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Evaluating Industry Perception of Biophilic Design in Enhancing Construction Job site Trailers' Physical Work Environment

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The stressors for the construction site managers include tight project deadlines, complex coordination, and workforce management, which impact their mental and physical well-being, resulting in loss of productivity. The productivity and well-being of the employees are greatly impacted by the physical conditions of the work environment. These include the layout of the workspace, lighting, temperature, noise, and ergonomics. Considering these factors, this research was initiated to measure the satisfaction level of on-site personnel with the design of their job site trailers in terms of physical and psychological comfort. It also focused on studying the benefits associated with incorporating biophilia in the design of job site trailers. Biophilic design helps to improve well-being and productivity by connecting occupants of a built space with the natural environment, like natural views, materials, water elements, sounds, indoor plantations, and even forms that mimic nature. A mixed-methods approach was used for data collection. The target population included construction project managers and site superintendents who had spent considerable time working in jobsite trailers. The qualitative data analysis highlighted the need for provision of efficient work spaces, natural light, nature views and noise control in trailers. Quantitative data collection showed that 73% of the respondents favored the idea of incorporating biophilic design in trailers.

Keywords: Biophilia, physical work environment, job site trailers, construction work stress

Introduction

The job stresses in construction industry including long working hours, exposure to harsh weather, high noise levels, dust, continuous visual stress along with managing risky tasks not only impart physical fatigue but also become a reason for mental stress. (Leung et al., 2008). These stresses lead to an immense loss in job productivity and work focus (Hsie et al., 2009). In any industry, the quality of the work environment is critical for the employees to manage the work stress, especially for the construction project managers who generally work both in office buildings and at the construction sites. (Love et al. 2010). Haynes & Love, 2004 state that the stress faced by construction site

managers are considerably higher than that of managers working in any other industry. A lot of research is available on improving the physical work conditions in workspaces but somehow a little or no literature is available for improving the physical work environment of construction site office trailers although the employees work for long hours in these trailers (Hui, 2004). In the latter half of the twentieth century, the impact of the man-made environment on human health became an attention-grabbing subject for the architects and planners which got accelerated in the twenty-first century with the introduction of practicing Biophilia in built environment (Kellert et al., 2018) The social psychologist Eric Fromm coined the term Biophilia for the first time in the 1960s, explaining it as a combination two Greek words; bio meaning *life* and philia meaning *attraction towards* (Abbas et al., 2022). Incorporating nature elements like natural light, nature forms and even imitating the natural features in built environment is one of the effective solutions to improve work focus and lower stress levels. (Gillis & Gatersleben, 2015).

Considering these conditions of the work environment, this research aims to measure the satisfaction level of the site managers with their existing job trailers in terms of physical design and comfort and gather feedback about the significance of incorporating biophilia in working environments of job site trailers for improving work productivity and well-being. Since this is an opinion-based study and due to time constraints, it focuses on only the randomly selected mid-sized construction companies in the Southeastern United States for data collection. The data was collected from construction industry professionals who had experience of working in job site trailers and were aged 25 or above. That means that the construction personnels who do not have experience of working in the trailers were excluded from the sample size.

Literature Review

Work Stress, Work Environment and Biophilia

Job-related stress has been identified as one of the most serious workplace health hazards for the employees in the United States and many other industrialized countries. (Spector, P. E. 2002). Low productivity, high absenteeism, and reduced job performance are all highly correlated with workplace stress. (McShane and Von Glinow., 2005). The construction industry involves great levels of job diversity and interdependency which with multitasking renders work tasks to be complex. (Leung et al., 2008). A study conducted with architects, contractors and civil engineers showed that the stress factors among these professionals were overwork, lack of thermal comfort, privacy and reasonable space, imbalances in the scope of work and lack of safety measures on the site. (Offia et al. 2011). The job site trailers are used as an office space at the construction site because of their compact sizes, ease of use and flexibility of shifting from one site to another. The job site offices are temporary and transient in nature where construction managers and employees work repeatedly during their careers.

