International Journal of Construction Management

ISSN: 1562-3599 (Print) 2331-2327 (Online) Journal homepage: https://www.tandfonline.com/loi/tjcm20

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International Journal of Construction Management, 2015
Vol. 15, No. 4, 332–344, http://dx.doi.org/10.1080/15623599.2015.1094849

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Determinants of construction labour productivity in Oman

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Notwithstanding the technological developments, construction continues to be a labour-intensive industry, and hence labour productivity remains the industry's predominant determinant of performance. One of the primary challenges facing the construction industry in the Sultanate of Oman is low labour productivity. Therefore, the objective of this study is to identify, explore and rank the relative importance of the cardinal determinants of construction labour productivity in Oman. A statistically representative sample of contractors was thus invited to participate in a structured questionnaire survey comprising 33 productivity factors. Using the relative importance index technique, the findings distinguish the following factors as most significant: (1) errors and omission in design drawings; (2) changes to orders during execution; (3) delay in responding to requests for information; (4) lack of labour supervision; (5) clarity of project specifications; (6) coordination level amongst design disciplines; (7) working overtime; (8) rework; (9) inclement weather; and (10) physical fatigue. The outcomes not only fill a gap in knowledge of the critical determinants of labour productivity in the Sultanate, but may also be used by academics and industry practitioners to develop a deeper and wider perspective on the factors influencing the efficiency of the construction labour force.

Keywords: construction labour productivity; efficiency; operatives; contractors; Sultanate of Oman

Introduction

Notwithstanding the technological developments, construction continues to be a labour-intensive industry, and thus labour productivity remains the industry's predominant determinant of performance. Labour costs, in most countries, comprise 30–50% of the overall project's cost (Kazaz et al. 2008; Jarkas & Bitar 2012; Jarkas et al. 2012); therefore, it is regarded as a true reflection of the success of the construction operation. Nevertheless, in today's turbulent economic conditions, improving the efficiency of labour is becoming more pressing than ever.

It has long been argued, however, that one of the major challenges facing the construction industry in the Sultanate of Oman is low labour productivity. Despite the local availability to contractors of financial facilities, modern equipment and tools, and construction materials, construction costs are constantly rising, completion schedules are often experiencing serious slippage and projects are frequently overrunning their budgets.

The objective of this study, therefore, is to identify, explore and rank, based on contractors' perspectives, the relative importance of the cardinal determinants of construction labour productivity in Oman, so that the findings can be used by local and international contractors, in addition to consultants, clients, policy makers and academics, to develop a deeper and wider perspective of the primary factors affecting the efficiency of labour, on the one hand, and to provide guidance to project managers for effective planning and efficient utilization of the labour force, on the other; and hence assist in achieving a reasonable level of competitiveness and cost-effective operations.

The paper starts with a literature review of research studies relevant to this investigation, presents the research method, provides a discussion of the results obtained, and concludes, based on the outcomes of the study, with recommendations geared towards improving the efficiency level of the labour force, and ultimately the overall productivity of the construction industry.

Literature review

In general, productivity is an economic measure defined as the ratio of output to input (Sumanth 1984). However, depending on the measurement objectives and the availability of data, several definitions and mathematical expressions are reported in the literature.

The US Department of Commerce defines productivity as 'dollars of output per person-hour of labour input' (Adrian 1987). Peles (1987) depicts productivity as 'the performance accomplished by operatives', while Finke (1998) portrays productivity as 'the quantity of work produced per man-hour, equipment-hour or crew-hour'.

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The American Association of Cost Engineers characterizes productivity as a 'relative measure of labour efficiency, either good or bad, when compared to an established base or norm' (Allmon et al. 2000). Arditi and Mochtar (2000), however, interpret productivity as 'the ratio between total outputs expressed in dollars and total inputs expressed in dollars as well', whereas Horner and Duff (2001) delineate productivity as 'how much is produced per unit input'.

Although construction productivity is a multifaceted, complex issue, which is difficult to measure, and thus is often defined by reference to the basic resources used (Radosavljevic 2001), based on the above discussion it is obvious that the general consensus among researchers is to define productivity as the ratio of output to input. In view of this, construction productivity can be regarded as a measure of outputs which are obtained by a combination of inputs. As a result, two measures of construction productivity emerge: (1) total factor productivity (TFP), where outputs and all inputs are considered; and (2) partial factor productivity (PFP), often referred to as single factor productivity, where outputs and single or selected inputs are considered (Talhouni 1990; Jarkas & Bitar 2012).

In comparison with PFP, where the definition is best exemplified by the term 'labour productivity' – i.e. units of work accomplished per labour-hour (Halligan et al. 1994) – the disadvantages of TFP measure are twofold: (1) it is difficult to reasonably determine and measure all input resources utilized to achieve the output; and (2) it is impractical, especially for researchers, to monitor, observe and assess the impacts of selected factors on the output. The complex nature of the construction process and the interaction of its activities, in addition, make the PFP measure the popular option, since effective control systems monitor each input separately.

