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CYBERSICKNESS ASSOCIATED WITH DIGITAL TOOL USE AMONG CONSTRUCTION PRACTITIONERS: SYMPTOM PATTERNS, ASSOCIATED FACTORS AND COPING STRATEGIES

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Abstract

Digital technologies have transformed the way construction work is planned, coordinated and executed, resulting in increasingly digital and screen-intensive work environments. However, prolonged digital exposure has also raised concerns regarding cybersickness and occupational well-being. Although generally not considered a serious medical condition, cybersickness may adversely affect user comfort and potentially hinder the sustainable adoption of digital technologies. Despite the industry's growing digitalisation, empirical evidence on cybersickness among construction practitioners remains limited, leaving a lack of evidence-based guidance to promote healthier Construction 4.0 work environments. Therefore, this study investigated the self-reported occurrence and severity of cybersickness among Malaysian construction practitioners, examined demographic and digital usage factors associated with symptom severity, and explored coping strategies adopted to mitigate discomfort. A quantitative approach was employed using a structured questionnaire survey involving 109 construction practitioners in Malaysia. The findings revealed that more than half of the respondents experienced cybersickness symptoms intermittently, predominantly in the form of oculomotor discomfort, including eye strain, headaches and difficulty focusing. Higher symptom severity was observed among female and younger practitioners and was associated with

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prolonged continuous screen exposure rather than overall daily digital exposure. To alleviate discomfort, practitioners primarily adopted behavioural and ergonomic measures, with regular breaks, screen adjustment and ergonomic posture emerging as the most common coping strategies. This study extends cybersickness research beyond gaming and laboratory settings by providing empirical evidence from professional construction practice and offering insights for industry practitioners, organisations, and policymakers to develop healthier, more sustainable digital work environments.

Keywords: Industry 4.0, cybersickness, digital tools, digital well-being, construction practitioners, construction industry

INTRODUCTION

The global construction industry is undergoing rapid digital transformation driven by Industry 4.0 technologies and the emerging transition to more human-centred, sustainable Industry 5.0 paradigms. Consequently, investments in digital construction technologies, including Building Information Modelling (BIM), artificial intelligence (AI), cloud computing, digital twins and extended reality (XR), have increased substantially over the past decade as organisations seek to enhance operational efficiency and competitiveness (McKinsey Global Institute, 2017; Deloitte, 2025). Global investment in construction technologies reached approximately US\$50 billion between 2020 and 2022, driven by the potential of digital transformation to improve productivity by 14-15% and reduce project costs by 4-6% (Koeleman et al., 2019; McKinsey Global Institute, 2024).

While the widespread adoption of digital technologies has significantly improved productivity, collaboration and project delivery, it has also inevitably increased workers' exposure to screen-based and immersive digital environments. Consequently, new occupational health concerns have emerged. Among these, cybersickness has become an increasingly important issue as digital technologies become integral to everyday construction practice.

Cybersickness refers to a collection of physiological and psychological symptoms experienced during or after interaction with digital and virtual environments. Prior studies have demonstrated that immersive environments and prolonged screen exposure may negatively affect physical comfort, concentration and task performance (Dennison et al., 2016). In occupational settings, these effects may contribute to mental fatigue, reduced work efficiency, and decreased cognitive performance, particularly in professions that require prolonged visual attention and precision-based decision-making. These concerns are increasingly relevant within the construction industry, where practitioners frequently engage

in digitally intensive workflows involving modelling, coordination, visualisation, and remote collaboration.

Within the construction industry, empirical evidence concerning cybersickness among construction practitioners remains limited. Existing cybersickness research has predominantly focused on gaming environments, simulator systems, healthcare applications and controlled laboratory settings, with particular emphasis on immersive virtual reality (VR) systems and head-mounted displays (HMDs) (Rebenitsch & Owen, 2016; Weech et al., 2019). Consequently, relatively little is known about cybersickness associated with the routine use of conventional screen-based digital tools in professional construction practice. As digital technologies become increasingly integrated into construction practice, the impact of cybersickness on practitioners remains poorly understood. This knowledge gap may compromise worker well-being, productivity, and the long-term sustainability of Construction 4.0 initiatives.

Therefore, this study investigates cybersickness among Malaysian construction practitioners using digital tools within Construction 4.0 environments. Specifically, the study examines the occurrence and severity of cybersickness symptoms, identifies demographic and digital-use factors that influence cybersickness, and evaluates coping strategies practitioners use to mitigate discomfort.

This study addresses an important knowledge gap by providing baseline empirical evidence on self-reported cybersickness among construction practitioners. Extending existing research beyond gaming and laboratory settings, it examines symptom occurrence, associated factors, and coping strategies in real-world digital construction environments. As a perception-based study, it does not aim to provide a clinical or physiological diagnosis of cybersickness but rather to describe practitioners' self-reported symptoms and perceived digital well-being. The findings contribute to the emerging literature on digital well-being and occupational health while informing ergonomic guidelines and human-centred digital work practices.

LITERATURE REVIEW

Construction 4.0 and Digital Tool Adoption

Construction 4.0, derived from the broader Industry 4.0 paradigm, integrates advanced digital technologies, automation and data-driven processes into construction to enhance productivity, efficiency and project performance (Oesterreich & Teuteberg, 2016). Its adoption has been driven by the need to overcome fragmented workflows, inefficient information exchange and low productivity within the construction industry (McKinsey Global Institute, 2017). Consequently, digital technologies have become integral to modern construction practice. As practitioners increasingly rely on these technologies throughout the

project lifecycle, prolonged interaction with screen-based digital environments has become an inherent feature of contemporary construction work.

Cybersickness and Construction

While these technologies have substantially improved collaboration and operational performance, they have also increased practitioners' exposure to screen-based and digitally intensive work environments. Prolonged interaction with digital interfaces has been associated with visual fatigue, cognitive strain, reduced concentration and other ergonomic-related discomforts, highlighting growing concerns regarding the occupational implications of digital work (Dennison et al., 2016; Chen et al., 2022).

Cybersickness refers to a collection of physiological and psychological symptoms experienced during or after interaction with digital or virtual environments. Common symptoms include nausea, dizziness, headaches, eye strain, visual fatigue, disorientation and general discomfort (Rebenitsch & Owen, 2016). As digital technologies become increasingly embedded in construction workflows, these symptoms have attracted growing attention due to their potential effects on user comfort, cognitive performance, and workplace productivity (Dennison et al., 2016; Stanney et al., 2020).