Over the past years, several tools have been established to improve the dynamics between buildings, occupants, and the environment like Leadership in Energy and Environmental Design (LEED) by U.S. Green Building Council, Building Research Establishment Environmental Assessment Method (BREEAM) by Building Research Establishment, , WELL Building Standard (WELL) administered by the International WELL Building Institute (IWBI) , Fitwell from the Center for Active Design, and the Living Building Challenge by the International Living Future Institute (Ildiri et al., 2022). Among these, WELL is one of the most comprehensive and fastest growing standards that focuses primarily on the health and well-being of building occupants. (McArthur & Powell, 2020). Biophilic design elements are one of the multiple WELL features which aim to promote mental and emotional well-

being through design interventions in the built environments. (Investing in Health Pays Back | IWBI, n.d.).

In the latter half of the twentieth century, the impact of the man-made environment on human health became a significant attention-grabbing subject for the architects and researchers which got accelerated in the twenty-first century with the introduction of practicing Biophilia in work environment. (Kellert, 2012). The Biophilia hypothesis supports the fact that that people have an innate bond with nature and connection and access to nature is essential for human well-being. (Kellert & Calabrese, 2015). Biophilic features experienced by human senses can either be directly or indirectly experienced in built spaces. Direct experiences include direct connection with light, air, water, plants, and animals. Indirect experience includes using images of nature, natural materials, colors, simulating natural light and air, naturalistic shapes and forms, natural geometries, biomimicry (Gullikson, C. 2010).

Research suggests that people would experience high levels of stress in confined settings like hospitals, prisons, and offices where the inhabitants stay and work for a long duration. (Nadkarni et al., 2017). The appropriate application of ergonomics in the working spaces can provide safety, improve physical and mental well-being of employees, and add value to job focus and satisfaction. (Vischer, 2007). Bringing nature in contact with restrained environments can be fruitful in stress reduction and improving work productivity. (Atmaja & Puspitawati, 2018). So far, very little literature is available which directs attention towards the improvement of physical environment in the job site trailers in terms of design and comfort. For exploration of this fact, this research was initiated to gather opinions from construction practitioners working in job site trailers and ways to improve the trailer design with physical and psychological comfort in mind.

Research Methodology

The preliminary data was collected through extensive literature research. The role of an effective physical working environment in built spaces by incorporating natural elements in design was explored with a focus on improving employee's work focus and productivity. The target group for the research study was the managerial staff and supervisors working at the job sites and affiliated with the mid-sized construction firms within the Southeastern US. The figure below shows the breakdown of steps involved in both qualitative and quantitative data collection.

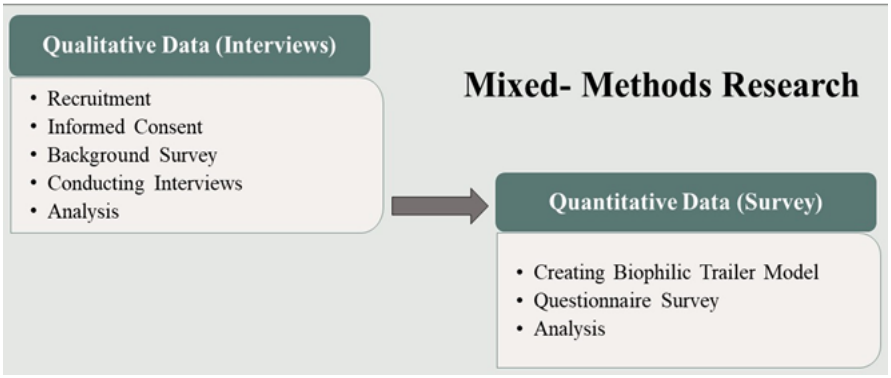


Figure 1. Steps of the Study

Qualitative Data Collection

Being an opinion-based study and due to time constraints for conducting research, 20 mid-sized construction companies were shortlisted from the Southeastern US to participate. The target population for this study was construction project managers and superintendents having experience working in job site trailers and aged 25 or above. Of this larger grouping, five participants were randomly selected for interviews. Interviews were conducted via an online meeting platform lasting 20 minutes. The questions related to the physical design of the working environment in the job site trailers were asked followed by opinions and suggestions for improvements. The interviewees were asked about challenges of working in an office (building) versus working in a job site trailer in terms of physical design of work environment. They were asked about their comfort level at their workplace regarding size, spatial layout, natural light, and interior finishes. Also, the research collected their feedback about the addition of natural elements like indoor plants, nature images, water sounds, materials to their working spaces for improving work focus and productivity. The responses from interviewees were recorded and analyzed using thematic coding to capture, analyze, and summarize the results.