Construction labour productivity has been the subject of several research studies. Horner et al. (1989), in a questionnaire survey aimed at isolating the factors influencing labour productivity in the UK construction industry, identified the following significant determinants: skill of labour; constructability/buildability; quality of supervision; method of working; incentive scheme; site layout; complexity of construction information; crew size and composition; length of working day/overtime; and availability of power tools.

Lim and Alum (1995) investigated the variables impacting on the productivity of the construction industry in Singapore, and reported the following crucial factors: lack of qualified supervisors; shortage of skilled labour; high rate of labour turnover; labour absenteeism; and communications with foreign operatives.

In a survey geared toward establishing the constraints on Iranian construction productivity, Zakeri et al. (1996), differentiated the following five factors as major determinants of operatives efficiency: materials shortage; weather and site conditions; equipment breakdown; drawing deficiencies/change in orders; and lack of proper tools and equipment. Kaming et al. (1997), furthermore, explored the factors affecting craftsmen productivity in Indonesia and found lack of materials; rework; absenteeism of operatives; and lack of suitable tools to be the most important.

Factors influencing the productivity of the construction operation in Thailand were further examined by Makulsawatudom et al. (2004), whose results identified the following causes as most significant: lack of materials; incomplete drawings; incompetent supervisors; lack of tools and equipment; labour absenteeism; poor communication; instruction time; poor site layout; inspection delay; and rework.

Abdul Kadir et al. (2005) additionally investigated the factors impinging upon the efficiency of labour in Malaysian residential projects, and declared the following as most important: shortage of material; non-payment to suppliers causing stoppage of materials delivery to sites; change in orders issued by consultants; late issuance of construction drawings by consultants; and the ineffectiveness of site management.

Alinaitwe et al. (2007) reported the following factors as affecting craftsmen productivity in Uganda: incompetent supervisors; lack of skill; rework; lack of tools and equipment; and poor construction methods. Enshassi et al. (2007), moreover, evaluated the various causes impacting on labour productivity in building construction projects in the Gaza Strip, Palestine, and discerned the following factors as most important: shortage of materials; inexperienced labour; lack of labour supervision; misunderstanding between labour and superintendents; drawings and specifications altered during execution; delay in payment; labour disloyalty; inspection delay; no weekend breaks; and shortage of tools and equipment.

Durdyev and Mbachu (2011), on the other hand, explored constraints on construction labour productivity in New Zealand, and recognized the following key determinants: rework; inaccurate estimates; labour skills; labour motivation; suitability of plant and equipment employed; construction method; buildability issues; project complexity; supervision; and clients' overt influence on the construction process.

Jarkas and Bitar (2012) investigated the factors affecting construction labour productivity in Kuwait, and identified the following as most significant: clarity of technical specifications; the extent of changes in orders during execution; coordination among design disciplines; lack of labour supervision; proportion of work subcontracted; design complexity; lack of incentive scheme; lack of construction manager's leadership; stringent inspection by the engineer; and delay in responding to requests for information.

Jarkas et al. (2012) further surveyed the factors influencing the productivity of construction operatives in Qatar, and recognized the following causes as most crucial: labour skills; shortage of materials; labour supervision; shortage of experienced labour; communication between site management and labour force; lack of construction managers' leadership; high temperatures; delay in responding to requests for information; lack of transportation for labour; and proportion of work subcontracted.

El-Gohary and Aziz (2014) explored the factors affecting labour productivity in Egypt, and disclosed the following as most prominent: labour experience and skills; incentive programmes; availability of materials and ease of handling; leadership and competency of construction management; and competency of labour supervision.

In a recently published study, Jarkas (2015) researched the factors influencing labour productivity in Bahrain's construction industry and reported as most critical: labour skills; coordination among design disciplines; lack of labour supervision; errors and omissions in design drawings; delay in responding to requests for information; rework; stringent inspection by the engineer; working overtime; lack of incentive scheme; and inclement weather.

Even though the relative importance of factors impinging upon construction labour productivity, depending on the cultural, economic, political and environmental conditions, may be different in different countries, an overall reasonable consensus exists on the primary factors reported in the literature. Nevertheless, in order to effectively explore and reasonably determine the relevance and applicability of such factors to the construction industry of a specific geographical setting, not only is a simultaneous assessment of a large, yet interrelated number of factors, which can be categorized under various classifications, required, but this must also be checked and verified by local industry experts, professionals and practitioners.

To classify the factors affecting construction labour productivity into major groups, which can best be related to the various corresponding factors, numerous approaches have been previously attempted; however, a general consensus among the different researchers is yet to be reached.

For instance, Herbsman and Ellis (1990) reported two main divisions of important factors: (1) technological and (2) administrative, while Talhouni (1990) suggested the following four classifications: (1) management; (2) site; (3) design; and (4) weather. Administrative- or management factors include inadequate supervision; inappropriate selection of construction methods; sequencing problems; crew size and composition; working overtime; shortage of materials; and the unavailability of suitable equipment or tools. Site-related factors comprise restricted access to the site; stringent control procedures; confinement of working space; site layout; and congestion. Technological factors, on the other hand, mainly pertain to buildability/constructability or the lack of it. This includes, inter alia, design errors and/or omissions; uncoordinated and illegible drawings; complex designs of unusual shapes and heights; ambiguous or out-dated technical specifications; excessive delay in responding to contractors' requests for information and submissions; in addition to stringent inspection procedures. Weather-related factors are high or low temperatures; high humidity; high winds, rain and snow.