One of the principal explanations of cybersickness is the Sensory Conflict Theory, originally proposed by Reason and Brand (1975). The theory suggests that cybersickness arises when discrepancies occur between visual, vestibular and proprioceptive sensory inputs. Although such sensory conflicts are most evident in immersive virtual environments, prolonged interaction with visually demanding screen-based applications may also contribute to eye strain, visual fatigue and cognitive discomfort (Keshavarz et al., 2015; Rebenitsch & Owen, 2016). Another widely recognised explanation is the Postural Instability Theory (Riccio & Stoffregen, 1991), which proposes that cybersickness results from prolonged difficulties in maintaining postural stability and spatial orientation. Within construction practice, extended engagement with digital modelling, visualisation and other visually intensive applications may increase visual and cognitive demands, thereby contributing to discomfort during prolonged work sessions.

Cybersickness Symptoms

Cybersickness symptoms are commonly classified into three dimensions: oculomotor, nausea-related, and disorientation (Kennedy et al., 1993). This classification is widely adopted in cybersickness and simulator sickness research and provides the conceptual framework for assessing symptom severity in the present study.

Oculomotor symptoms involve visual discomfort associated with prolonged interaction with digital systems, including eye strain, headaches, blurred vision, difficulty focusing and visual fatigue (Kaur et al., 2022). Prolonged screen exposure and visually demanding tasks have been shown to increase digital eye strain and reduce visual comfort (Beeson et al., 2024; Jahangiri et al., 2023). These symptoms are particularly relevant to construction practitioners who routinely engage with BIM, digital modelling and project coordination platforms.

Nausea-related symptoms comprise physiological discomfort such as dizziness, stomach awareness, sweating and motion-related uneasiness (Kennedy et al., 1993; Rebenitsch & Owen, 2016). They are commonly associated with immersive virtual environments, where sensory conflicts between the visual and vestibular systems are more pronounced (Oh & Son, 2022). Although less common in conventional screen-based applications, prolonged digital interaction may still contribute to discomfort and reduced concentration during digitally intensive construction tasks.

Disorientation symptoms include vertigo, balance disturbances and spatial confusion arising from inconsistencies between visual perception and physical movement (Kennedy et al., 1993; Rebenitsch & Owen, 2016). While these symptoms are typically associated with immersive virtual environments (Jochmann et al., 2025), prolonged engagement with visually intensive digital workflows may also contribute to cognitive fatigue and spatial discomfort among construction practitioners.

Factors Influencing Cybersickness

Previous studies have identified both demographic characteristics and technology usage patterns as important factors influencing the occurrence and severity of cybersickness (Rebenitsch & Owen, 2016; Stanney et al., 2020; Saredakis et al., 2020).

Demographic characteristics, including gender, age, professional experience and job role, have been associated with variations in cybersickness susceptibility. Female users generally report greater symptom severity than males, potentially due to physiological, perceptual and ergonomic differences (Stanney et al., 2020; Fulvio et al., 2021). Age may also influence susceptibility, as visual adaptation, cognitive response and familiarity with digital technologies vary across age groups (Weech et al., 2019). In addition, greater professional experience and familiarity with digital systems have been associated with improved adaptation and reduced discomfort during prolonged digital interaction (Saredakis et al., 2020). Consequently, practitioners with limited experience using advanced digital technologies may be more vulnerable to cybersickness.

Technology usage patterns also influence symptom severity. Prolonged screen exposure and sustained visual concentration have consistently been associated with visual fatigue, headaches and cognitive strain (Dennison et al., 2016; Sheppard & Wolffsohn, 2018). Within construction, practitioners engaged in BIM modelling, project coordination and digital visualisation are likely to experience greater digital exposure than those performing less screen-intensive tasks.

Finally, the type of digital technology may affect the severity of cybersickness. Immersive technologies, such as VR and augmented reality (AR), are generally associated with greater sensory conflict and motion-related discomfort than conventional screen-based systems (Rebenitsch & Owen, 2016; Weech et al., 2019). Nevertheless, prolonged use of non-immersive digital tools may also contribute to cybersickness through continuous visual engagement and repetitive screen-based interaction.

Coping and Mitigation Strategies

Various strategies have been proposed to reduce cybersickness symptoms and improve user comfort during digital interaction (Stanney et al., 2020; Saredakis et al., 2020). Behavioural strategies, particularly taking regular breaks, are among the most effective approaches for reducing visual fatigue, cognitive strain and prolonged sensory exposure, thereby improving comfort and concentration.

Ergonomic interventions, including appropriate screen brightness, viewing distance, display positioning and workstation design, can further minimise eye strain and visual discomfort associated with prolonged screen use (Moore et al., 2024; Sheppard & Wolffsohn, 2018). Optimising ambient lighting and reducing screen glare have also been shown to improve visual comfort during digitally intensive tasks.

In immersive digital environments, gradual exposure and adaptation training may enhance users' tolerance to virtual systems and reduce susceptibility to cybersickness (Saredakis et al., 2020). In addition, training and awareness programmes that promote symptom recognition, ergonomic practices and digital wellness can encourage healthier technology-use behaviours and support occupational well-being among construction practitioners.

Conceptual Framework

Based on the reviewed literature, a conceptual framework was developed to examine the relationships between demographic characteristics, digital usage patterns and cybersickness severity among construction practitioners (Figure 1). The framework proposes that demographic characteristics and digital usage patterns influence the occurrence and severity of cybersickness, while coping strategies can mitigate symptom severity.

Demographic characteristics include gender, age, professional experience, and job role, whereas digital usage patterns include screen exposure, digital tool usage, and exposure to immersive technologies. Cybersickness severity is represented by three symptom dimensions: **oculomotor**, **nausea-related** and **disorientation**, adapted from the Simulator Sickness Questionnaire (SSQ) framework (Kennedy et al., 1993). Coping strategies, including regular breaks, screen adjustment, and ergonomic practices, are incorporated as mitigating factors and illustrated with a dashed arrow to indicate their buffering role in reducing cybersickness associated with prolonged digital interaction.

