Confined Site Construction and its Impact on Personnel Productivity


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CONFINED SITE CONSTRUCTION AND ITS IMPACT ON PERSONNEL PRODUCTIVITY

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ABSTRACT

Inner city, confined site construction is quickly becoming the norm within the construction sector. The aim of this paper is to identify and document the effect, if any, that a confined construction site environment has on the productivity of on-site personnel. In order to compile the relevant information and attain appropriate results on the matter in question, a qualitative analytical approach is adopted. This process incorporates multiple cases studies from Ireland, Northern Ireland and USA. From the resulting case studies, a minimum of three individual interviews and focus group seminars are conducted to aid in the collection of the data while also assisting in the confirmation of the factors identified from a critique of the relevant literature. From the resulting case studies and discussions, a list of the key issues pertaining to the on-site productivity of personnel emerged and is documented as follows; 1) Overcrowding of personnel at workstations, 2) Lack of space for the effective movement of personnel on-site, 3) Numerous trades working within the one space on-site. Through identifying the issues highlighted and proactively mitigating or eliminating the factors detailed, on-site management professionals can strive to ensure maximum productivity from the industry’s most important resource – people.

Keywords: city centre development, overcrowding, project management, site management, space.

INTRODUCTION

With the migration of populations from rural environments to urban centres, particularly over the last decade (United Nations, 2008), the need to develop these urban city centre areas also increases. This is predominantly due to the need to facilitate the services required by this influx of population (Waddell, 2002). With figures illustrating increased population densities throughout Europe, construction within this geographical area is set to face continued renewal and expansion (Gale and Fellows, 1990). With the development of these spatially restricted centres, there are numerous key points noted in the successful delivery and completion of inner city confined sites. Some examples include increased material management (Spillane, \textit{et al.}, 2010; 2012), overcrowding (Singer, 2002) and increased health and safety (Spillane, \textit{et al.}, 2009; 2011a; 2011b). But fundamental to this is the effective utilisation of the industry’s most important resource – its people (Egan, 1998). Winch (2010) indicate that personnel account for a significant proportion of the costs attributable to a project while Druker and White (2007) outline that effective personnel management is often undervalued, hence, there is a high possibility of underutilisation and thus, reduced productivity of this important resource in the industry. Where interruptions occur in the fluidity of personnel output on-site, there is a possibility of uneven flow of work, thus resulting in reduced productivity (Thomas,
In order to sustain assigned project completion parameters, compressing the project schedule is sometimes suggested, but often with adverse consequences (McDonald and Zack, 2007). However, the construction industry is renowned for being notoriously unproductive, particularly in relation to labour productivity (Koskenvesa, et al., 2010), thus it has received attention from various academics vying to resolve the issue at hand (Koskela, 1992; Thomas and Napolitan, 1995; Ballard, 2002; Ballard and Howel, 2003). In order to assist on-site project managers with the onerous task of effectively managing the construction process, it is beneficial to identify the impact the site environment has on personnel productivity on-site. Through the use of a qualitative approach including individual and focus group interviews coupled with the inclusion of three case studies, it is possible to gain an insight into industry perceptions on the issue.

Three case studies are identified for inclusion in the research, with a minimum of three on-site professionals questioned with regards personnel productivity, in respect to their particular confined construction site. By introducing mind mapping, it is possible to identify and disseminate the impact of constructing sometimes intricate structures in an environment where space is often to the fore, particularly in relation to being a finite resource requiring effective, continuous management (Tommelein and Zouein, 1993). In documenting the factors which impact personnel productivity on a confined construction site, it will aid on-site project managers to identify the critical factors and in doing so, will asset in the implementation of mitigation measures to reduce or eliminate the resulting reduction in productivity on-site. Thus, through ensuring that optimum levels of productivity are not only achieved but also sustained, the possibility of achieving successful project completion is ever more attainable.

