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NIGHT SHIFT IN OFFSITE AND HYBRID CONSTRUCTION DELIVERY: DRIVERS, CHALLENGES AND A DECISION SUPPORT FRAMEWORK

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Abstract: Night shift operations are a growing feature of offsite and hybrid construction delivery, driven by traffic management restrictions and programme demands that confine module transport, crane lifts, and structural installation to overnight windows. Night working is widely adopted across building, infrastructure, and civil engineering projects to accelerate delivery and recover schedule float, yet adoption decisions remain largely intuitive and unsupported by integrated analytical tools. This paper presents a systematic literature review examining the drivers and challenges of night shift adoption across construction project types and introduces the Shift Strategy Decision Support System (SSDSS) as a conceptual framework to address the identified gap. Based on a review of construction scheduling, occupational health and safety, environmental compliance, stochastic modelling, and multicriteria optimisation literature, eleven drivers across three categories and fourteen challenges across four categories are identified. The SSDSS integrates seven modules encompassing resource-constrained scheduling, fatigue and safety risk assessment, environmental compliance evaluation, and Multi-Criteria Decision Making (MCDM) using AHP-TOPSIS. Worker safety and human factors are embedded as core planning parameters. The framework is designed for integration with BIM-based environments and establishes theoretical foundations for a digital decision support tool applicable across offsite, hybrid, and conventional construction projects.

Keywords: night shift; offsite construction; hybrid construction; decision support system; worker safety; human factors; fatigue risk; AHP-TOPSIS; MCDM; BIM integration

1. INTRODUCTION

Construction is one of the world's largest industries, yet as Zohrehvandi et al. (2024) document, it continues to underperform on schedule, cost, and safety with remarkable consistency. The rise of offsite and hybrid construction methods, where volumetric modules and prefabricated components are manufactured in controlled factory environments before being transported and assembled on site, has added a new dimension to this challenge. Li et al. (2025) and Yuan et al. (2024) show that module deliveries, crane operations, and structural connections often need to happen at night when roads are quieter and surrounding communities less disrupted, making night shift working not just a schedule recovery tool but an operational necessity in many offsite projects. The same pressure applies across building, infrastructure, and civil engineering, where contractors face growing demands to deliver faster, more safely, and with less environmental impact (Singh et al. 2024).

Working at night is considerably more complex than simply extending the day. Night shifts impair worker alertness and raise accident rates (Heng et al. 2024; Dinges et al. 2023), reduce productivity (Barraza 2011), strain shared equipment and labour across a contractor's portfolio (Hartmann and Briskorn 2010), and attract cost premiums that are routinely underestimated (Yuan et al. 2024). Add noise regulations and permit constraints (NYC DEP 2023), and it becomes clear that a decision to work nights is far more consequential than it might first appear.

Yet despite all of this, the construction industry has no integrated tool to support shift strategy decisions. Most project teams still rely on deterministic Critical Path Method scheduling; a technique that assumes unlimited resources and constant productivity and therefore cannot account for the real-world complexities of night working (Lazari et al. 2024; Hartmann and Briskorn 2010). As Dong et al. (2015) and Wagstaff and Sigstad Lie (2011) have both shown, the result is a pattern of ineffective acceleration, preventable safety incidents, and unexpected cost overruns that a more structured approach could have avoided. In the UK, the HSE HSG256 guidance (HSE 2006) and the CDM Regulations 2015 place clear legal obligations on duty holders to assess shift-related risks, yet as Zohrehvandi et al. (2024) note, no planning tool currently operationalises those obligations at project level.

This paper sets out to address this gap through three contributions: (i) it draws on an integrative review of the literature to identify and categorise the drivers that lead construction teams to adopt night working; (ii) it systematically examines the challenges that make those decisions difficult to get right; and (iii) it introduces the Shift Strategy Decision Support System (SSDSS); a conceptual seven-module framework designed to bring structure, evidence, and transparency to shift strategy decisions across offsite, hybrid, and conventional construction projects.

2. RESEARCH METHODOLOGY

The paper is based on an Integrative Literature Review (ILR). As Torraco (2016) explains, an ILR is specifically suited to research that aims to build new conceptual frameworks by drawing together knowledge from multiple disciplines distinct from a systematic review, which aggregates evidence on a single focused question. The shift strategy problem touches on construction scheduling, occupational health, stochastic planning, environmental compliance, and decision-making, and as Snyder (2019) and Page et al. (2021) argue, no single field covers it adequately on its own. An ILR allows these streams to be woven into a coherent framework rather than reviewed in isolation.

Table 4 presents the explicit inclusion and exclusion criteria applied during the review. Key UK regulatory documents were additionally included given the statutory duty-of-care obligations they place on construction employers.

Following database searches, 112 records were identified. After duplicate removal and title/abstract screening, 48 records were assessed for eligibility, of which 30 met the inclusion criteria and were included in the synthesis (Figure 1). Sources were grouped inductively into drivers of night shift adoption, challenges of night shift operations, and decision support approaches, shaping both the structured tables in Section 3 and the SSDSS framework design (Snyder 2019; Page et al. 2021).

