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Spatial factors contributing to worker time management at construction sites

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Abstract
Construction delays often create cost and quality issues in time intensive urban projects. Even though, many researchers have attempted to find the factors that contribute to these delays, sufficient attention has not been paid to spatial factors and their contribution to the time management of construction workers. Thus, the aim of this study was to investigate the management of spatial factors that influence the time management of workers at construction sites. A multi-method qualitative research approach was used in the study. Semi-structured interviews and case studies were used for data collection. The empirical data collected from the interviews and case studies were analysed using manual content analysis. Spatial factors that contribute to the time management of workers at construction sites, the type of contribution they make, and the strategies that can be adopted to manage them were identified through a literature review and a set of interviews. The influence that the identified strategies exert on the time management of construction workers was determined through the interviews and the findings of the interviews were verified through the case studies. The study findings indicated the importance of introducing spatial factor management to the construction industry. Properly enforcing regulations, increasing the awareness about spatial factors, and conducting studies on spatial factor management will solve construction delays because they can increase the efficiency of construction workers. Studies that have been conducted on spatial factor management are scarce. This study can be used as a benchmark for in-depth research studies in the area.

Keywords
Construction sites, Construction workers, Spatial factors, Time management.

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1. Introduction

Inefficient time management at construction sites can cause serious consequences because it leads to waste of money, work-related disputes and arguments, and the degradation of construction quality (Owusu & Aggrey, 2020; Tafazzoli & Shrestha, 2017). Construction delays affect the economics of construction projects and lead project stakeholders to incur losses (Kumar, 2020) and only some of these losses can be compensated (Fakunle & Fashina, 2020). Therefore, finding measures that can resolve the issues has become essential (Memon et al., 2014). With urbanization, people tend to move to cities and therefore, the population density in cities seems to rapidly increase (Ritchie & Roser, 2018). Authors further state that, construction projects within and around city limits has increased as there is an urge created to build amenities such as houses, schools, restaurants and many more to facilitate this increasing population. However, only little attention is given to the spatial arrangements in urban construction projects because of the volatility and the disorganised state of these congested construction sites (Zolfagharian & Irizarry, 2014). They further state that this disregard of special arrangements could be a key factor contributing to waste and poor management of time at construction sites. Some spatial arrangements may generate shorter work-cycles than the others do (Kothiyal, 1995; Sanad et al., 2008). Little attention is paid to the contribution made by spatial factors to time management in construction sites (Bansal, 2018; Marx, 2010), especially in sites located in Sri Lanka. Moreover, the stakeholders of construction projects, such as project managers, are not aware that spatial factors can influence time efficiency in construction sites (Mamat & Zin, 2016). These spatial factors can differ from project to project (Bar & Ullman, 1996; Delbosc & Currie, 2011). Thus, the influence of spatial arrangements in construction sites on the time management of workers at the sites and the strategies that would assist in the successful management of the factors require investigation. Thus, the aim of this study was to investigate the management of spatial factors contributing to the time management of construction workers at sites with the objectives of investigating the spatial factors that contribute to the time management of construction workers at sites, how these spatial factors influence the time management of the workers, the strategies that could be adopted to manage the spatial factors, and how the identified strategies influence the time management of construction workers.

2. Literature review

2.1. Spatial factors

Spatial factors define spaces by assisting people to collect and process information about the elements and space around them (Dogu, 2000). People identify their environments by first using spatial factors partially; they also found that it has been long recognized that the underlying spatial structure of a certain space is important to configure that space (Silavi et al., 2017). Thus, spatial layout and appearance play a critical role in enabling people to comprehend and perceive that place (Fard, 2014). Previous scholars have found that spatial factors such as permeability, variety, and legibility make an environment responsive and engaging (Bentley et al., 1985; Ewing & Handy, 2009; Gomez, 2011; Herath, 2005; Khalaf & Ja`afar, 2020). Legibility, robustness, and personalization make a space interesting (Bentley et al., 1985; Herath, 2005; Khalaf & Ja`afar, 2020). Unity affects the spatial cognition of people (Gauthier & Gilliland, 2006; Rapoport, 1977; Ujang, 2012; Yeo et al., 2016). In busy environments, the spatial factors safety and imageability influence human minds (Ujang et al., 2012). Openness is a spatial factor (Gauthier & Gillilan, 2006; Ujang, 2012; Yeo et al., 2016). Scale is a spatial factor that influences people in cities (Gehl, 2010). By changing the physical characters of a space, the spatial factor comfort can be introduced into the space (Ujang, 2012). Tidiness also is a spatial factor that can influence the human mind (Ujang et al., 2012). The effectiveness of the utilization of

a construction site, therefore, can be identified only by accurately analysing the influence exerted by spatial factors on worker behaviour (Acar et al., 2020; Montgomery, 1995).

2.2. How spatial factors can influence the workers in a construction site

The structure of a physical environment can significantly affect the ability of an individual to orientate within that environment (Slone et al., 2014). Thus, the physical elements of a worksite can influence the satisfaction, anxiety, tension, productivity, and efficiency of a worker (Samani et al., 2017). Construction industry is labour intensive and the work environments in many construction sites are not satisfactory (Hashiguchi et al., 2020). In every construction project, worksite layout is developed regularly and routinely. The decisions made about worksite layout depend on the locations of temporary offices, rest and dining areas, material storage areas, cranes, access points, sanitary facilities, access routes, workshop areas, utilities, and other important facilities (Small & Baquer, 2016). The productivity of a workspace can be determined by how well the different areas in the worksite layout are being used and how efficient the workers are (Garzon, 2005). Therefore, spatial factors of construction sites, which depend on the spatial arrangements of the sites, can influence worker performance in numerous ways. The proper consideration of the spatial factors of a workspace can have a huge impact on the productivity and time management of the workers (Paljug, 2020).