Quantitative Data Collection

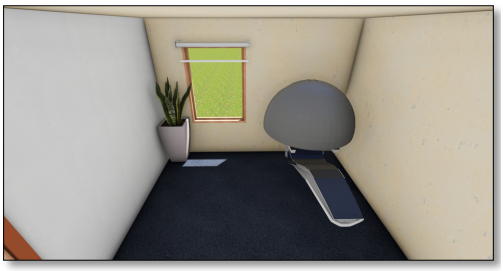
After analysis of the interviews, a one-minute walkthrough video of the job site trailer was developed with a preference for incorporating nature elements using the software Revit and Lumion and uploaded on YouTube. The web link of the walkthrough was embedded in the web-based questionnaire survey. A separate group from the interviewees mentioned in the qualitative data collection phase was engaged to watch the walkthrough video and answer the questions afterwards. The questionnaire was randomly distributed to construction industry professionals (construction project managers and superintendents) within the Southeastern US. They were asked about their physical and psychological comfort levels with the proposed trailer that included biophilic design features. A total of 70 responses were received. Thirty-eight responses were deemed complete and analyzed for this paper (n=38).

The standard size of 12’x60’ was considered for the design of the trailer. The proposed model consisted of two offices which are separated by a wooden partition. A conference room with printers, screens, and whiteboards was provided. A kitchenette was also proposed. A nap room was also provided for the staff to take a rest during their break hours. This nap area was also considered for doing light workouts and stretching. Each space had its own window to receive ample daylight and outside views inside the trailer. Soundproof wall solutions like a cotton bat, fiberglass insulation, or other soundproof insulation were proposed. Upholstered furniture, curtains, carpets, and plants were used to control the noise. The respondents also suggested adding colors to the interior which would help in breaking the monotony and boredom of the space. The interviewees also stated that they do not have sufficient storage space in their offices. They also stated that they felt very *suffocated* in the confined offices. For that consideration, smart office furniture was proposed with additional storage space. The partitions act as a soft physical barrier between offices with the added benefit of storing office supplies. Adding plants to the partitions also provided visual privacy. Each office had its own whiteboard to note important reminders. The images below show different spaces in the trailer.

A. Layout

B. Conference Area

C. Workstation



D. Nap Area

Figure 2. Proposed Trailer Design

Results and Discussion

Qualitative Analysis

The interviews were analyzed using manual thematic coding. Themes were developed, carefully described, and color-coded by identifying recurring ideas, concepts, and patterns of meaning that captured the essence of the data. Some of the identified themes were healthy workplace and productivity, nature connection and stress management, workplace requirements, and improvements. The respondents suggested that working in an office building is better because of the comfortable furniture and quality workmanship. Natural light was mentioned to be an important consideration while designing the trailers. They also mentioned that adding plants to trailers would make it feel more comfortable. Providing a break room and ensuring the privacy of the workstation was suggested. They said that paying attention to interior finishes and colors could improve the quality of the workspace. They also suggested having sufficient storage spaces for office supplies and documents. They were proponents of the fact that a connection with nature relieves stress and burnout. High noise levels inside the site offices were highlighted to be a major distraction during work.

Quantitative Analysis

A web-based questionnaire with an embedded link for the walkthrough was developed using Qualtrics. The questions were designed to get feedback from the respondents about the proposed design of the trailer and suggest improvements. After distributing the survey, the responses were collected over a period of two weeks. Thirty-eight complete responses were received (n=38),

compiled. These final responses were then included in the quantitative data analysis. The central limit theorem was taken as a reference for validating the number of responses received from the survey. Generally, sample sizes of around 30-50 are deemed sufficient for the Central Limit Theorem to hold, meaning that the distribution of the sample means is normally distributed. (Chang et al., 2006). The flowchart of the response collection is illustrated in Figure 3.