LABOUR PRODUCTIVITY
Labour productivity can be defined subjectively in analytical form or in a broader sense. One of the more universal definitions is provided by Hanna, et al., (2008), where, from an economists point of view, labour productivity is defined as the ratio between inputs; such as labour, material and plant, and outputs; the value of completed work. This view is also shared by Schwartzkopf, (2004) who elaborates on the definition by highlighting the various methods of labour productivity. These include ‘direct methods’ such as percentage of work complete, ‘work sampling’ which involves reviewing the work being undertaken over time. In addition, ‘Craftsman questionnaire sampling’ and ‘earned value methods’ are also included in the methodology reviewed. From a construction manager’s point of view, productivity can be defined as the ‘ratio between earned work hours and expended work hours’ (Hanna, 2008). Within labour productivity, there are a number of factors which have been identified as detrimental to labour productivity on-site. Some of these factors include over manning (Hanna, 2007), stacking of trades (McDonald and Zack, 2007), lack of materials (Thomas and Napolitan, 1995), extended overtime (Hanna, et al., 2005), changing working time (Ibbs, 2005) and shift work (Hanna, et al., 2008), but to name a few. However, one of the more pronounced factors adversely effecting personnel productivity is that of the construction schedule (Ritz, 1994) and more particularly schedule compression (Thomas, 2000) – a methodology which outlines the systematic approach in the monitoring and control of productivity.
Productivity of labour has proved a fickle topic, particularly in regards to the construction sector. In the case where additional resources are introduced to a particular work package, Hanna, *et al.*, (1999) argues that the resulting stacking, particularly of trades, may result in inefficiencies. Tse and Love (2008) share the viewpoint that overtime and shift work are more cost effective ways of schedule acceleration although it must be noted that a decline in productivity has been linked where overtime is introduced on a long-term basis and thus, should only be used as necessary. In addition, Ibbs (2005) compounds the issue by documenting that late change and lack of notice exasperate the problems in regards to productivity and therefore must be avoided where possible. Overcrowding is one of the core factors attributable to confined site construction (Spillane, *et al.*, 2011b) with both personnel (Cotton, 2009) and plant and equipment proving detrimental (Uher and Loosemore, 2004; Kim *et al.*, 2005). Makulsawatudom and Emsley (2001) establish, during a study of factors affecting craftsmen’s productivity, that overcrowding is ranked as the fourth most influential factor, with only lack of materials, lack of equipment and incomplete drawings causing a greater loss in personnel productivity on-site. Makulsawatudom and Emsley’s (2001) report found that project managers rank overcrowding as the sixteenth most significant factor, thus further compounding the issue and the severity of the research in question. Finally, a leading study by Thomas, (2006) concludes that overcrowding is directly correlated to craftsman’s productivity, but in order to assist in associating these results with that of a confined site construction, it is necessary to review the findings and to consider the results in relation to that of a spatially restricted environment.

**METHODOLOGY**

In order to achieve the research objective, a primarily qualitative approach is adopted. Firstly, a literature review is conducted on the topic of personnel productivity, with particular emphasis on the construction sector. Secondly, to capitalise on the information acquired along with verifying the factors identified, while also eliciting further possible factors, three case studies are identified for inclusion. The case studies included for discussion are a low rise, high rise and underground services contract located in Ireland, Northern Ireland and USA respectively. Each case study is selected after being shortlisted from a total of 12 possible case studies and is chosen due to the availability of individuals to participate in the research, the internal varying intricacies on-site, the scale of the project in question and the overall complexities associated with each, due to the confined nature of the projects in question. Specific emphasis is then placed on productivity within the construction sector while also reviewing the construction sector as a whole. Thirdly, with regards to the qualitative data collection, a number of construction sector companies within each case study are approached and requested to participate in the research through individual interviews and also focus group seminars. Based on the numerous factors in the literature, analysis of three industry specific and diverse case studies, examination of individual interviews and also focus group seminars, a plethora of factors are identified for further qualitative analysis and discussion.

**ANALYSIS**

From the exhaustive list of factors identified, a process of factor examination through the use of mind mapping and causal loop assessment is undertaken (Figure 1). By reviewing the results of the qualitative analysis by means of confirmatory discussions, it is then possible to identify the leading impacting factors of personnel productivity.
in a confined construction site environment. Table 1 documents the 15 factors identified in relation to the case studies chosen, tabulated in order of preference as prescribed by the interviewees questioned.

