cheap, when compared with other more advanced countries of the world. All the companies surveyed utilised security guards on their sites in addition to other measures.

With regard to the adoption of relevant technology for security, responding construction managers felt that ICT-based security systems should be adopted and used on construction sites in high risk areas. Where there is difficulty in securing site perimeter, site managers strive to secure storage rooms, which house valuable materials. Participants argued that construction sites are complex working environments, for the demands of implementing ICT-based security. About (55%) of them felt that costs of appropriately implementing ICT-based security systems on complex sites makes such ventures impractical. About (45%) regarded the costs as being prohibitive when compared to the financial value of loss due to theft.

Figure 2 shows the costs in South African rands, of site theft and implementing ICT-based site security systems, according to location of site. Four out of the six cases considered had relatively close margins between costs of theft and costs of implementing security systems technologies. In addition it is arguable that certain aspects of implementation would remain the same regardless of site type, size and location. That could account for the similarity in implementation costs between the university campus and township. In this regard it is noteworthy that some of the initial expenditure would not be repeated in the short term. Furthermore the costs represented here refer mostly to theft incidents which occurred and were reported in each case. When the range of possible theft incidents and losses are accounted for, it would most probably become more reasonable to consider most of the implementation costs of security technologies as initial capital expenditure with long term benefits. Despite the arguments of some participants regarding the cost of implementing ICT-based security systems on site, they all agreed to the benefits of deploying such systems. All participants agreed that ICT based security systems provide appreciable advantage in deterring theft. Moreover up to (80%) of respondents, who were not currently using ICT-based security systems on site, agreed that that such security systems are beneficial and should be used.

5. CONCLUSION AND RECOMMENDATIONS

The pilot study presented in the paper focused on construction site theft and the adoption of recent ICT to combat it, in the context of South Africa. Deductions from relevant literature reviewed were complimented with field work, which involved observations, interviews and survey by questionnaire. Academic and institutional limitations were placed on the research. In addition some respondents were reluctant to give response in some cases. Furthermore logistics constraints also limited the extent of data collection. Nevertheless, being a case study strategy, findings provide rich basis for propositions on which to base future studies.

Analysis of data and findings discussed in the preceding sections suggest that construction site theft is a common and most probably daily occurrence on most construction sites in South Africa. However it is also suggested that a high percentage of contractors rely solely on traditional or manual security systems. Writers such as Hinze (2004) and Sharma and Bausman (2009) support this finding in their related works. Findings also demonstrate that such systems have obvious limitations, which could be addressed by utilisation of recent ICT. Clark (2007); Wilson (2009) and Kelleger (2007), support the existence of limitations in traditional security systems. Wilson (2009) and Hampton (2004) among others, also highlight the usefulness of exploiting potential in ICT for such purposes.

Although contractors feel the need to improve their security management through ICT, there is poor adoption of such technologies due to their perception of cost, and complexity of implementing such systems on sites. They also do not seem to adequately provide for such costs during the tendering processes for construction jobs. Ozumba and Shakantu (2013) using a study of challenges to site ICT usage in South Africa, highlighted cost and the existence of information related issues which fuel some identified challenges. Earnshaw (1984) also stated the popular use of inadequate contractual provisions for site security, by contractors.

A strong link between site location and high site theft rate was also suggested from the current study. The suggestion is supported by assertions in literature reviewed for the paper, such as Sales (2006). It is further supported by a positive correlation of the number of night security personnel deployed on sites with theft ratings of various locations, see Figure 1. In addition the apparent awareness of security implications for certain sites, did not translate to more adoption of available technologies. This finding is aligned with results of recent studies on South Africa that are focused on site utilisation of ICT. Koekemer and Smallwood (2007) referred to the low occurrence of ICT by contractors in Durban and the prevalence of basic usage of ICT identified on sites. Ozumba and Shakantu (2012) highlighted sub-optimal occurrence of ICT usage amongst project and site management level practitioners, based mainly in the Gauteng Province. The authors also highlighted the sub-optimality in translating the demonstrated awareness to adoption. Similarly there was only basic usage for adopted ICT. Ozumba and Shakantu (2013) used a focus on challenges to ICT utilisation, to highlight the apparent lack of exploitation of available ICT, even when it has been adopted in a project. Likewise the current paper demonstrates the existence of challenges to site security; limitations of traditional site security management; availability of relevant technology; possible cost saving from implementation of such technology; and yet the persistent low level of adoption.

In terms of the link between deployment of ICT-based security systems and improvement of site security, respondents who use such technology attest to the resultant deterrence of theft and capacity to monitor their sites. Time savings in management effort was also realised. Therefore ICT-based security systems could bring measurable improvement to site security management. It will increase remote control capacity for monitoring and control of site. In addition the preponderance of visible security measures would create the awareness of management presence throughout the site. Despite the advantages, full implementation and adequacy of technologies deployed must be given attention in order to realise the benefits.

From the preceding paragraphs in this section, the study highlights the local site theft situation; importance of ICT-based security systems for construction sites; and poor adoption of such technologies by local contractors. It also brings to light some of the challenges towards good site security and the adoption of recent ICT-based security systems in construction. In reaching this conclusion, a number of implications emerge. Firstly there is implication for construction planning and design on the part of contractors, project managers and site managers. Extrapolating from findings of the study, local site security management is most probably in need of appreciable improvement. As such site security implementation with modern ICT-based systems should be prioritised as opposed to being treated as secondary. Secondly there is implication for project cost estimation and planning, and the involvement of relevant parties in the security aspect of the project site, at the contractual level. Following results of the study, it is necessary to incorporate the cost of security systems during the tender stage. Thirdly it is also implied here that provisions for cost of site security systems should be detailed enough to account for site location, complexity of the project, and the economic landscape of site surroundings. To this end, a generic template would be very useful. There is also a sustainability aspect to the implications of the study, in the case of South Africa as an emerging economy. Considering the financial burden of loss due to theft on emerging contractors (Charlett, 1992), there is implication for regulatory standardisation of cost provisions for site security. It is also important to ensure the implementation of the security provisions after the contract award, in order to forestall the adverse effects of site theft on such small businesses. Furthermore, there is implication for the expedient implementation of ICT in site management, within the local context. This implication emanates from the need to effectively address challenges to site ICT usage in projects. It could be more expedient and effective in the short term for project executors to combine ICT-based security systems with manual systems. This approach would reduce the associated technology costs and increase efficiency of some traditional systems, especially in high risk areas.

In conclusion, theft on construction sites contributes to the national crime statistics of South Africa. The current paper, though limited in terms of national spread of the study, contributes towards developing an understanding of ICT availability and capacity for site security systems. The study also provides a basis for understanding the links between location, site theft, adequate security measures, and the adoption of ICT-based security systems. The use of such technologies and their products in site management is an area of research paucity in the local context. As such the study contributes to the local body of knowledge with regard to ICT in construction. Following preceding discussions, emerging issues include the need to investigate contractual arrangements relating to liability for loss due to site theft in the local context. It is also important to study the costs of site theft in detail; according to site location, nature of project, and security system in place. Furthermore the study on costs should be elaborated to accommodate comparisons between costs of implementing various ICT-based security systems and the cost of construction site theft. Ultimately a system for determining the risk and real cost of theft for various project site scenarios should be developed. Moreover, the development of proper contractual frameworks for covering such risks during tendering would be a beneficial step forward from the current paper.

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