Heizer and Render (1996) categorized productivity factors into the following three major groups: (1) labour characteristics; (2) project conditions; and (3) non-productive activities. Labour characteristics combine skills, experience, satisfaction and motivation of the labour force. Project conditions are ascribed to the type, design, material and location factors. Non-productive activities are those that are either counterproductive or do not contribute directly to the progress of tasks at hand, e.g. late start and early finish; frequent breaks; unscheduled breaks; waiting idle; simultaneous involvement of labour in several tasks; and the engagement of operatives in extended personal discussions.

Sugiharto (2003) additionally assigned the key factors influencing construction productivity in Indonesia to the following groups: (1) characteristics of contractors; (2) inadequate management strategy; and (3) the organization's focus. The characteristics of contractors include ownership type; qualifications; accumulated experience; classifications; and the calibre of staff employed. Management strategy pertains to the tools and managerial approaches adopted to minimize waste and unproductive activities, and hence promote lean, efficient and cost-effective operations, while the organization's focus refers to the client's objectives and motivations, the project goal and the active involvement of parties to the project in the construction process.

Enshassi et al. (2007), however, were excessively elaborate in their classification criteria when they partitioned productivity factors into the following 10 major groups: materials/tools; supervision; leadership; quality; time; manpower; project; external; motivation; and safety. Similarly, Durdyev and Mbachu (2011) identified the multiple factors affecting the productivity of labour under the following eight groups: statutory compliance; unforeseen events; external forces; project finance; workforce; technology/process; project characteristics; and project management.

Jarkas and Bitar (2012), Jarkas et al. (2012) and Jarkas (2015) classified the various productivity factors under: management group; technological group; labour group; and external group, whereas El-Gohary and Aziz (2014) classified the identified labour productivity factors under: labour; industrial; and management.

Although several group taxonomies have been suggested by different researchers, a thorough consideration of the different terminologies proposed, we argue, reveals a great deal of redundancy among some of the discussed groups. For instance, the 'non-productive activities' group suggested by Heizer and Render (1996) can be reasonably lumped under 'labour characteristics', while the 'organization's focus' proposed by Sugiharto (2003) may be allocated to the 'management strategy' group. Furthermore, the expanded groups proposed by Enshassi et al. (2007) and Durdyev and Mbachu (2011) can reasonably be combined within the categorization criteria considered by Jarkas and Bitar (2012), Jarkas et al. (2012) and Jarkas (2015).

While it is acknowledged that the factors affecting labour productivity can be different in different countries, across sites and possibly within the same construction site, depending upon certain circumstances (Olomolaiye et al. 1998), we argue that a global agreement on a classification system is possible, under which such factors can be partitioned. Thus, on the grounds that the categorization scheme proposed by Jarkas and Bitar (2012), Jarkas et al. (2012) and Jarkas (2015) – that is (1) management; (2) technological; (3) labour; and (4) exogenous – can encompass most of the factors discussed, it forms the basis for classifying the multiple corresponding productivity determinants explored in this study.

Research method

This study is inherently quantitative and although it may be criticized on the grounds of causal explanation (Ackroyd & Hughes 1981), the outcomes are primarily used to underpin the qualitative interpretations, and hence it is not in conflict with the phenomenological paradigm.

The data were collected by a structured, closed-ended, questionnaire survey – i.e. a 'quantitative' data collection instrument, which comprises a series of questions that limit the respondents' answers to a fixed set of responses in order to obtain statistically useful information about a topic under investigation (Foddy 1993). The logic underlying the selection of such a data collection technique is fourfold: (1) it is less intrusive and cost-effective when compared to unstructured, open-ended, questionnaires that allow the participants to respond in any way they choose, telephone or face-to-face interviews, and thus is especially advantageous for collecting large sample sizes; (2) the questionnaire survey concept is familiar to most potential respondents; (3) it is practical and relatively simple to analyse the returned questionnaires; and (4) in comparison with telephone and face-to-face interviews, it assists in reducing the bias that may be introduced by researchers' verbal and visual clues, respectively (Jarkas & Younes 2014).

On the other hand, the factors potentially affecting labour productivity in Oman were identified based on the following criteria: (1) previous reviewed investigations on construction labour productivity; and (2) their relevance, and thus applicability to the geographical setting within which this study focused, as recognized by a group of local industry experts and practitioners.

Consequently, 33 factors, which were subsequently categorized under the previously indicated four major groups, were shortlisted as being conceivably significant, or amongst the relatively influential factors on the productivity of the construction labour force in the Sultanate. Table 1 shows the factors explored, and the related groups under which they were partitioned.