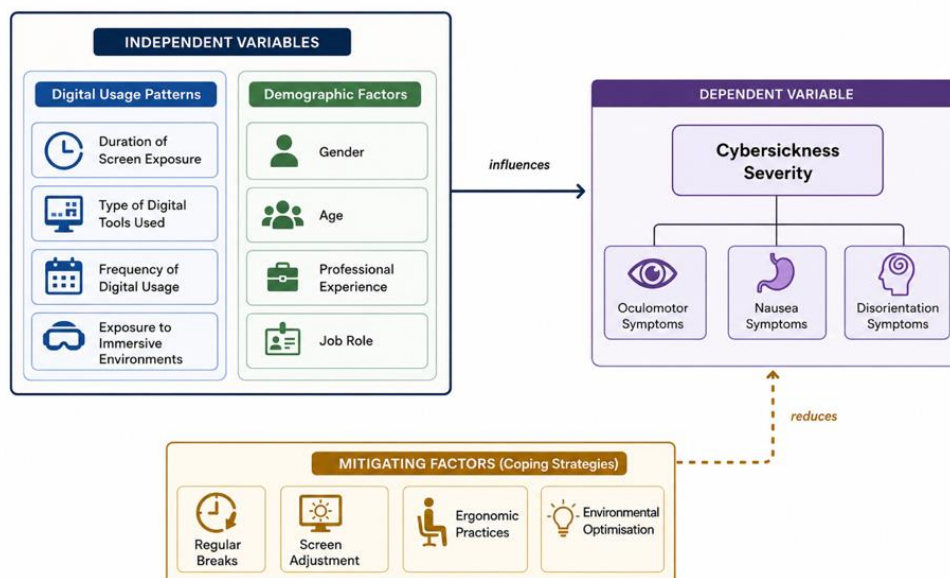


Figure 5: Conceptual Framework of Cybersickness Among Construction Practitioners
Source: Developed by the authors based on the research questions and synthesis of the existing literature. The visual layout and graphical elements were refined using Gemini (January 2026).

RESEARCH METHODOLOGY

This study employed a quantitative research design to investigate self-reported cybersickness among construction practitioners in Malaysia. A structured questionnaire survey was developed based on an extensive review of the literature on cybersickness, digital ergonomics, occupational health and digital construction. The literature review informed the development of the conceptual framework and questionnaire, with particular emphasis on identifying factors associated with cybersickness and on existing approaches to its assessment and mitigation.

The questionnaire comprised four sections. Section A collected respondents' demographic information, including gender, age, professional background, job role and years of professional experience. Section B assessed cybersickness severity using symptom-related items adapted from the SSQ (Kennedy et al., 1993). The original SSQ symptom items were reviewed and adapted to reflect routine digital technology use among construction practitioners, with items retained and organised under the three SSQ dimensions of oculomotor, nausea-related, and disorientation. Terminology referring specifically to simulator- or headset-based experiences was contextualised to broader digital work environments where necessary, while the underlying symptom constructs were retained.

Section C examined digital usage patterns, including the types of digital tools used, frequency of use, daily screen exposure and interaction with immersive technologies. Section D assessed the coping strategies adopted by respondents to alleviate cybersickness-related discomfort.

A stratified purposive sampling approach was adopted to obtain responses from construction practitioners representing a range of professional disciplines, including architects, engineers, quantity surveyors, project managers and site supervisors. Eligible respondents were required to be actively involved in construction-related work and routinely use digital technologies, such as BIM software, project management platforms, communication tools and other screen-based applications.

The questionnaire was administered online using Google Forms and distributed via email and professional social media networks between 9 October and 12 December 2025. Prior to the main survey, a pilot study was conducted to evaluate the clarity, reliability and relevance of the questionnaire, and minor revisions were made based on participant feedback.

This study complied with the university's ethical guidelines. Participation was voluntary, informed consent was obtained from all respondents prior to data collection, and all responses were anonymised to ensure confidentiality.

The collected data were analysed using IBM SPSS Statistics. Descriptive statistics (frequency, percentage, mean and standard deviation) were used to summarise respondents' demographic characteristics, digital usage patterns, cybersickness occurrence and severity, perceived contributing factors and coping strategies. Pearson correlation analysis was performed to examine the relationships between digital usage variables and overall cybersickness severity, while independent-samples t-tests were used to determine differences in cybersickness severity across demographic groups. These analyses provided a descriptive and exploratory understanding of cybersickness and the factors associated with symptom severity among construction practitioners.

ANALYSIS AND DISCUSSION

Response Rate and Reliability Analysis

A total of 111 survey responses were received for this study. After screening for consent, 109 responses (98.2%) were retained for analysis, while 2 responses (1.8%) were excluded due to the absence of participant consent. The sampling frame comprised construction practitioners in Malaysia who were actively engaged in construction-related work and routinely used digital technologies as part of their professional activities. Respondents from different construction-related professional roles and experience levels were recruited through email and professional online networks using a stratified purposive sampling approach. The final sample of 109 respondents provided an adequate basis for descriptive and exploratory quantitative analysis, enabling meaningful interpretation of cybersickness experiences and group comparisons the study objectives. Given the purposive sampling approach, the findings are interpreted as empirical evidence of cybersickness experiences within the sampled construction practitioners rather than as statistically representative of the entire Malaysian construction workforce.

Prior to analysis, all retained cases ($n = 109$) were examined for completeness and data quality. Overall, the responses were suitable for statistical analysis, with only minor missing values identified in a small number of questionnaire items. Missing data were handled using valid response analysis, which automatically excluded incomplete entries from statistical calculations for the respective variables.

The internal consistency of the survey instrument was assessed using Cronbach's alpha reliability analysis. The overall questionnaire achieved a Cronbach's alpha of 0.960, indicating excellent reliability and strong internal consistency.

Respondent Profile and Digital Usage

Figures 2 and 3 summarise the demographic and digital usage characteristics of the respondents. The sample comprised 109 construction practitioners representing diverse demographic backgrounds, professional roles and experience levels. Male respondents accounted for 53.2% of the sample, while females represented 46.8%. The respondents spanned a broad age range, with the largest proportion aged 45-54 years (27.5%), followed by 25-34 years (25.7%). Nearly half (49.5%) had more than 10 years of professional experience, and the sample included a range of occupations, led by quantity surveyors (25.7%), followed by engineers (11.9%), site supervisors (8.3%) and project managers (7.3%), providing perspectives across multiple construction disciplines.

The findings indicate extensive reliance on digital technologies in routine construction practice. More than half of the respondents (55.0%) reported using digital tools for over six hours per day, while a further 22.0% reported 4-6 hours of daily use. Word-processing, communication, and spreadsheet applications were the most frequently used digital tools, whereas Computer-Aided Design (CAD)/BIM applications were used moderately, and VR applications were used least frequently. Digital technologies were primarily employed for communication and collaboration (63.3%), project management and coordination (57.8%), design and drafting (48.6%), site monitoring (47.7%), and quantity take-off and cost estimation (45.9%), while only 24.8% reported using immersive technologies for training and simulation. The findings demonstrate that construction practitioners routinely engage with screen-based technologies, although immersive applications remain relatively uncommon.