2.3. Influence of spatial factors on time management in construction sites

Time management can be described as the act of planning and controlling the amount of time spent on various activities, especially those involved in improving worker productivity and efficiency (Ahmad et al., 2012). Physical environments directly influence worker performance and productivity (Kamarulzaman et al., 2011). Certain spatial arrangements can influence how one engages in different tasks and actions (Solman & Kingstone, 2019). Thus, the spatial factors of a workspace can have a huge impact on worker productivity (Paljug, 2020). For example, a legible road sign will help a person to find his/her way around while helping to determine where he/she is and minimize the time spent on getting to any given place (Stamps, 2004). Permeability improves worker efficiency by encouraging the workers to use "through movements" and manage time efficiently (Stoner, 2016). Imageability helps make a strong and useful visual image (Mohankumar, 2014). Robustness improves the adaptability of space, which will help enhance the speed, quality, and the efficiency at which the desired work would be completed (Nickl, 2020). Safety improves openness, flexibility, and interdependence required for high performance (Delves, 2020). Also, safety affects productivity by improving self-confidence and trust, and that it increases worker involvement and commitment (Clarke, 2020). An environment that has vitality is vibrant, thriving, and alive, and thus can increase collaboration, engagement, well-being, and productivity of those who work within that space (Mars Drinks, 2015). Openness also can influence time management by improving worker satisfaction and collaborative spirit (Bernstein & Turban, 2018). Comfort can create a space "healthier" because when the environmental conditions are optimum, employee health is improved and employee absenteeism is reduced, which in turn enhances employee efficiency (Ali et al., 2015). The scale of a building and the spaces within it have to be proportional to the human scale for people to feel secure (Gehl, 2010). When the feeling of security is developed in an employee, employee productivity will eventually appear to increase (Harter, 2020). Tidiness improves the ability of the workers to process information, and increases their productivity because it minimizes the time spent by workers on finding lost items and improves the mental health of the workers to help them focus on their work (Sander, 2019).

2.4. How to manage spatial factors at construction sites

Spatial factor management involves tracking, controlling, supervising, and properly utilizing the available space of an organisation to manage its physical layout and improve its space configuration (Prasad, 2019). The landmarks in the area have to be recognizable and prominent, the different sections in the area should have distinct characteristics to enable their easy identification, the access ways have to be clear with important points of interest along the paths, and the borders of different sections or access ways should have structures or features inherent to them (Ingram & Benford, 1996; Yavuz et al.,2020). A layout that encourages permeability should be well connected and should offer a choice of direct routes to any of the destinations (Essex planning officers association, 2019). To improve safety, construction sites should have proper fall protection measures (Roux, 2014). Construction sites requires to display appropriate signboards to protect employees from hazards (The American Society of Safety Professionals, 2019). Robustness can be achieved by introducing adaptable spaces that can be utilized for various uses and activities, probably at different times or according to the demand (Carmona, 2018). Comfort can be attained by providing a superior acoustic environment, maintaining optimal thermal comfort, creating a high-quality visual environment, and by providing workstations, furniture, and equipment that enhance worker performance (WBDG Productive Committee, 2018). Unity can be achieved by repeating elements, such as colours, shapes, or materials, throughout the space (Mastroeni, 2020). By allowing employees to personalize their workstations by changing their configurations to meet their evolving needs for collaboration or privacy, can improve employee efficiency (Pearce & Hinds, 2018). By improving the scale factor by having standardized heights for furniture and by considering anthropometrics when creating service route widths can improve the comfortability and safety of a workspace (Hatch Interior Design, 2021). Tidiness in a construction site can be achieved by providing designated areas to keep rubbish and waste, stacking and storing materials properly, and keeping access routes clear (Darley PCM Ltd, 2018).

2.5. Why spatial factor management is important for construction workers for improved time management at construction sites

The effect of the perception of workspace arrangement of a person on his/her overall behaviour and task achievement has drawn little attention so far (Samani et al., 2017). However, improving time management through spatial factor management is effective because it increases the speed of the workers by improving their workspace satisfaction (Revoy, 2020). Spatial factor management includes managing the layout of the worksite, location of the elements and equipment, and the flow between employee workspaces (Post, 2020). Negative workspaces create work stresses that adversely affect the health and productivity of the workers because absenteeism, demotivation, and distrust significantly increase the costs (Anderson, 2017). As a result of urbanization, populations are increasingly moving from rural areas to urban centres for livelihood purposes (Kummitha et al., 2020). With this population growth in urban areas, many construction projects are happening nowadays (Venditti, 2022) and because construction workers spend most of their time at these sites, the physical attributes of the sites can affect the health, job performance, and efficiency of the workers (Lemma et al., 2022). The productivity of employees who are satisfied with the physical environments of their workplaces is generally high (Kamarulzaman et al., 2011). The topic "construction time management" has attracted the interest of many researchers. Thus, many studies have been conducted to identify the different factors affecting time management in construction sites (Akanni et al., 2015; Bekr, 2017; Dolage & Rathnamali, 2013; Meeampol & Ogunlana, 2006; Pheng & Chuan, 2006). However, studies on the influence of spatial factors on time management in construction sites is rare (Bansal, 2018;