The target population included the contractors, which are classified by the Oman Tender Board (OTB). The prequalification criteria for construction firms in the Sultanate are based on: previous experience; financial position and strength; equipment and tools available; and the credentials of the technical staff employed. Consequently, the total number of contractors classified under the 'excellent' and 'first' grades is 339 (OTB 2014).

To obtain a statistically representative sample of the population, the formula shown in Equation 1 was used (Hogg & Tannis 2009):

$$n = \frac{m}{1 + \left(\frac{m-1}{N}\right)} \tag{1}$$

where n, m and N represent the sample size of the limited, unlimited and available population, respectively, whereas m is estimated by Equation 2:

$$m = \frac{z^{2*}\, p^{*}\, (1 - p)}{\varepsilon^2} \tag{2}$$

where z is the statistic value for the confidence level used, i.e. 2.575, 1.96 and 1.645 for 99%, 95% and 90% confidence levels, respectively; p is the value of the proportion of the population which is being estimated; and ε is the sampling error of the point estimate.

Since the value of p is unknown, Sincich et al. (2002) suggest a conservative value of 0.50 be used so that a sample size that is at least as large as required be obtained. Using a 95% confidence level, that is a 5% significance level, the unlimited

Table 1. Productivity determinants explored and related groups under which categorized.

No.	Productivity determinant	Related group
1	Unrealistic design schedules imposed on designers	Management
2	Construction method	Management
3	Unrealistic scheduling and expectations of labour performance	Management
4	Low design fees	Management
5	Payment delay	Management
6	Accidents due to poor site safety	Management
7	Congestion and labour interference	Management
8	Incompetent supervisors	Management
9	Site layout	Management
10	Ineffective communication between site management and labour force	Management
11	Crew size and composition	Management
12	Lack of labour supervision	Management
13	Working overtime	Management
14	Quality of drawings	Technological
15	Clarity of project specifications	Technological
16	Errors and omissions in design drawings	Technological
17	Coordination level amongst design disciplines	Technological
18	Design complexity	Technological
19	Delay in responding to requests for information	Technological
20	Rework	Technological
21	Sequencing problems	Technological
22	Inspection delay by the engineer	Technological
23	Stringent inspection by the engineer	Technological
24	Confinement of working space	Technological
25	Change orders during execution	Technological
26	Labour skills	Labour
27	Labour motivation	Labour
28	Labour's physical fatigue	Labour
29	Unavailability or shortage of materials	Exogenous
30	Inclement weather	Exogenous
31	Unforeseen ground conditions	Exogenous
32	Excessive delay in statutory approvals	Exogenous
33	Frequent changes in statutory regulations	Exogenous

sample size of the population, m, is determined by Equation 2 as follows:

$$m = \frac{(1.96)^{2*}\ 0.50^{*}\ (1-0.50)}{(0.05)^2} = 385$$

Consequently, for the total number of 339 classified contractors, i.e. N, the representative sample size of the population required is quantified by Equation 1:

$$n = \frac{385}{1 + \left(\frac{385-1}{339}\right)} = 181$$

The questionnaire survey comprised an ordinal measurement scale ranking the importance level discerned for each factor examined in ascending order from 1 to 5. It is important to note, however, that the numbers assigned to the scale indicate neither equal intervals nor absolute quantities, but rather the degree of importance of each factor for labour productivity, based on the respondents' judgement.

In order to establish a reasonable validity of the outcomes – i.e. to ensure that the questions do measure what they are supposed to measure – and assess the reliability of the questionnaire, a pilot test was conducted on samples of the prospective respondents. As suggested by Polit et al. (2001), 10–20% of the sample size required for a study is a reasonable number of respondents to consider enrolling in a trial run in preparation for a major research project.

The questionnaire was therefore distributed to construction project managers representing 20 contractors from the classified firms (i.e. 11% of the sample size required), who had expressed a genuine interest in providing objective assessment and feedback on the research data collection instrument.

The aim of this test was fourfold: (1) to assess the clarity, comprehensibility, interpretation and appropriateness of the questions provided in capturing the factors affecting the productivity of construction operatives in Oman; (2) to test the adequacy of the range of response choices; (3) to assess the internal consistency of the questionnaire; and (4) to determine the efficiency with which the respondents complete the questionnaires (Jarkas et al. 2014).

Except for minor comments, which were mainly related to interpretations of a few questions, the respondents' feedback was generally positive. As a result, the authors rearticulated such questions using incontrovertible background to avoid any future confounding of the framework, within which the response of the participants is sought.

The internal consistency of the questionnaire was tested by computing the Cronbach's Alpha of the sets returned. The alpha coefficient ranges in value from 0 to 1, and is used to describe the reliability of factors extracted from dichotomous, multipoint formatted, or ordinal rating scale questionnaires. Cronbach's alpha (α) is calculated by Equation 3 (Howitt & Cramer 2008):

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum V_i}{V_{\text{test}}}\right) \tag{3}$$

where n is the number of questions; V_i is the variance of scores on each question; and V_{test} is the total variance of the overall scores. The higher the alpha coefficient score, the more reliable is the generated scale. Nunnaly (1978) has indicated that a value of 0.700 is an acceptable reliability coefficient; nonetheless, lower thresholds are commonly reported in the literature.