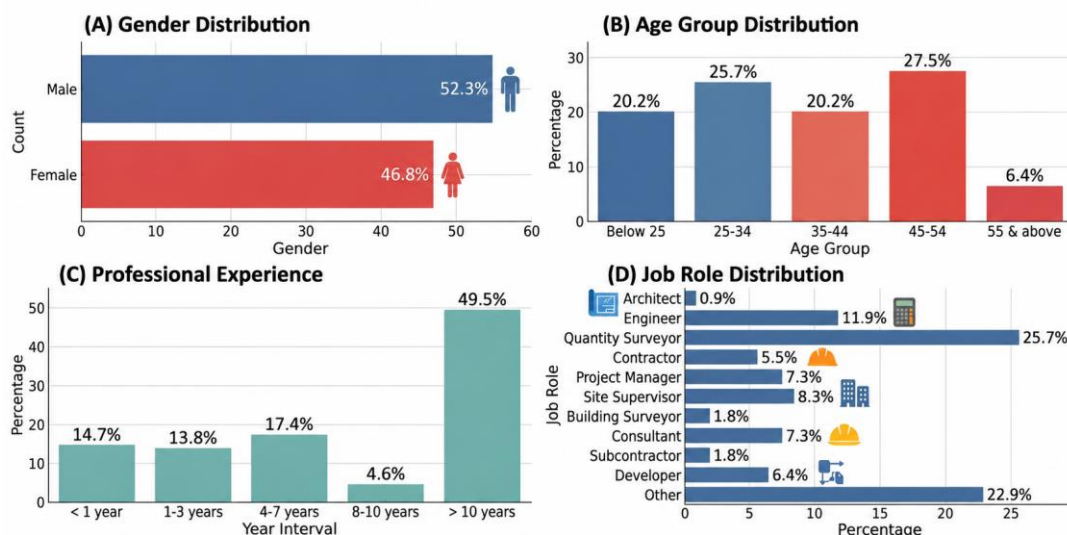


Figure 2: Demographic Profile of Sample Population (N=109), illustrating percentage distributions across: (A) gender breakdown, (B) age group distribution, (C) professional experience intervals, and (D) organisational job positions.

Source: Developed by the authors based on the survey results. The visual layout and graphical elements were refined using Gemini (June 2026).

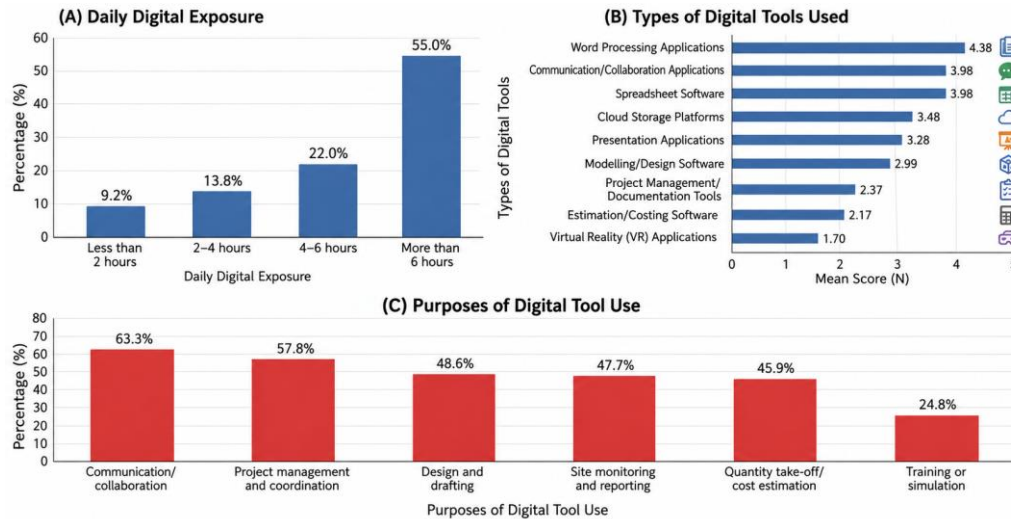


Figure 3: Digital Usage Characteristics of Sample Population (N=109), showing the distribution of (A) daily digital exposure, (B) mean frequency of use across different categories of digital tools, and (C) the primary purposes of digital tool use among construction practitioners.

Source: Developed by the authors based on the survey results. The visual layout and graphical elements were refined using Gemini (June 2026).

Occurrence and Severity of Cybersickness

Frequency of Cybersickness Occurrence

Figure 4 presents the frequency of cybersickness among construction practitioners. Slightly more than half of respondents (50.5%) reported experiencing cybersickness symptoms at least occasionally, whereas 49.5% had never experienced them. Frequent symptoms were uncommon, with fewer than 10% reporting weekly or more frequent occurrences. These findings indicate that cybersickness is generally intermittent rather than chronic, suggesting that digital tool use in construction is more likely to result in recurring discomfort than persistent health problems. This pattern is consistent with previous studies reporting that prolonged digital interaction primarily causes temporary visual and cognitive discomfort rather than severe physiological effects (Rebenitsch & Owen, 2016).

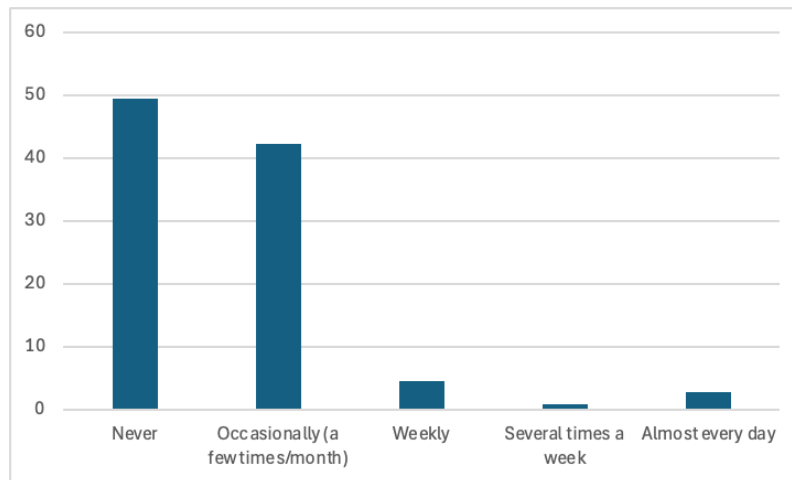


Figure 4: Frequency of Cybersickness (%)
 Source: Developed by the authors based on the survey results.