Table 1. *Interviewee details.*

Interviewee code	Details					
	Profession	Designation	Key role	Total experience in years	Type of buildings handled in the projects involved	Key experiences related to the area
I1	Architect	Principal Architect	Designing	21	Residential, Industrial, and commercial buildings	Design and supervision experience in 1 shopping mall, 8 apartment complexes, 5 factories,15 hotels and nearly 40 housing projects
I2	Architect	Principal Architect	Designing	27	Residential, Industrial, and commercial buildings	Design and supervision experience in 3 Hospital buildings, 2 factories,1 school building, 5 apartment complexes, 8 restaurant buildings, 18 hotels and over 50 housing projects
I3	Architect	Project Architect	Designing and site inspection	5	Residential and commercial buildings	Design and supervision experience in a factory, 1 shopping mall, 1 cinema complex, 2 religious' buildings, 2 hotels and nearly 3 housing projects.
I4	Architect	Project Architect	Designing and site inspection	12	Residential, Industrial, and commercial buildings	Design and supervision experience in a public market complex, 2 factories, 22 hotels, 2 public parks, 8 restaurants, 2 bank buildings and over 16 housing projects.
I5	Architect	Junior Architect	Support designing and site inspection	3	Residential and commercial buildings	Design and supervision experience in a school, 2 saloons, 1 apartment complex and 4 housing projects.
I6	Civil Engineer	Project Manager	Planning, executing, and monitoring of the project	11	Residential, Industrial, and commercial buildings	Engaged in 2 factories, 1 shopping mall, 2 cinema complexes, 5 hotels and over 15 housing projects.
I7	Civil Engineer	Project Manager	Planning, executing, and monitoring of the project	5	Residential and commercial buildings	Engaged in a Hospital building, 1 apartment complex, 2 hotels and nearly 3 housing projects
I8	Civil Engineer	Project Manager	Planning, executing, and monitoring of the project	3	Residential buildings	Engaged in 2 apartment complexes and 2 housing projects
I9	Mason	Skilled worker	Concreting	12	Residential and commercial buildings	Engaged in a public market complex, 2 nursery buildings, 10 hotels, 1 public park, 1 library building, 8 restaurants and over 20 housing projects.
I10	Mason	Skilled worker	Plastering	10	Residential, Industrial, and commercial buildings	Engaged in 3 factories, 1 public market complex, 1 children hospital, 2 cinema complexes, 5 hotels and over 15 housing projects.
I11	Painter	Skilled worker	Painting walls	5	Residential and commercial buildings	Engaged in a Hospital building, 1 school building, 4 restaurant buildings, 2 hotels and nearly 8 housing projects
I12	Plumber	Skilled worker	Installing pipes and fixtures	8	Residential and commercial buildings	engaged in 1 factory, 1 Hospital building, 3 apartment complexes, 10 restaurant buildings, 12 hotels and over 15 housing projects
I13	Plumber	Skilled worker	Installing pipes and fixtures	4	Residential and commercial buildings	engaged in 3 religious building complexes, 3 restaurant buildings, 5 hotels and over 12 housing projects
I14	Titanium Worker	Skilled worker	Attending to floor finishes	11	Residential and commercial buildings	engaged in 16 hotels, 10 restaurant buildings and over 30 house projects
I15	Tile worker	Skilled worker	Attending to floor finishes	4	Residential buildings	Engaged in construction of 5 hotels, 1 apartment complex and 20 houses

Marx et al., 2010). Thus, there is a need to identify and introduce the strategies that spatial factors might influence the time constraints of a construction site.

3. Research methodology

Qualitative methods can be used when studying relationships among individuals, and those between individuals and their environments, and the factors that determine the behaviours and actions of people (Gunnell, 2016). Qualitative research is a step-by-step investigation of social phenomena that occur in natural settings (Teherani et al., 2015). Qualitative multi-methods consist of several qualitative data collection techniques and the analysis of the collected data (Saunders et al., 2019). Multiple methods would be helpful if they could provide opportunities for answering research questions and evaluate the research findings (Tashakkori & Teddlie, 2003). Thus, the study adopted the qualitative multi-method because in-depth information about human behaviours, human abilities, and spatial factors had to be collected.

3.1. Semi-structured interviews

Interviews are effective in qualitative studies because they help understand the opinions, behaviours, and experiences of the interviewees (Virginia Tech University Libraries, 2018). Interviews have been long known in qualitative research as a data-collection method (Palmgren & Liljedahl, 2009). Therefore, semi-structured interviews were conducted with professionals and construction workers to identify the connections among the spatial factors in construction sites and the influence of the spatial factors on the time management of construction workers. The details of the interviewees are presented in Table 1.

3.2. Case studies

Case study surveys enable researchers to use several tools to understand the subject concerned comprehensively (Salmon, 2017). In this study, three case studies were conducted to collect the required data. Due to the limited resources and time availability, case studies had to be selected carefully. Therefore, by considering that majority of the projects happen in urban areas and the state of the disorganized spatial arrangement of these congested sites, urban residential building projects were selected considering the limited resources and within the

time available. The cases were selected from within the Colombo area which is highly urbanized and many time-intensive buildings projects were being implemented. The selected case studies were used to validate the data collected from the literature and interviews using interviews and observations. Interviews help obtain unknown and reliable information, and authoritative opinions; make serious and professional assessments of the research topic; and assess possible options (Libakova & Sertakova, 2015). Physical observations enable researchers to learn about the activities of the people under study when they are in their natural settings (DeWalt & DeWalt, 2002). In this study, physical observations were used to observe how spatial factors influence construction workers in the management of their time. Details of the selected case studies are provided in Table 2, while the details of the case study interviewees are provided in Table 3.