Cronbach's alpha for the sample group of respondents was computed by the Statistical Package for the Social Sciences (SPSS V18) software, where the coefficient value of 0.809 was obtained, which indicates an acceptable measure of questionnaire reliability by all respondents. Thus, a total of 200 randomly chosen firms from the OTB list of registered contractors were invited to participate in the survey, and this was followed up by frequent reminders. It is worth noting that the logic behind the random selection technique was to eliminate any bias in the selection process by allowing equal selection probability for contractors surveyed.

The data collection phase spanned three months, after which a total of 132 usable questionnaires were received, representing approximately 73% of the required sample size. However, such a response rate, in comparison with most previous related investigations, suggests reasonable reliability, validity and robustness of the findings. The respondents are considered senior officials within their organizations, mainly comprising project directors and construction project managers, with a minimum practical experience of 20 years in the construction industry.

The data collected were analysed using the relative importance index (RII) technique (Jarkas & Bitar 2012; Hughes & Thorpe 2014). The RII for each factor investigated, which ranges in value from 0 (not inclusive) to 1, was determined by the formula shown in Equation 4:

$$RII = \frac{5(n5) + 4(n4) + 3(n3) + 2(n2) + n1}{5(n1 + n2 + n3 + n4 + n5)} \tag{4}$$

where $n1$; $n2$; $n3$; $n4$; and $n5$ are the number of respondents who selected: 1, for no effect; 2, for little effect; 3, for moderate effect; 4, for strong effect; and 5, for very strong effect, respectively.

The rank of each group, on the other hand, was established by quantifying the average value of the relative importance indices for all factors categorized; the higher the average value, the stronger the influence of the group factors on labour productivity (Enshassi et al. 2007; Jarkas et al. 2012).

Results and discussion

The effects of the 33 factors surveyed on construction labour productivity in Oman are determined. The relative importance indices and ranks of the factors examined are presented, discussed and, where possible, compared to previous related

Table 2. Overall relative importance indices, related groups and ranks of productivity determinants explored.

Productivity determinant	RII	Related group	Rank
Errors and omissions in design drawings	0.922	Technological	1
Change orders during execution	0.896	Technological	2
Delay in responding to requests for information	0.878	Technological	3
Lack of labour supervision	0.867	Management	4
Clarity of project specifications	0.862	Technological	5
Coordination amongst design disciplines	0.854	Technological	6
Working overtime	0.846	Management	7
Rework	0.838	Technological	8
Inclement weather	0.832	Exogenous	9
Labour's physical fatigue	0.827	Labour	10
Unrealistic design schedules imposed on designers	0.821	Management	11
Labour skills	0.813	Labour	12
Construction method	0.806	Management	13
Unrealistic scheduling and expectations of labour performance	0.802	Management	14
Quality of drawings	0.781	Technological	15
Unavailability or shortage of materials	0.776	Exogenous	16
Low design fees	0.763	Management	17
Payment delay	0.758	Management	18
Stringent inspection by the engineer	0.752	Technological	19
Sequencing problems	0.743	Technological	20
Labour motivation	0.739	Labour	21
Inspection delay by the engineer	0.724	Technological	22
Accidents due to poor site safety	0.713	Management	23
Unforeseen ground conditions	0.702	Exogenous	24
Congestion and labour interference	0.679	Management	25
Incompetent supervisors	0.663	Management	26
Site layout	0.639	Management	27
Excessive delay in statutory approvals	0.627	Exogenous	28
Design complexity	0.612	Technological	29
Confinement of working space	0.571	Technological	30
Ineffective communication between site management and labour force	0.552	Management	31
Frequent changes in statutory regulations	0.526	Exogenous	32
Crew size and composition	0.517	Management	33

findings. The main groups' average relative importance indices, moreover, are quantified, and therefore a comparison among their influence levels is carried out. Table 2 presents the relative importance indices and ranks achieved for each factor explored.

Based on the overall perceived importance of the factors surveyed, the results obtained show that the cardinal, i.e. the top ten, construction labour productivity determinants in Oman, in descending order, are the following: errors and omissions in design drawings; change in orders during execution; delay in responding to requests for information; lack of labour supervision; clarity of project specifications; coordination among design disciplines; working overtime; rework; inclement weather; and labour's physical fatigue.

It is noteworthy to highlight that since some of the primary determinants identified share common characteristics, to avoid redundancy the discussion of such factors shall be carried out collectively, irrespective of the ranks achieved.

With relative importance indices of 0.922, 0.878, 0.862 and 0.854, errors and omissions in design drawings, delay in responding to requests for information, clarity of project specifications and coordination among design disciplines, rank first, third, fifth and sixth in their impacts on labour productivity, respectively.