**Figure 1: Causal loop of factors impacting personnel productivity**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Case Study 1</th>
<th>Case Study 2</th>
<th>Case Study 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overcrowding of personnel at workstations</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lack of space for the effective movement of personnel</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Numerous trades working within the one space</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Difficult to transport material because of the lack of space</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>One contractor holding up another due to the lack of space</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A risk to personnel because of vehicular traffic on-site</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Difficult to facilitate several contractors at one work location</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reduced personnel output due to inadequate space</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Difficult to complete tasks due to the spatial restrictions</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Concern of the close proximity of neighbouring structures</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Start-stop nature to activities due to overcrowding</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Difficult to get to / from the work place</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Difficult to co-ordinate personnel in the assigned spaces</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor project programming resulting in overcrowding</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Restricted access at work stations to complete work tasks</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Table 1: List of factors identified and corresponding case studies**
DISCUSSION

The most prominent factors identified are listed accordingly, based on cluster, hiset and domain analysis of the extracted datasets using mind mapping software. Each of these factors are core to each of the discussions and resulting individual case studies documented and reviewed and thus, are prevalent within a confined site environment, regardless of being a low rise, high rise or underground development.

Overcrowding of personnel at workstations
From the qualitative analysis and the case study examination, the leading factor identified by all and which resonates throughout each case study, interview and focus group is the issue of personnel overcrowding at workstations. Thomas and Riley, (2006) compound the severity of the issue by documenting that congestion in the workplace is detrimental to labour productivity and thus, must be avoided at all costs. In addition, Mokobane, (2006) furthers this point by indicating that productivity is adversely affected due to the increased health and safety concerns which result in reduced productivity within such environments. Where the possibility of overcrowding at workstations is realised, on-site management must take all possible actions to mitigate or eliminate the adverse effects of such an environment, in order to ensure that productivity of personnel is not adversely affected.

Lack of space for the effective movement of personnel
The second factor identified is the lack of space which results in impairing the effective movement of personnel in and around site. Again, as before, the leading trait identifiable is the lack of space and the resulting adverse effect on personnel productivity on-site. Thomas and Riley (2006) also identify difficulties in the movement of personnel on-site as one of the leading issues in relation to productivity with Ning, et al., (2011) also highlighting the difficulties with multiple trips by personnel on-site. Therefore, the negative impact of this factor on personnel productivity is firmly rooted and must be acknowledged, thus enabling on-site management to proactively manage the limited space, with the aim of ensuring the effective movement of personnel on-site, thus improving the overall productivity.

Numerous trades working within the one space
The third and final factor for discussion is again noted in all three of the case studies and encompasses stacking of trades on-site and particularly within one location on-site. McDonald and Zack, (2007) argue that this practice has a detrimental effect on productivity on-site. In addition, they highlight that each trade should have sufficient space within their work environment to ensure that they can perform their tasks sufficiently while not being interfered by either oncoming or trailing trades. Furthermore, they conclude that the practice of schedule acceleration can also have a negative effect on trade stacking, but this factor is exasperated in confined site environments, where spatial restrictions are evident throughout.

CONCLUSION
With the continued development and expansion of urban centres (Heimlich and Anderson, 2001), the need for redevelopment has continued at pace. One of the negative aspects of developing within this environment is the spatial deficiency which persists in the vast majority of inner city sites. This can result in a number of issues, one of which is the negative effect on labour productivity on-site. As documented, by adopting a qualitative approach in the form of a critique of the literature along with
mixed method case study analysis individual interviews and focus groups, 15 factors are identified which negatively contribute to a reduction in personnel productivity on inner city, confined construction sites. The subsequent leading negative impacting factors are 1) overcrowding of personnel at workstations, 2) lack of space for the effective movement of personnel, and 3) numerous trades working within the one space. Where on-site management professionals are faced with ensure project success in such a spatially restricted environment, the findings presented are of particular interest and benefit. By acknowledging and counteracting the factors identified, it is possible to mitigate the negative impact of reduced labour productivity, thus increasing the possibility of ensuring project completion and thus, project success.

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