Overall Severity of Cybersickness

To further characterise these experiences, Figure 5 presents the mean severity scores for the three symptom dimensions. Oculomotor symptoms were rated as the most severe ($M = 2.30$), followed by disorientation ($M = 1.72$) and nausea-related symptoms ($M = 1.59$), with an overall mean score of 1.87, corresponding to symptoms rated “Rarely” to “Sometimes”. These findings indicate that cybersickness associated with routine construction work is predominantly characterised by visual discomfort, whereas vestibular and gastrointestinal symptoms remain relatively mild. The greater variability observed for oculomotor symptoms further suggests that visual fatigue differs according to individual work patterns and digital exposure.

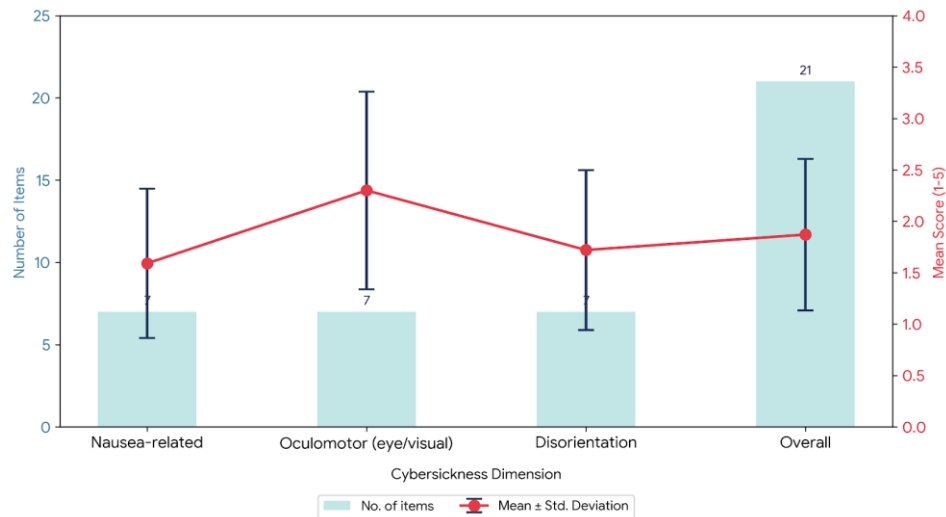


Figure 5: Mean Severity Scores Across Cybersickness Dimensions

Source: Developed by the authors based on the survey results. The visual layout and graphical elements were refined using Gemini (June 2026).

Symptom Profiles

Figure 6 presents the severity of individual cybersickness symptoms. Oculomotor symptoms emerged as the predominant manifestation, with eye strain, headaches and difficulty focusing recording the highest severity, whereas disorientation- and nausea-related symptoms, including vertigo, spatial confusion, nausea and vomiting, were reported less frequently. This symptom profile suggests that cybersickness among construction practitioners is primarily associated with prolonged visual workload arising from routine use of conventional screen-based technologies rather than the motion-induced sensory conflicts typically observed in immersive virtual environments. The relatively low prevalence of vestibular and gastrointestinal symptoms is consistent with respondents' limited use of immersive technologies. These findings extend previous research by demonstrating that conventional digital tools used in construction practice may also induce cybersickness symptoms, particularly visual fatigue, even in non-immersive settings (Rebenitsch & Owen, 2016; Rosenfield, 2016; Oh & Son, 2022).

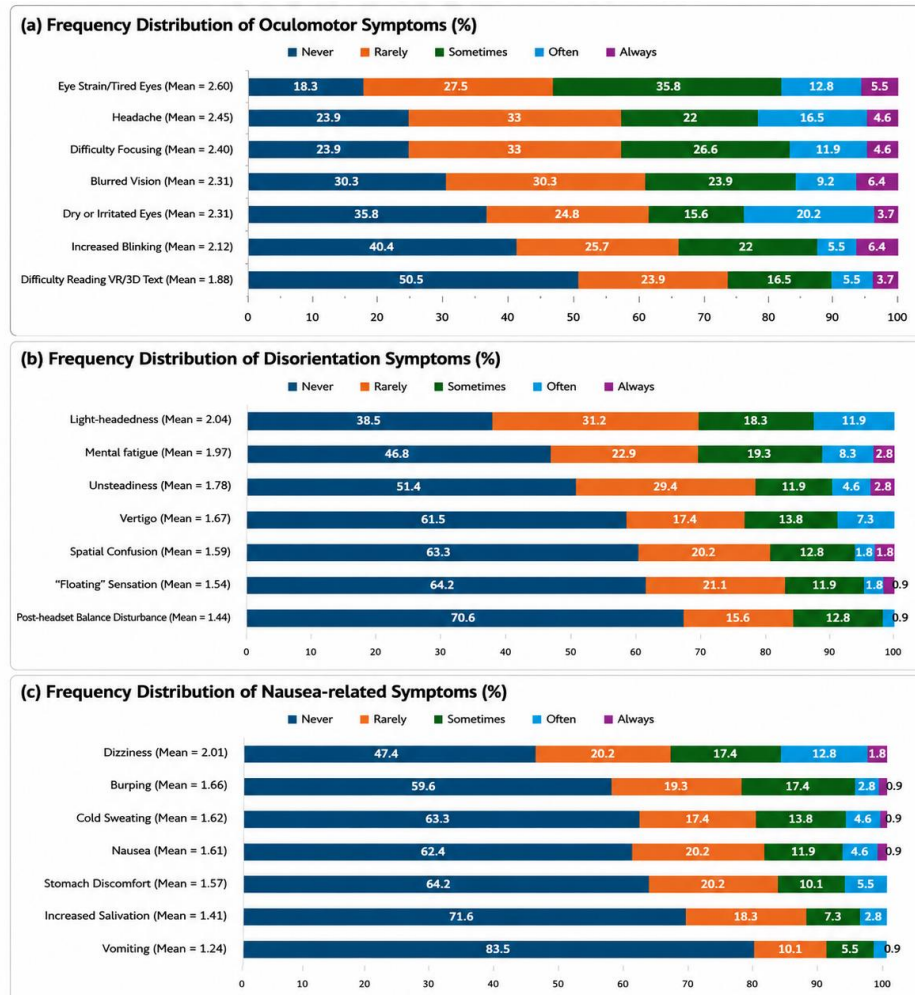


Figure 6: Frequency Distribution of Cybersickness Symptoms (%)

Source: Developed by the authors based on the survey results. The visual layout and graphical elements were refined using Gemini (June 2026).