This pattern further corroborates the outcomes of Horner et al. (1989), Zakeri et al. (1996), Durdyev and Mbachu (2011), Jarkas and Bitar (2012), Jarkas et al. (2012), Hughes and Thorpe (2014) and Jarkas (2015), whose research recognized such buildability/constructability factors as among the most significant determinants of labour productivity in the UK, Iran, New Zealand, Kuwait, Qatar, Queensland-Australia and Bahrain, respectively.

'Buildability', commonly referred to as 'Constructability' in North America, is defined by the Construction Industry Research and Information Association (CIRIA) of the UK as 'the extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building' (CIRIA 1983). On the other hand, the Construction Industry Institute (CII) of the US defines constructability as 'the optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives' (CII 1986). Although both expressions target similar issues, the term constructability covers a wider range of disciplines including conceptual planning, design, procurement and construction.

Nonetheless, an early attempt to address the buildability concept is credited to Sir Harold Emmerson (1962), when he suggested a new form of relationship between designers and contractors. The point of concern was the lack of cohesion between the two parties and their inability to see the whole construction process through each other's eyes.

Lack of buildability practices exhibited by errors and omissions in design drawings, absence of coordination among design disciplines, obscure technical specifications, in addition to excessive delay in responding to requests for information, may not only translate into inflated bids at the project tendering stage, but can also lead to disruptions and interruptions to work under progress. Moreover, numerous changes or alterations to design documents during construction may lead to a complete halt of related activities, productivity and quality degradation, possible demolition and rework, schedule slippage and, ultimately, significant time and cost overruns (Subramanyan et al. 2012; Jarkas 2013).

The recognized adverse influence of such buildability factors on labour productivity may be attributed, in whole or in part, to the following reasons: (1) the insufficient times and tight schedules, coupled with low design fees, imposed upon designers – a practice that is regionally widespread (Jarkas & Marenjak 2014), and further confirmed by the findings of this study, where these two factors, although rank-wise are not among the top 10, still have important effects on labour productivity, as indicated by the relative importance indices of 0.821 and 0.763 – to develop and review design alternatives, related details, technical specifications and consistent contract documents, so that the documents produced are often unclear, incomplete and contain serious discrepancies, errors and omissions among the various disciplines involved; (2) the shortfall in applying buildability principles among several designers operating in the Sultanate, which may suggest a lack of awareness on their part of the significance of this concept to the successful progress of construction projects; and (3) the possible negligence of some designers in providing 'quality' work and efficient professional services.

In comparison with the 33 factors surveyed, 'change in orders during execution', with an RII of 0.896, ranks second in its influence on labour productivity. This outcome is consistent with the previous findings of Koushki et al. (2005), Oladapo (2007), Kaliba et al. (2009), Osman et al. (2009), Turkey (2011) and Alinaitwe et al. (2013), whose research studies have distinguished the adverse effect of changes in orders on the performance of construction projects in Kuwait, South Africa, Zambia, Malaysia, Ethiopia and Uganda, respectively.

According to Parker (2002), a change in orders is defined as 'works, processes or methods that deviate from original plans and specifications'. Frequent disruptions and redirection of works associated with changes in orders can result not only in poor labour productivity, but also in prolongation of construction schedules, rework, additional procurement activities and possibly disputes and litigation, all of which can further translate into significant construction cost overruns in projects under development.

This outcome may be largely ascribed, individually or collectively, to the following reasons: (1) clients' minimal involvement, in particular those belonging to the private sector, in the various design phases of projects, hence resulting in design modifications during the construction stages (Alnuaimi et al. 2010); (2) designers' failure to apply buildability principles at the pre-construction stage of projects, as was previously highlighted; or (3) simply clients' 'change of heart', particularly regarding plans (i.e. architectural layout and circulation), fixtures, ornamental features and finishes. As a result, changes are often requested after contractual agreements have been executed; at times even after physical erection of major parts of a project have taken place.

In further support to the results obtained by Horner et al. (1989), Alinaitwe et al. (2007), Enshassi et al. (2007), Durdyev and Mbachu (2011), Jarkas and Bitar (2012), Jarkas et al. (2012), El-Gohary and Aziz (2014), Hughes and Thorpe (2014) and Jarkas (2015), whose research distinguished the significance of supervision on labour productivity in the UK, Uganda, Palestine, New Zealand, Kuwait, Qatar, Egypt, Queensland-Australia and Bahrain, respectively, with an RII of 0.867, 'lack of labour supervision' ranks fourth among the 33 factors surveyed.

The perceived importance of this factor suggests that quality and continuous on-site management and supervision of labour is required to optimize the productive input. Lack of supervision can encourage operatives, especially those who are under direct employment, to take frequent unscheduled breaks, wait idle, engage in unproductive activities or leave the work site during working hours to attend to personal matters. Additionally, direct supervision of labour is necessary to avoid work that is faulty and does not conform to plans and specifications, and thus assists in minimizing expensive incidents of rework, and the possible associated delays to subsequent activities.

'Working overtime', with an RII of 0.846, comes seventh in rank, corroborating the results obtained by Horner et al. (1989), Enshassi et al. (2007), Soham and Rajiv (2013) and Jarkas (2015), whose research classified this factor among the critical determinants of labour productivity in the UK, Palestine, the South Gujarat Region of India and Bahrain, respectively.