3.3 Data analysing techniques used

Because a qualitative approach was used in the study, manual content analysis was used for data analysis. Content analysis is used to identify patterns in recorded communication (Luo, 2021). Readers have to be informed how the results of the analysis were obtained to enable them to understand the analysis and resulting conclusions (Schreier, 2012).

4. Findings and analysis

4.1. Spatial factors influencing the time management of construction workers

Spatial factors that influence the time management of construction workers when they work in sites were identified from the literature. The findings were verified using the semi-structured interviews. The interviewees were requested to identify any additional spatial factors that could contribute to the time management of workers at construction sites. Then the identified spatial factors were confirmed using case study interviews and observations. Table 3 lists the findings.

Most of the interviewees agreed that the spatial factors identified using the

Table 2. *Details of the case studies.*

Description	Case 1	Case 2	Case 3
Type of Building	Residential	Residential	Residential
Area of the Building	2323 m^2	1487 m^2	978 m^2
Area of the exterior space	54 m^2	42 m^2	29 m^2
Total Area	2377 m^2	1529 m^2	1007m^2
Number of Floors	4	3	3
Project duration	3 years	2 years	2 years
Spatial arrangement	The building had an open courtyard in the middle around which the rest of the building was designed.	The building had an open courtyard with a pool and the simple building structure surrounded the pool area.	The building was located in a linear land and built to suit the shape of the land. It had a compact space distribution.
Respondent	Project Architect with seven years of experience in residential, industrial, and commercial building projects.	Project Architect with 10 years of experience in residential, industrial, and commercial building projects.	Project Architect with five years of experience in residential, industrial, and commercial building projects.

Table 3. *Spatial factors influencing the time management of construction workers working at sites.*

Spatial factors that can influence the time management of construction workers at sites								Way the spatial factors influence the time management of construction workers in the sites							
		Case A		Case B		Case C			Case A		Case B		Case C		
Spatial Factor	Interview Results	Interviews	Observations	Interviews	Observations	Interviews	Observations	Interview Results	Interviews	Observations	Interviews	Observations	Interviews	Observations
Legibility	✓	✓	✓	✓	✓	✓	✓	Helps identify spaces, routes, and locations	✓	✓	✓	✓	✓	✓
								Helps identify the shortest routes to increase the productivity of logistics	✓	✓	✓	✓	✓	-
								Decreases the confusions related to space identification within the sites	✓	✓	✓	✓	✓	✓
								Increases the ability of workers to issue and understand instructions	✓	✓	✓	✓	✓	✓
Safety	✓	✓	✓	✓	✓	✓	✓	Reduces accidents within construction sites and lowers absenteeism	✓	-	✓	✓	✓	✓
								Improves the confidence of the workers	✓	✓	✓	✓	✓	✓
								Improves employee trust and commitment	✓	✓	✓	✓	✓	✓
Openness	✓	✓	✓	×	×	✓	×	Improves communication among workers	✓	✓	✓	×	✓	✓
								Makes spaces flexible and adaptable for use	✓	✓	✓	✓	✓	✓
Comfort	✓	✓	✓	✓	✓	✓	✓	Creates a healthy, work-friendly environment for the workers	✓	✓	✓	✓	✓	✓
								Improves worker satisfaction	✓	✓	✓	✓	✓	✓
Permeability	✓	✓	✓	✓	✓	✓	✓	Provides a choice of the routes and increases the ability to create short cuts within the site	✓	✓	✓	✓	✓	✓
								Provides visual permeability and increases the ability to observe work	✓	✓	✓	✓	✓	✓
								Reduces traffic associated with material transportation within the site by providing alternative routes	✓	✓	✓	✓	✓	✓
Robustness	✓	✓	✓	✓	✓	✓	✓	Improves worker efficiency when the spaces have to be changed	✓	✓	✓	✓	✓	✓
								Minimizes the logistics if the adjacent spaces can be used to facilitate ongoing constructions within a certain space	✓	✓	✓	✓	✓	✓
Scale	✓	✓	✓	✓	✓	✓	✓	Creates a sense of connectedness between a worker and the site.	✓	✓	✓	✓	✓	✓
								Makes it comfortable for workers to work	✓	✓	✓	✓	✓	✓
Tidiness	✓	✓	✓	✓	✓	✓	✓	Creates a pleasant work environment	✓	✓	✓	✓	✓	✓
								Minimizes the time spent on finding lost items	✓	✓	✓	✓	✓	✓
								Increases worker ability to focus on work	✓	✓	✓	✓	✓	✓
								Creates a healthy environment, thereby lowering absenteeism.	✓	✓	✓	✓	✓	✓
Imageability	✓	✓	✓	✓	✓	✓	✓	Helps identify spaces and routes within the site without any confusion	✓	✓	✓	✓	✓	✓
Personalization	✓	✓	✓	✓	✓	✓	×	Improves worker commitment by providing the workers with a sense of ownership	✓	✓	✓	✓	✓	-
								Creates a comfortable workspace satisfying worker preferences	✓	✓	✓	✓	✓	-
Vitality	✓	×	✓	✓	✓	×	✓	Creates an interesting and encouraging work environment within the site	×	✓	✓	×	×	✓
Unity	✓	✓	✓	✓	✓	✓	✓	Creates an interesting and sequential space to work	✓	✓	✓	✓	✓	✓
								Increases visual comfortability and makes working easy	✓	✓	✓	✓	✓	✓

Table 4. *Spatial factor management strategies and how the strategies can improve the time management of construction workers.*