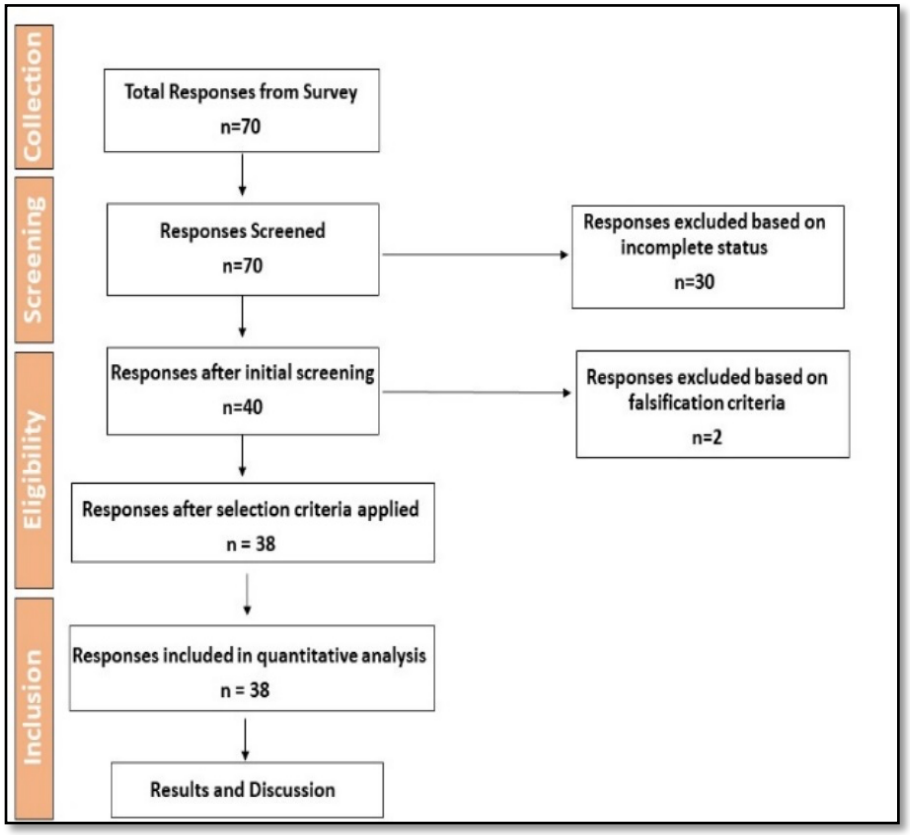


Figure 3. Questionnaire Response Collection

The results from the quantitative analysis show that 5% of the respondents were owners, 50% were project managers, 13% were general contractors, 13% were superintendents and the remaining 18% were estimators, owner's representatives, and suppliers.

When asked about the physical comfort of the proposed trailer, almost 78% of the respondents were satisfied with the design, 15% of the respondents were not satisfied and 5% had a neutral response. Almost 80% of the respondents felt psychologically comfortable being in the environment as proposed, 8% showed a neutral response, and 11% felt somewhat uncomfortable.

When asked about the size and spatial layout of the proposed trailer design, 80% of the respondents were satisfied and 15% were somewhat dissatisfied with the proposed layout. It is obvious from the results that only 7% of the respondents were not satisfied with the provision of natural light inside the trailers, 8% were neutral about giving an opinion, 23%were somewhat satisfied and 62% were extremely satisfied. The results indicated that 46% of the respondents were extremely satisfied with

the interior finishes including color scheme, materials and furniture provided in the trailer, 46% were somewhat satisfied and only 8% were somewhat dissatisfied.

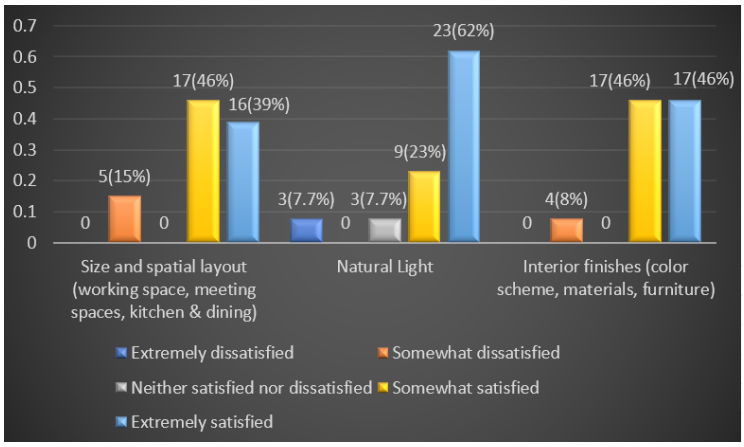


Figure 4. Size & Spatial Layout, Natural Light, Interior Finishes

62% of respondents favored the idea of incorporating biophilic design in trailers design, 13% had a neutral response and only 3% disagreed with the proposal.