Demographic Associated with Cybersickness

Gender

Figure 7 compares cybersickness severity between male and female respondents. An independent-samples t-test examined differences in overall cybersickness severity between male and female respondents. A statistically significant difference was observed, with female respondents reporting higher mean severity

($M = 2.05$, $SD = 0.85$) than male respondents ($M = 1.70$, $SD = 0.58$), $t(106) = -2.50$, $p = 0.014$. The magnitude of the difference was moderate (Cohen's $d = 0.49$). This finding is consistent with previous studies reporting greater susceptibility to cybersickness among females, which has been associated with differences in visual processing, motion sensitivity and physiological factors (Golding, 2006; Stanney et al., 2020). The finding suggests that gender-related differences in cybersickness susceptibility may warrant consideration when developing digital well-being and ergonomic interventions for construction practitioners.

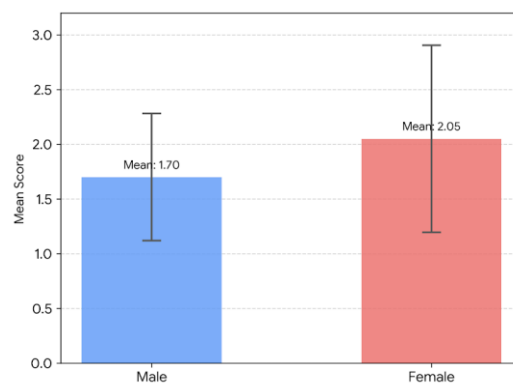


Figure 7: Mean Cybersickness Severity by Gender

Source: Developed by the authors based on the survey results. The visual layout and graphical elements were refined using Gemini (June 2026).

Age and Professional Experience

Figure 8 illustrates cybersickness severity across age groups and professional experience. A declining trend was observed for both variables, with younger practitioners and those with fewer years of experience reporting higher symptom severity. Respondents aged 20-25 years reported the highest mean severity (≈ 2.15), whereas those aged 35+ reported the lowest (≈ 1.62). Likewise, respondents with less than 1 year of professional experience exhibited the highest severity (≈ 2.40), while those with 8-10 years of professional experience reported the lowest (≈ 1.53).

These findings suggest that greater age and professional experience may enhance adaptation to digitally intensive work environments. Previous research similarly reported that repeated exposure to digital systems improves user tolerance and reduces cybersickness over time (Fernandes & Feiner, 2016). Consequently, younger and less experienced practitioners may benefit from greater guidance on healthy digital work practices and ergonomic awareness.

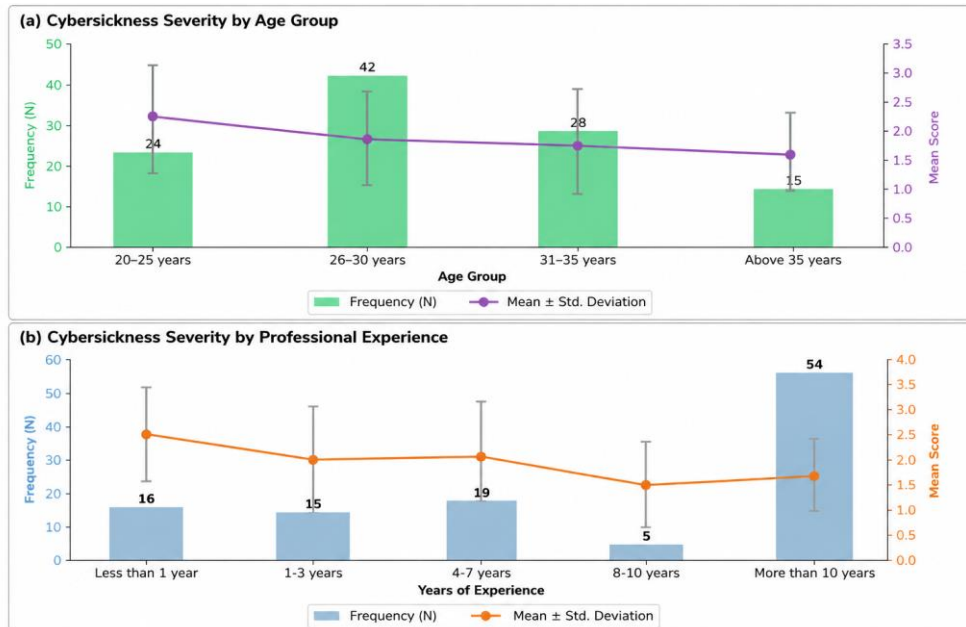


Figure 8: Cybersickness Severity by Age Group, and Professional Experience

Source: Developed by the authors based on the survey results. The visual layout and graphical elements were refined using Gemini (June 2026).

Perceived Contributing Factors Associated with Cybersickness

Figure 9 presents respondents' perceptions of factors contributing to cybersickness, grouped into display and visual factors, motion and interaction factors, user-related factors, and environmental and physical factors. Overall, respondents perceived these factors as exerting low to moderate influence on symptom severity, with environmental and visual factors receiving the highest ratings.

Among the display and visual factors, display brightness and contrast emerged as the most influential ($M = 2.82$), followed by low frame rate/image smoothness ($M = 2.49$), text legibility ($M = 2.46$), motion blur/visual latency ($M = 2.44$) and field-of-view mismatch ($M = 2.40$). These findings suggest that display quality and visual presentation play an important role in user comfort during prolonged digital interaction.

For motion and interaction factors, system response latency recorded the highest perceived influence ($M = 2.32$), followed by camera/viewpoint motion and navigation method (both $M = 2.23$), whereas virtual movement speed had the lowest mean score ($M = 2.21$). Although the perceived influence was modest, the findings indicate that smooth system responsiveness reduces discomfort during digital tool use.

Regarding user-related factors, pre-use fatigue emerged as the most influential factor ($M = 2.46$), followed by exposure duration ($M = 2.19$), while motion sickness susceptibility ($M = 1.99$) and prior immersive experience ($M = 1.90$) were perceived as less influential. This suggests that temporary physical and mental conditions may have a greater impact on cybersickness than individual predisposition.