Spatial Factor	Management Strategy	How the strategy can improve the time management of workers at construction sites	Case A		Case B		Case C	
			Interviews	Observations	Interviews	Observations	Interviews	Observations
Legibility	Setting landmarks within the site	Enables easy identification of locations, destinations, and routes based on the landmarks within the site	✓	✓	✓	✓	✓	✓
	Setting landmarks around the site	Enables easy identification of locations, destinations, and routes by considering the landmarks that are located at a visual distance around the site	✓	✓	✓	✓	✓	✓
	Creating a network of major and minor routes	Improves travelling within the site	✓	✓	✓	✓	✓	✓
	Creating common identifiable districts (medium to large sections) with clear borders	Enables the workers to identify their locations, destinations, and routes easily	✓	-	✓	-	✓	-
	Creating attractive nodes (centers of attraction) within the site to serve as landmarks	Helps workers to identify their locations, destinations, and routes and creates a lively and encouraging work environment within the site	✓	✓	✓	✓	✓	✓
Safety	Installing fall protections, fences, and nets	Decreases the time wasted by reducing the accidents and improves worker confidence	✓	✓	✓	✓	✓	✓
	Installing sign boards and marking the site properly to protect workers from hazards by drawing their attention to potential hazards and how to avoid them	Reduces accidents which lead to project delays	✓	-	✓	-	✓	✓
	Keeping the construction site clean	Reduces unexpected injuries from accidents caused by clutter and improves work efficiency	✓	✓	✓	✓	✓	✓
Openness	Improving the view and illumination of the site, and enabling a feeling of being in the open	Makes the work environment interesting and motivational to improve worker efficiency	✓	✓	✓	✗	✓	✗
		Increases the opportunities available to collaborate and communicate with co-workers	✓	✓	✓	✓	✓	✓
	Improving surface textures	Improves the feeling of spaciousness and makes the work environment relaxing	✓	✓	✓	✓	✓	-
	Improving the space sequence	Facilitates ease of movement within the site	✓	✓	✓	✓	✓	✓
Comfort	Providing a superior acoustic environment	Increase the ability of the workers to focus on work and thereby increase their efficiency	✓	✓	✓	✓	✓	✓
	Maintaining optimal thermal comfort	Increases the ability of the workers to focus on the work	✓	✓	✓	✓	✓	✓
		Creates an attractive and interesting work environment to increase the efficiency of the workers	✓	✓	✓	✓	✓	✓
		Contributes to worker health workers to reduce absenteeism	✓	-	✓	-	✓	-
	Creating a quality visual environment	Creates an attractive and interesting work environment to increase the efficiency of the workers	✓	✓	✓	✓	✓	✓
	Providing furniture and equipment that will enhance worker comfort	Increases the ability of the workers to focus on the work, thereby increasing their performance	✓	✓	✓	✓	✓	✓
Permeability	Creating a well-connected layout which offers a choice of direct routes	Improves travelling within the site	✓	✓	✓	✓	✓	✓
		Enables the workers to feel safe and secure to make them work with confidence.						
		Supports easy communication among co-workers.	✓	✓	✓	✓	✓	✓
Robustness	Creating spaces that can be used for different activities, probably at different times of the day	Creates the work space flexible and interesting to enable workers to work efficiently and effectively.	✓	✓	✓	✓	✓	✓
	Having adjacent spaces for ongoing constructions within a certain space	Reduces unnecessary travelling, eases the logistics to decrease the time lost unnecessarily	✓	✓	✓	✓	✓	✓
Scale	Using standardized heights and ergonomic measures to design worksite furniture.	Increase the ability of the workers to focus on work, thereby increasing their performance	✓	✓	✓	✓	✓	✓
		Supports healthy postures, which help to reduce injuries and reduces absenteeism.	✓	✓	✓	✓	✓	✓
	Establishing service route widths based on anthropometrics	Makes the travelling of workers effective	✓	✓	✓	✓	✓	✓
Tidiness	Providing a designated area to keep rubbish and waste	Prevent bad smells and creates a pleasant work environment to increase worker efficiency	✓	✓	✓	✓	✓	✓
	Stacking and storing materials properly	Reduces the time spent on searching for lost items	✓	✓	✓	✓	✓	✓
	Keeping access routes clear	Eases worker travelling and material logistics	✓	✓	✓	✓	✓	✓
Imageability	Improving the identity of the site to distinguish it from other objects	Leads workers to identify their locations, destinations, and routes easily	✓	✓	✓	✓	✓	✓
	Improving the structure of the site (relationships with the large patterns of other elements)	Increases the ability of the workers to focus on work, improves the visual comfortability of the workers and increases the ability of the workers to memorize things, thereby improving the performance of the workers	✓	✓	✓	✓	✓	✓
	Improving the meaning (practical and emotional value the site offers to the observer) of the site	Creates a motivational work environment	✓	-	✗	-	✓	-
Personalization	Allowing employees to rearrange their workstations or furniture as they wish, to meet their evolving needs for collaboration or privacy	Creates a flexible and motivational work environment	✓	✓	✓	✓	✓	-
Vitality	Improving accessibility within the site	Increases the ease of travelling within the site	✓	✓	✓	✓	✓	✓
	Improving sustainability in the site	Creates an attractive and interesting work environment to increase worker efficiency	✓	✓	✓	-	✗	-
	Improving environmental quality	Improves worker health to reduce absenteeism	✓	✓	✓	✓	✓	✓
	Creating vibrant and diverse spaces and facilities	Creates a lively and encouraging work environment within the site	✗	✓	✓	✗	✗	✓
Unity	Creating a sense of cohesion in the space by repeating selected elements throughout the entire space, such as colors, shapes or materials	Makes the space visually pleasant and interesting to work	✓	✓	✓	✓	✓	✓