Typically, overtime refers to the hours that operatives work beyond a regular 40-hour working week. The construction industry typically employs overtime to complete critical activities on time, overcome delays through accelerations in the schedule, attract additional labourers with higher pay, or take advantage of favourable weather conditions. However, there is evidence to show that labour productivity, on average, decreases by 10−15% for 50- and-60-hour working weeks, which would worsen further as more hours per week are worked (Thomas & Raynar 1997).

The detrimental effect of overtime work on productivity can be mainly related to the following causes: labour's physical fatigue − another perceived significant factor ranking tenth with an RII of 0.827 − and hence decreased labour agility, stamina and motor skills; low morale, poor mental attitude and demotivation; and, in the case of acceleration of the schedule, frequent disruptions caused by the inability of site management to provide materials, tools, equipment and information at an accelerated rate. All of this not only leads to low labour productivity, but also to a high probability of poor workmanship and quality of output; and therefore rework, time and cost overruns, and possible disputes among parties involved in the project.

Supporting the findings of Kaming et al. (1997), Makulsawatudom et al. (2004), Ng et al. (2004), Alintaitwe et al. (2007), Durdyev and Mbachu (2011), Hughes and Thorpe (2014) and Jarkas (2015), whose studies asserted the importance of 'rework' for the productivity of the construction industry in Indonesia, Thailand, Hong Kong, Uganda, New Zealand, Queensland- Australia and Bahrain, respectively, with an RII of 0.838, this factor ranks eighth in its influence on labour productivity.

Rework, which involves correcting and/or replacing defective or non-conforming items and activities during or after site inspection, can result from various reasons, such as poor supervision, buildability issues, labour errors, over-inspection, change in orders, poor coordination, physical fatigue of labour due to overtime or ineffective communication. Nevertheless, operatives take considerable pride in the output they achieve (Jarkas & Radosavljevic 2013), and having to redo the work can be frustrating and discouraging, thus translating into unsatisfactory performance and lower than expected productivity.

The perceived effect of weather on construction labour productivity in Oman, ranking ninth with an RII of 0.832, is not unexpected. However, to develop a wider and deeper perspective of this outcome, the prevailing climatic conditions in the Sultanate merit further discussion.

In general, the weather in Oman, as with the rest of the Gulf Cooperation Council (GCC) countries − Saudi Arabia, Kuwait, Bahrain, Qatar, and United Arab Emirates − is extremely hot and relatively humid most of the year. The long summer season lasts from April to October, when the highest temperature in the shade usually exceeds 50 °C.

The average summer temperature in the capital (Muscat) is 33 °C, however, the strong western wind that blows from the Saudi desert usually raises the temperature by 10 °C. Because of the low elevation of the plains, the humidity, moreover, can be as high as 90, making working conditions, especially externally, rather unbearable. Yet temperatures during the short winter season, which spans from December to March, are relatively mild and pleasant, ranging between 15 and 23 °C (Oman Climate 2014).

Based on the preceding discussion, it is apparent that high temperatures and severe humidity are the predominant climate conditions in the Sultanate. It is conceivable, therefore, that working under such conditions affects labour performance and efficiency levels; hence the outcome.

Table 3 depicts the overall ranking of the four major groups under which the factors investigated are categorized.

In further substantiation of the results obtained by Jarkas et al. (2012) and Jarkas (2015), whose studies have confirmed the prominent influence of the labour group factors on the productivity of construction operations in Qatar and Bahrain,

Table 3. Group factors: average relative importance indices and ranks achieved.

Productivity group	Group factors average RII	Group rank
Labour	0.793	1
Technological	0.786	2
Management	0.725	3
Exogenous	0.693	4

respectively, with an average RII of 0.793, the labour group factors rank first in their overall impact on labour efficiency in Oman.

The ‘technological’ group factors, with an average RII of 0.786, rank second over the ‘management’ and ‘external’ group factors, which come in third and fourth, with average relative importance indices of 0.725 and 0.693, respectively. However, the quantified average relative importance indices of the factors belonging to the four groups, for all practical purposes, display nearly equivalent effects on labour productivity − a pattern that lends further credibility to the factors explored, on the one hand, and the results obtained, on the other.

Practical applications

It is a common objective among contractors, designers, employers and policy makers in Oman to enhance the performance of the construction industry. The findings that emerged from this study can assist in achieving this objective by focusing and acting upon the prominent factors perceived to affect labour productivity.

In the first instance, increasing the designers’ awareness of the significant impact of the buildability/constructability concept on the productivity of the construction operation can substantially help in improving the efficiency of the labour force. Such an effort may be augmented by encouraging contract procurement or project delivery methods which permit the involvement of contractors during the design stage of projects, such as the Design−Build (DB), Design−Build−Operate−Transfer (DBOT), or Turnkey/Engineering, Procurement and Construction (EPC), and hence facilitate incorporating the construction experience at an early stage of the project’s development process, so that the related benefits can be reaped during the execution phase. In view of the results obtained, perhaps policy makers may further consider instigating a formal buildability assessment application as a condition for granting construction permits, where minimum requirements of buildability principles must be satisfied before a permit can be issued.