Among all categories, environmental and physical factors recorded the highest overall ratings. Ergonomic posture ($M = 2.78$), ambient lighting ($M = 2.74$) and environmental distractions ($M = 2.67$) were perceived as the principal contributors, highlighting the importance of ergonomic workstation design and appropriate working environments in reducing cybersickness.

These findings shows that cybersickness among construction practitioners is primarily influenced by visual demands, ergonomic conditions, and user fatigue, rather than by motion-related characteristics typically associated with immersive virtual environments. This pattern is consistent with the predominance of oculomotor symptoms observed in the present study and suggests that improving display quality, workstation ergonomics and working conditions may be more effective than technology-specific interventions alone.

Pearson correlation analysis was conducted to examine the relationships between digital usage patterns and overall cybersickness severity (Table 1). Continuous screen use without breaks showed a significant positive association with cybersickness severity ($r = 0.295$, $p = 0.002$), indicating that longer uninterrupted periods of screen use were associated with greater symptom severity. The correlation was small to moderate. In contrast, the interval between breaks was negatively associated with cybersickness severity ($r = -0.254$, $p = 0.008$), also representing a small-to-moderate association. This indicates that longer intervals between breaks were associated with higher reported severity. Total daily digital-tool use was not significantly associated with cybersickness severity ($r = 0.147$, $p = 0.127$), indicating a small and statistically non-significant relationship. The findings suggest that the pattern of screen exposure, particularly uninterrupted use and break intervals, may be more closely associated with cybersickness severity than total daily exposure alone. The results reinforce recommendations in digital ergonomics literature advocating regular breaks to reduce visual fatigue and cognitive strain during prolonged digital work (Sheppard & Wolffsohn, 2018).

Table 2: Pearson Correlation between Digital Usage Patterns and Overall Cybersickness Severity

Usage pattern	Pearson correlation, r	p -value	Effect Interpretation
Continuous screen exposure	0.295	0.002	Small-to-moderate positive association
Break interval	-0.254	0.008	Small-to-moderate negative association
Daily digital exposure	0.147	0.127	Small, non-significant association

Source: Developed by the authors based on the survey results.

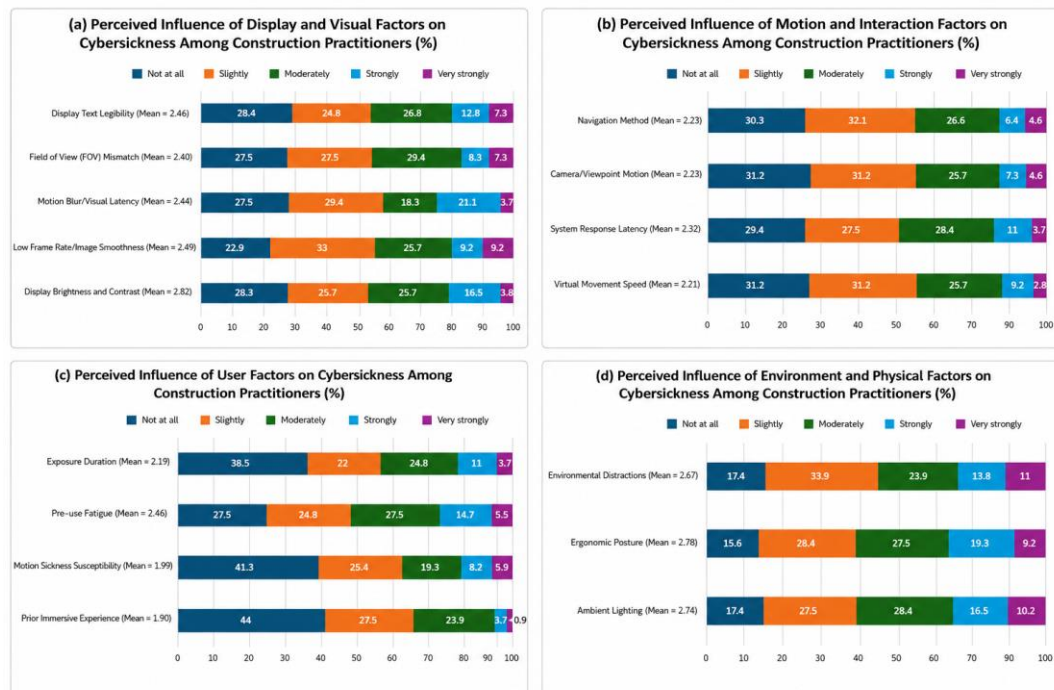


Figure 9: Perceived Contributing Factors Associated with Cybersickness

Source: Developed by the authors based on the survey results. The visual layout and graphical elements were refined using Gemini (June 2026).

Perceived Effectiveness of Coping Strategies

Having identified the factors associated with cybersickness, the study further examined the coping strategies adopted by construction practitioners to manage digital-related discomfort. As shown in Figure 10, most strategies were adopted moderately to frequently (mean = 2.39-3.27). Regular breaks emerged as the most frequently adopted and effective strategy ($M = 3.27$), followed by screen adjustment ($M = 3.17$) and maintaining ergonomic posture ($M = 3.17$). Visual

rest practices (M = 3.00) and hydration and wellness measures (M = 2.97) were also commonly adopted, indicating that practitioners primarily relied on simple behavioural and ergonomic approaches to alleviate discomfort.

In contrast, digital exposure management (M = 2.85) and the use of ergonomic aids (M = 2.69) demonstrated moderate levels of adoption, whereas immersive technology reduction (M = 2.39) and blue-light protection (M = 2.39) were perceived as the least effective strategies. This pattern likely reflects the relatively limited use of immersive technologies among respondents, together with mixed evidence regarding the effectiveness of blue-light filters.

Overall, the findings suggest that construction practitioners manage cybersickness primarily through behavioural and ergonomic interventions rather than technology-specific solutions. The prominence of regular breaks, screen adjustment and ergonomic posture aligns with the factors identified as contributing to symptom severity and supports previous recommendations that periodic breaks and ergonomic practices are effective in reducing cybersickness and visual fatigue during prolonged digital work (Parry et al., 2013; Keshavarz et al., 2014).