literature review influence the time management of workers in construction sites. According to the Case A interviewee, all factors except vitality influence time management of construction workers at sites because vitality can lead construction workers to get distracted while working. However, the observations made in Case A indicate that all the spatial factors identified from the literature, including vitality, contribute to the time management of construction workers. The interviewee of Case B did not agree with openness by stating that at times it can distract construction workers from their designated work, which the observations of Case B confirmed. Interviewee from Case C did not agree with the factor vitality by saying that when vitality is increased, unwanted behaviours and unnecessary chaos could be created within the site, negatively affecting worker efficiency. According to the observations made in Case 3, vitality contributes to the time management of workers at a site. Observations made in Case C indicate that openness and personalization do not contribute to the time management of workers.

4.2. Spatial factor management strategies and how they can improve the time management of construction worker

Strategies that can be adopted to manage the identified spatial factors were first identified from the literature. Then, several other spatial factor management strategies that can influence the time management of workers at construction sites were identified during the semi-structured interviews. The way those strategies can contribute to improve the time management of construction workers was identified from the semi-structured interviews and case studies. Table 4 illustrates the findings.

At the interviews, most of the spatial factor management strategies that were identified from the literature were confirmed and new strategies were identified. The interviewees explained how each strategy influenced the time management of workers at construction sites. Case A interviewee agreed with all the management strategies ex-

cept the creation of vibrant and diverse spaces and facilities and argued that diverse spaces could create chaos and distractions within the site. The observations made related to Case A were not sufficient to confirm the management strategies that improve the special factors legibility, safety, comfort, and imageability. All other management strategies and their contributions were confirmed by Case A observations.

The Case B interviewee did not agree with the management strategy dealing with imageability that improves the meaning of the site by stating that the construction workers are at the sites only for short periods, and that, therefore, they would not want to maintain any ownership or emotional connection with the sites, making the strategy impractical. The observations made in Case B also were not sufficient to prove the strategy. They were not sufficient to prove even the other strategies related to legibility, safety, comfort, and vitality. The strategy of creating vibrant and diverse spaces and facilities to create a lively and encouraging work environment to increase vitality was found to be impractical in Case B. Although at the Case B site, these spaces and facilities have been provided, because of lack of supervision, they were used by the workers to gather and talk unnecessarily, which had a negative influence on their efficiency.

The interviewee of Case C disagreed with the two management strategies that could be used to improve vitality. With regard to the strategy dealing with sustainability, the interviewee was of the view that introducing sustainability to the site would be profitable and interesting to the owner. However, he said that because the workers would be at the site for only short periods, they would become satisfied only after they get the facilities they require and they would not be interested in the way the facilities are operated. The interviewee stated that vibrant and diverse spaces and facilities could create chaos and distractions within sites. The observations made were also not sufficient to prove the management strategies dealing with legibility, openness, comfort, imageability, personalization, and vitality.

4.3. Discussion

4.3.1. Spatial factors that can influence time management of construction workers at sites

Twelve spatial factors that influence the time management of people were identified from the literature. Then all those factors were investigated through interviews and case studies to identify their influence on workers. Urban residential projects were selected here by considering time and resource availability of study and due to the increasing number of urban projects which are time intensive and facing disputes due to their disorganized spatial arrangement. All the interviewees agreed and the case study findings proved that legibility and safety improve time management in a work environment. At the interviews, only one interviewee disagreed with openness. One case study interviewee and two case study observations did not verify that openness influences the time management of construction workers at sites. Although one interviewee disagreed with the strategy dealing with comfort, all the case study interviewees and observations confirmed that comfort influences the time management of construction workers at sites.

Two of the interviews of semi-structured interviews did not agree with the spatial factors, permeability and robustness. Both case study interviews and observations verified that permeability and robustness influence the time management of construction workers at site. Two interviewees disagreed with scale and another two interviewees disagreed with tidiness. However, all case study interviewees and observations proved that the spatial factors scale and tidiness influence the time management of construction workers. Similarly, while three interviewees disagreed with imageability, all of the other case study interviewees and observations proved that imageability influences the time management of construction workers at sites. At the

interviews, four interviewees disagreed with personalization, whereas all case study interviewees and two case study observations proved that personalization influences the time management of construction workers.

Four of the interviewees disagreed with the spatial factor vitality. Even though all of the case study observations confirmed that vitality influences the time management of construction workers, two case study interviewees disagreed with those observations. Five interviewees disagreed that unity influence construction workers at sites. All the case study interviews and two case study observations proved that unity influences the time management of construction workers.

4.3.2. How spatial factors influence the time management of construction workers at sites

Stamps (2004) described that legibility influences the time management of construction workers by helping the workers to find their way easily by identifying their locations and minimizing the time spent on finding the way back. None of the interviewees supported the third finding of the semi-structured interviewees. I7 added that within a legible space, head workers will find it easy to give instructions and that workers will find it easy to understand the instructions given by their superiors. The interviewees mentioned that legibility influences the time management at construction sites by letting the workers to identify short routes. Safety improves the openness, flexibility, and interdependence of a person and improves his/her performance (Delves, 2020). Safety improves the time management ability of workers by improving their self-confidence, trust, and commitment and by encouraging their involvement (Clarke, 2020). However, none of the interviewees agreed with Delves (2020), while few agreed with Clark (2020). Most of the interviewees believed that safety reduces absenteeism and the accidents within construction sites and that therefore it has an impact on the time management of construction workers. All of the case study interviews and observations proved the findings.