The outcomes, moreover, implicitly confirm that the notion of exerting pressure on designers to cut down design durations and fees is a ‘false economy’, since more opportunities exist to significantly lower the total project cost by directing more attention on the design than on the construction phase (Jarkas & Bitar 2012; Jarkas et al. 2012). Decisions made during the design stage of a project not only have a maximum influence on its construction cost, but also dictate its viability, future expenditure and duration. It can further justify, from the designers’ perspective, the ‘cutting corners’ approach commonly used in such circumstances to both, quality and design time, in order to rationalize the cost/benefit ratio of contracts (Jarkas & Marenjak 2014).

Such a practice leads to poor attention to detail, which is often associated with low buildability levels such as design errors and omission of essential details, uncoordinated drawings, especially among the various design disciplines, and unclear, inconsistent or incompatible project specifications. All of this can translate into frequent requests for information, possible change in orders and/or rework, and hence recurrent disruptions and interruptions to activities underway, resulting in low productivity, extended time scales and escalated costs of construction.

It may therefore be prudent for management to appoint a high calibre construction manager who can, at an early stage in the project, scrutinize the contract documents and detect potential pitfalls, obscurities and missing relevant details, and prepare an exhaustive ‘request for information’ list to obviate excessive delays in responding to intermittent and sporadic requests during the course of the construction process. Such an approach can prove useful in avoiding the necessity for ‘overtime’ to avoid delays, and thus may further help in mitigating incidents resulting from ‘labour’s physical fatigue’; an additional two factors which are perceived to critically impact on the efficiency of the labour force.

On the other hand, the outcomes suggest that applying effective labour supervision criteria which can optimize productivity on sites, and minimize faulty outputs and/or deviations from contractual specifications, coupled with planning, organizing and carrying out sensible working hours, in particular during inclement weather conditions, are essential determinants which deserve the attention of construction managers in order to improve labour productivity in the Sultanate.

Conclusions and recommendations

This research identified, explored and, based on the quantified relative importance indices, established the ranks of 33 factors seen to affect construction labour productivity in the Sultanate of Oman. The factors investigated were, moreover, categorized under the following four major groups: management; technological; labour; and exogenous.

In view of the relative importance perceived by the contractors surveyed, the findings distinguish the following determinants of construction labour productivity in the Sultanate: errors and omission in design drawings; change to orders during execution; delay in responding to requests for information; lack of labour supervision; clarity of project specifications; coordination among design disciplines; working overtime; rework; inclement weather; and labour’s physical fatigue.

On the other hand, the determined average relative importance indices of the four major groups, under which the productivity factors examined are classified, recognize the ‘labour’ group factors as most significant, followed by the ‘technological’, ‘management’ and ‘exogenous’ group factors, respectively.

Although the labour group factors are recognized as the salient determinants of labour productivity, the outcomes further indicate a lack of buildability/constructability practices among the various designers operating in Oman, which suggests a lack of awareness on their part of the importance of this concept to the productivity of the construction process.

The results reported in this study not only contribute to the overall body of literature related to the various factors impinging upon construction labour productivity, which can be valuable for researchers and academics, but also fill a gap in knowledge of the efficiency determinants of operatives in Oman, and thus can be further used to provide local and international contractors, designers and clients with guidance for focusing and acting upon the cardinal factors seen to impact on the productivity of the labour force employed in the construction industry of the Sultanate.

However, the small differences among most of the quantified relative importance indices of labour productivity determinants imply that distinguishing one factor from another is rather impractical. Consequently, what is suggested is to consider most of the factors investigated, with special emphasis being placed on the most prominent factors identified.

Notwithstanding that several findings have been drawn from this research, which may be further applicable and thus reasonably generalized to other GCC countries, primarily due to the distinct resemblance among these nations with respect to cultural, economic, political and environmental characteristics, it is recommended to replicate the study, taking into additional consideration the perception of designers. Such an approach can provide meaningful insights into the level of agreement between the two groups in relation to their ranking in importance of the factors explored.

It is recommended, moreover, to carry out similar investigations in different geographical settings, in order to unravel the influence of specific cultural, economic and environmental factors on the efficiency of construction operatives. This will assist researchers to deepen their understanding of the numerous factors that affect labour productivity, through modelling and cross-comparison of the various determinants identified.

It is important to conclude with the notion that construction labour productivity may be effectively ameliorated when the ‘effects’ of the factors explored are quantified. It is, therefore, encouraged to further determine, through an integrated approach geared toward linking the relationship between the factors surveyed, especially those perceived as most critical, and their tangible impacts on project schedules, budgets and quality. Such studies can provide useful insights into the main causes of low labour productivity, time and cost overruns, in addition to poor quality in the construction industry of both developing and developed countries.

Disclosure statement

No potential conflict of interest was reported by the authors.

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