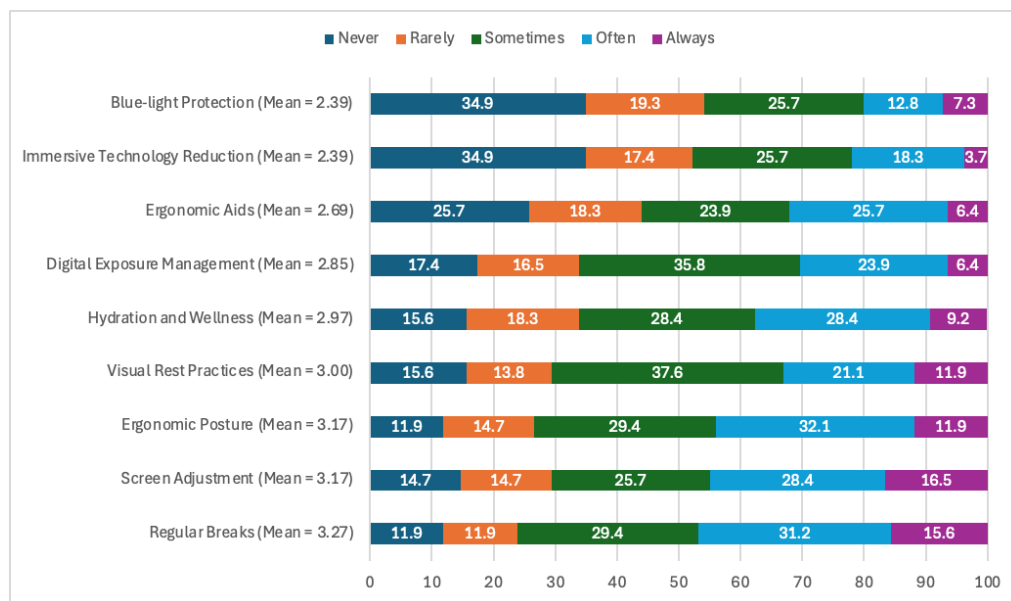


Figure 10: Perceived Coping Strategies for Cybersickness Mitigation Among Construction Practitioners (%)

Source: Developed by the authors based on the survey results.

Practical Implications

The findings have important implications for the management of occupational health in increasingly digital construction workplaces. Although digital technologies have become indispensable for project delivery, the results demonstrate that prolonged screen-based interaction may adversely affect practitioners' visual comfort and well-being, even in predominantly non-immersive work environments. Cybersickness should therefore be recognised as a broader digital ergonomics issue rather than a concern confined to virtual reality applications.

The findings further suggest that organisations should prioritise human-centred digital work practices alongside technological implementation. Given that continuous screen exposure, ergonomic posture and display conditions were identified as important contributors to cybersickness, workplace interventions should extend beyond technology adoption to include ergonomic workstation design, optimised display settings and structured work–rest schedules. Such measures may reduce visual fatigue, improve user comfort, and support sustained cognitive performance during digitally intensive tasks.

From an organisational perspective, integrating digital well-being into occupational health and safety policies, employee training and digital transformation initiatives may enhance both workforce well-being and operational performance. Particular attention should be directed towards younger and less experienced practitioners, who demonstrated greater susceptibility to cybersickness. As digital technologies continue to reshape construction practice, embedding ergonomic and human-centred considerations into digital transformation strategies will be essential to achieving sustainable, productive digital workplaces.

CONCLUSION

This study investigated self-reported cybersickness among Malaysian construction practitioners engaged in digitally intensive work. Specifically, it examined the occurrence and severity of cybersickness symptoms, identified demographic and digital-use factors associated with symptom severity, and evaluated coping strategies used to mitigate digital-related discomfort.

The findings indicate that a substantial proportion of sampled practitioners reported cybersickness symptoms, although symptoms are generally intermittent rather than chronic. Oculomotor symptoms, particularly eye strain, headaches and difficulty focusing, were the predominant manifestations, whereas nausea-related and disorientation symptoms were comparatively less severe. Female and younger practitioners reported greater symptom severity, while continuous screen exposure and inadequate break intervals were associated with increased discomfort. In contrast, total daily digital exposure was not

significantly associated with symptom severity, suggesting that different patterns of digital use may be associated with cybersickness symptoms beyond total exposure duration alone.

The study further indicates that practitioners perceived ergonomic, behavioural and environmental factors as relevant to their cybersickness experiences. Display conditions, ambient lighting, posture and fatigue were perceived as key contributors, whereas regular breaks, screen adjustment and ergonomic practices were among the more frequently adopted coping strategies. These findings suggest that cybersickness experiences may be related not only to digital technologies but also to how they are used and the working conditions in which they are deployed.

This study contributes to the growing literature on cybersickness by providing empirical evidence from construction practitioners engaged in routine digital work, extending the context beyond the gaming and immersive virtual-reality settings commonly examined in previous research. Within the context of the sampled Malaysian practitioners, the findings provide an initial basis for further research on digital well-being, ergonomic practices and human-centred approaches to digital work in construction.

Limitation and Future Research

Several limitations should be considered when interpreting the findings. First, the study relied on self-reported measures of cybersickness symptoms, digital usage patterns and coping strategies. Although the questionnaire demonstrated excellent reliability, self-reported data are subject to recall bias and individual differences in symptom perception. Future studies should complement subjective assessments with objective measures, such as eye-tracking, physiological monitoring or digital activity logs.

Second, the cross-sectional design limits causal inference. Although significant associations were identified among continuous screen exposure, break intervals, and cybersickness severity, the temporal relationships among these variables cannot be established. Longitudinal and experimental research is therefore needed to examine the causal mechanisms underlying cybersickness in occupational settings.

Finally, the study was based on a moderate sample of Malaysian construction practitioners. Although respondents represented diverse professional roles and experience levels, some occupational subgroups were relatively small, limiting detailed comparisons within subgroups and broader generalisation. Future studies involving larger samples, multiple construction disciplines and cross-country comparisons would strengthen the robustness and generalisability of the findings.

Despite these limitations, this study provides one of the first empirical investigations of cybersickness among construction practitioners engaged in routine digital work. By establishing baseline evidence on symptom patterns, associated factors and coping strategies, it provides a foundation for future research and supports the development of healthier, more human-centred digital workplaces in the construction industry.

Declaration of Generative AI and AI-assisted Technologies in the Manuscript Preparation Process

During the preparation of this manuscript, the authors used ChatGPT to assist with language refinement and readability. Selected figures were visually enhanced using Gemini. However, all underlying data, analyses, interpretations and scientific content were produced and verified by the authors, with AI use acknowledged in the relevant figure captions. The authors reviewed and edited all AI-assisted outputs and take full responsibility for the content of this publication. No AI tools were used for data collection, statistical analysis, interpretation of results or the formulation of scientific conclusions.

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