Openness can influence the time management of workers by improving their satisfaction and collaborative spirit (Bernstein & Turban, 2018). I7 added that openness makes spaces flexible and adaptable for use. The interviewees of all three case studies agreed with this feature of openness. However, Case B observations did not reveal how communication among workers could be improved. Comfort improves worker health, thereby reducing worker absenteeism and improving worker productivity (Ali et al., 2015) and according to the semi- structured interview findings it increases worker satisfaction and improves worker efficiency; the case study interviews and observations confirmed these influences of comfort.

Permeability helps manage time efficiently and improves worker efficiency by encouraging "through movements" (Stoner, 2016). Permeability supports time management by providing the ability to control the flow of people witbhin a site, which was endorsed by a majority of the interviewees because permeability provides a choice of routes for moving through and increases the short cuts within the site (Alagamy, 2019). I6 added that visual permeability increases the ability of a worker to observe his/her work. I10 added that permeability reduces the traffic associated with material transportation within the site by providing alternative routes. Robustness improves time management by enabling adaptability, which increases worker efficiency (Nickl, 2020). Some of the interviewees were of the view that it would be convenient for the workers if adjacent spaces could be used to facilitate ongoing constructions within a given space because then the logistics would be minimized. Case study interviews and observations confirmed these interview findings.

A building scale and spaces have to be proportional to human scale for people to feel secure within the building (Gehl, 2010). Worker productivity increases along with the feeling of safety (Harter, 2020) although none of the interviewee agreed with this fact. However, a majority of the interviewees stated that scale creates a sense of connectedness between the workers and the

site. I1 believed that the optimum level of scale would makes the space comfortable for the workers enabling them to manage project time effectively. All the case study interviews and observations confirmed the above-mentioned facts about building scale and spaces. Tidiness influences time management by reducing the stress and anxiety of the workers, improving workers' ability to process information, minimizing the time wasted in searching for lost items, and improving the mental health of the workers, which would help them to focus on their work (Sander, 2019). The interviewees, however, did not agree that tidiness improves workers' ability to process information and minimize the time wasted in searching for lost items. A majority of the interviewees stated that tidiness creates a pleasant work environment which drives workers to work efficiently. I3 and I4 who were professionals explained that tidiness creates a healthy environment and that, therefore, it reduces absenteeism. I6 who was also a professional believed that tidiness minimizes the time spent on searching for lost items. The case study interviews and observations confirmed these semi-structured interview findings.

Imageability influences the time management of construction workers by improving the capacity of the workers to make a strong visual image of their work, and by increasing their ability to see and remember patterns within a space (Mohankumar, 2014). A majority of the interviewees were of the view that imageability influences the time management of construction workers because it provides them with the ability to create a mental image of the site, which will help them to identify the spaces and routes within the site easily. The case study interviews and observations also confirmed this view expressed by most of the interviewees. Personalization makes the interactions within the daily workflow and activities easy (Lehman, 2021). However, this fact was not confirmed by the interviewees. A majority of the interviewees added that personalization improves the time management of workers of construction sites by giving them a sense of ownership of the sites, which increases their commitment to work. I5 and I6 argued that personalization creates a comfortable workspace that would suit the individual preferences of the worker concerned. All the case study interviews and observations confirmed the interview findings.

Vitality makes a space vibrant and alive and has the potential to increase worker collaboration, engagement, well-being, and productivity (Mars Drinks, 2015). however, the interviewees did not agree with this fact. A majority of the interviewees agreed that vitality influences the time management of construction workers in a site because it creates an interesting and encouraging work environment within the site. This fact could not be confirmed through the case studies because only one case study interviewee and two case study observations confirmed it. Unity contributes to improve worker productivity by providing a sense of calmness, limiting chaos at the workplace, and increasing the comfort level of the work environment (Hatch Interior Design, 2021). Most of the interviewees stated that unity influences the time management of construction workers because it can create an interesting and sequential space to work. I1 and I3 argued that unity influences the time management of construction workers by increasing the visual comfortability of the workers, which makes it easy for them to work. The case study interviews and observations confirmed these interview findings.

4.3.3. Strategies that can be used to manage spatial factors and the way they influence the time management of construction workers in sites

There are management strategies, such as creating landmarks within and around the site, for the spatial factor legibility (Harten, 2018). Also creating a network of paths, identifiable districts with clear borders, and attractive nodes within the site could be used as strategies to manage legibility (Lynch, 1960). The interview findings revealed how these management strategies influence the time management of construction workers in sites. The case study findings confirmed the interview findings. strategy of installing proper

fall protections, fences, and nets ensures worker safety at sites (Roux, 2014). Another strategy that can be used to ensure worker safety at sites is to display signboards to protect workers from hazards (American Society of Safety Professionals, 2019). The semi-structured interviews revealed how these strategies influence the time management of construction workers. I8 stated that keeping the construction site clean could be used as a strategy to improve the time management of construction workers because it would reduce unexpected injuries from accidents due to clutter and improve worker efficiency. The case study findings confirmed all these interview findings.

Strategies that can be used to manage openness are improving the view, light, feeling of being in the open, surface textures, and sequence of spaces (Donnell Day Architects, 2021). Similarly, comfort can be managed by providing a superior acoustic environment, maintaining optimal thermal comfort, creating a high-quality visual environment, and providing furniture and equipment that enhance comfort. The interviewees explained how these strategies influence the time management of construction workers in sites. All the strategies that were identified at the interviews to manage comfort were confirmed by case study interviewees and observations. However, the first strategy of managing openness by improving the view, light, and the feeling of being open was not confirmed by Case B observations.