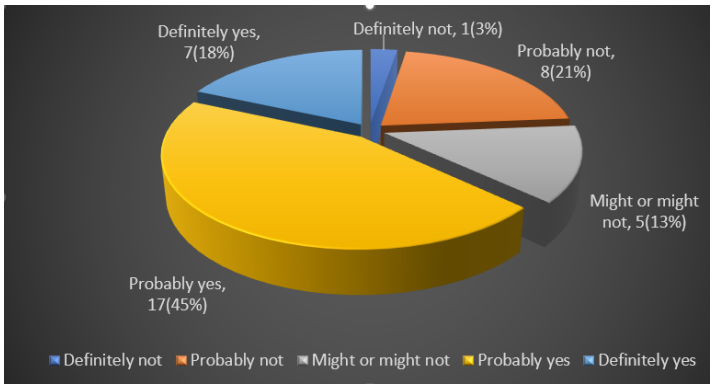


Figure 5. Biophilic Design for Job site Trailers

Generally, the respondents commented that the proposed design was efficient, and it would be a *step-up* from the norm. However, they did suggest that soundproof private meeting spaces, and strategies for dust and dirt control should be ensured inside the trailers.

Conclusion

It is important to educate employers about the importance of a healthy physical and psychological work environment and its impact on employees' work performance and wellbeing. Adding natural features to the interior spaces like natural light, indoor plants, natural materials etc. improves work

efficiency with added benefits of visually pleasant appeal to the interior spaces and energy saving. Aloe vera, snake plant, English ivy, lady palm, rubber plant, are to list a few of the best air purifying plants which can be kept indoors. A soundproof nap area with some natural elements like plants and natural finishes in the trailers could be helpful where the employees can take a rest in break hours and can do some stretches or meditate.

It would be fair enough to say that the respondents of the interviews were proponents of the fact that work focus and productivity are enhanced when the working environment is comfortable and functional. As indicated by the respondents, job sites are stressful due to day-to-day site challenges and job demands. The job site trailers do not have the comfort that a typical office space has. They stated that there is a need for improvement in the trailers as they do not feel comfortable as office buildings are designed with special consideration for the comfort and functionality of spaces. The job site trailers have issues due to limited spaces available at the sites. They mentioned that these concerns are generally overlooked when it comes to trailer design although a job site trailer is an office space and like any other office it must be designed considering both functional and aesthetic aspects of the space. They supported the concept of a biophilic environment and suggested that bringing natural elements into their workspaces would create a homier environment which could help to manage work stress and improve their work efficiency. It was obvious from the responses of the interviewees that natural light was lacking in their workspaces. Another important issue that was repeatedly highlighted was the noise inside the trailers. As indicated by the respondents, there is not sufficient space for storage in the trailer offices. They also stated that there is hardly any strategy that is being implemented by the employers to ensure health and well-being at the job sites, especially in the job site trailers. They were also concerned about the banal and monotonous interior finishes inside the trailer and suggested that improvement is needed in terms of interior finishes and furnishing.

Limitations

Due to time constraints, the study was conducted with construction industry professionals working in the Southeastern USA (n=38). The results cannot be generalized to the entire population of the construction industry in the United States. The standard dimensions of 12’x60’ were considered for designing the trailer but the design has the flexibility of making modifications as per requirements of the occupants, employers, and the owners. The study was initiated to improve the office environment of the job site trailers and therefore conclusions cannot be generalized for all office environments. Another limitation was the time constraint for data collection and cost analysis. A period of three weeks was not sufficient to collect many responses and cost associated with the integration of biophilic design in trailers.

Future Research

Research needs to be done on the identification of the limitations and barriers in adopting the implementation of biophilic design in construction job site trailers. Furthermore, extensive studies can be performed doing longitudinal research to find significant differences in occupant satisfaction levels, productivity, and well-being working in biophilic site offices versus those working in non-biophilic site offices. The cost analysis associated with the implementation of this design concept in the construction of the job site trailers needs to be investigated. It is expected that this future research would be beneficial at providing a basis to add biophilic design features creating environments that are not only functionally efficient but also highly psychologically supportive.

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