Permeability within the site can be managed by creating a well-connected layout which could offer a choice of direct routes (Essex Planning Officers Association, 2019). To manage robustness, the strategy of creating spaces that can adapt to different uses and activities, perhaps at different times of the day, can be used (Carmona, 2018). I2 proposed to arrange adjacent spaces to facilitate ongoing constructions within a certain space as a strategy to increase robustness. Scale can be managed by strategies such as the use of standardized heights and ergonomic measures in the design of site furniture and setting service route widths based on anthropometrics (Hatch Interior Design, 2021). To manage tidiness, strategies such as providing designated areas for rubbish and waste, stacking and storing materials properly, and keeping clear access routes can be used. Imageability can be managed by improving the identity of the site to distinct it from other objects, improving the structure of the site (its relationship to the pattern of other large elements), and improving the meaning of the site (practical and emotional value that the site holds for an observer) (Damayaniti & Kossak, 2015). A strategy that can be used to manage personalization is to allow workers to rearrange their workstations or furniture to suit their evolving needs for collaboration and privacy (Pearce & Hinds, 2018). The interviewees disclosed how the use of this strategy could influence the time management of construction workers in the sites. The interviewees explained how these strategies influence the time management of construction workers. The case study findings confirmed the interview findings.

Management strategies such as increasing accessibility, sustainability, and environmental quality to manage vitality (Drewes & van Aswegen, 2010). Another management strategy that has been mentioned in the literature is to create vibrant and diverse spaces and facilities (March et al., 2012). Data on how these strategies could contribute to the time management of construction workers were collected through the interviews. Case C interviewee did not agree with the strategy of increasing sustainability. Case A and C interviewees did not confirm the strategy of creating vibrant and diverse spaces and facilities, and it was not confirmed by Case B observations also. A strategy that can be used to manage unity is to create a sense of cohesion in the space by repeating certain elements, such as colours, shapes, or materials, throughout the entire space (Mastroeni, 2020). The interviewees explained how this strategy influences time management of construction workers and case study results confirmed the interview findings.

5. Conclusions and recommendations

This study reveals the influence of spatial factors on the time management of construction workers and the methods that can be used to manage spatial factors and achieve satisfactory time management at urban residential construction sites. From the literature, 12 spatial factors that influence the time management of construction workers were identified: legibility, permeability, imageability, robustness, safety, vitality, openness, comfort, unity, personalization, scale, and tidiness. The interview and case study findings indicated that all 12 spatial factors contribute to the time management of construction workers in sites.

The impact of the spatial factors on construction projects were identified from the literature review, interviews, and case studies. How the identified spatial factors influence the time management of workers in urban residential construction sites was determined through semi-structured interviews, and case study interviews and observations. Improving communication among workers to enable openness and creating an interesting and encouraging work environment within the site to enable vitality could not be fully confirmed through the case studies because some case study interviewees and observations did not confirm them. The study findings revealed the impact of spatial factors on the time management of workers in construction sites and ways that the factors influence construction projects.

Strategies that can be used to manage the identified spatial factors were first identified from the literature and the strategies that can be used to manage the spatial factors that influence the time management of construction workers in sites were identified during the semi-structured interviews. How all those strategies contribute to improve the time management of construction workers was identified through semi-structured interviews and case studies. The case study observations were not sufficient to confirm some of the interview findings. Some strategies that will help manage openness, imageability, and vitality could not be fully confirmed through the case studies because some of the case study interviewees and observations did not confirm those strategies and the way they contribute to the time management of construction workers in sites.

The study findings can be used to achieve proper time management in construction projects and reduce construction delays. Using the knowledge gained on the spatial factors contributing to time management of workers in construction sites, and their impact on the projects, a framework can be developed to determine the floor plan of a construction site to improve worker behaviour and efficiency. Knowledge gained through the study about the way spatial factors influence the time management of construction workers would contribute to fill the knowledge gap in theory. Because this study was conducted using a qualitative approach, only a small number of interviewees and three case studies were used. Thus, the study findings cannot be generalized and would be limited to the study context. However, the study findings can be used as a benchmark for future studies.

If the following recommendations could be implemented, they would ensure the effective implementation of spatial factor management strategies to reduce delays in construction projects.

- Making it mandatory to Prepare Construction Site Layout Plan by considering spatial factor management strategies: Preparing proper construction site layout with involvement of professionals who are knowledgeable on spatial factors, human psychology and human behaviour can improve the chances of creating a construction site with optimum efficiency level.
- Conducting time-to-time inspections within the site to check whether spatial factor management strategies are implemented properly throughout the process: Since Construction sites are volatile, spatial arrangement may change over time by not considering initially prepared work site layout. Therefore, time-to-time inspections are nec-

essary to keep everything in place throughout the process.
- Including necessary clauses to tender documents about spatial factor management and making it compulsory for project managers to follow those guidelines: This improves contractors' awareness about spatial factor management and makes it compulsory for contractors to implement spatial factor management strategies within site.
- Organizational level awareness programs: This is the most practical way of engaging and giving awareness about implementation of spatial factor management strategies and its consequences in construction projects to people in all the levels.
- Conducting research and development: In-depth investigations are required to gather further knowledge on the implementation of spatial factor management strategies to reduce delays in construction projects and achieve satisfactory outcomes.

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