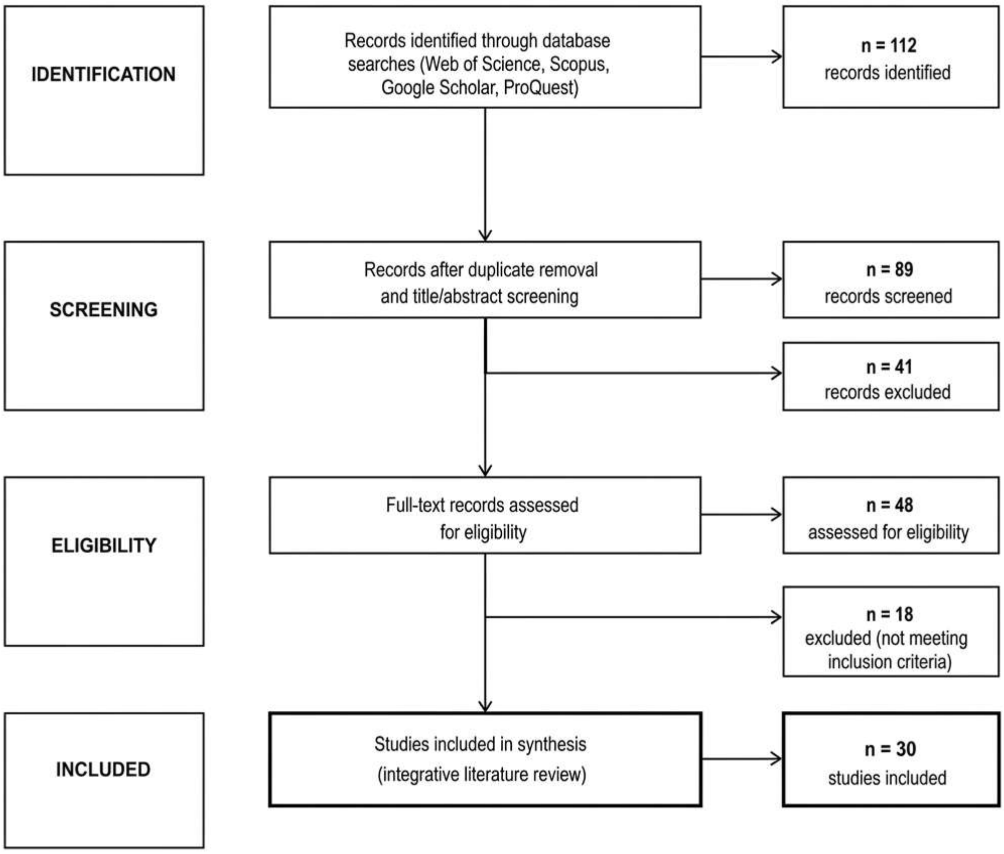

Figure 1: Integrative literature review flow diagram

Table 4: Inclusion and exclusion criteria for the integrative literature review

Criterion	Inclusion	Exclusion
Relevance	Construction project management, occupational health in construction, or shift work in industrial settings	Studies unrelated to construction management or shift work
Language	English language publications	Non-English sources
Document type	Peer-reviewed journal articles, conference papers, authoritative technical or regulatory reports	Opinion pieces, editorials, or sources without empirical or theoretical grounding
Date	Published 2010-2025; foundational pre-2010 works retained where no equivalent recent source exists	Sources published before 2010 unless seminal and unreplaced
Duplication	Unique sources only	Duplicate sources identified across databases

3. RESULTS AND DISCUSSION

3.1 Current State of Shift Strategy Decision-Making in Construction

Night shift decisions are rarely grounded in rigorous analysis. Teams typically add night shifts reactively when a schedule is slipping, relying on CPM tools never designed for this decision (Ding et al. 2023; Lazari et al. 2024). Wagstaff and Sigstad Lie (2011) and Dong et al. (2015) document the consequences: ineffective acceleration, cost overruns, and preventable safety incidents, echoed by Zohrehvandi et al. (2024) in the broader project performance literature.

3.2 Drivers of Night Shift Adoption Across Construction Projects

As the reviewed literature makes clear, the reasons why construction teams turn to night working are more varied than simple schedule pressure. Schedule and contractual drivers are universal, but operational and technical drivers such as traffic management windows and paving temperature requirements play out differently depending on the project type, while social and stakeholder pressures are particularly acute in urban and publicly visible schemes. Table 1 presents the eleven identified drivers, grouped by category, with supporting references from the reviewed literature.

Table 1: Drivers of night shift adoption across construction projects

Category	Driver	Description	Key References
Schedule and Contractual Drivers	Schedule acceleration and recovery	Project teams seek to compress duration by extending hours into the night without expanding site footprint. The schedule benefit is constrained in practice by resource availability and work programme dependencies.	Lazari et al. (2024); Yuan et al. (2024)
	Contractual penalty avoidance	Liquidated damages clauses and milestone obligations create financial incentives to adopt night work reactively when schedule slippage threatens contractual penalties, regardless of whether the shift will deliver the required improvement.	Lazari et al. (2024); Zohrehvandi et al. (2024)
	Float recovery after delays	Unforeseen delays from weather, supply chain disruption, or design changes erode programme float, leading project managers to invoke night shifts as a recovery mechanism to restore milestone compliance.	Hartmann and Briskorn (2010); Barraza (2011); Yuan et al. (2024)
	Client and stakeholder milestone pressure	Clients, funding bodies, and contract administrators impose milestone dates that create top-down pressure for accelerated delivery, compelling contractors to adopt extended shift regimes to demonstrate programme compliance.	Zohrehvandi et al. (2024); Herroelen (2005)

Operational and Technical Drivers	Traffic management and daytime access restrictions	Access constraints in urban construction, utilities, and infrastructure works frequently limit productive daytime working, making overnight windows the only viable option for disruptive activities such as carriageway works, utility diversions, structural connections, and below-ground excavations near live services.	NYC DEP (2023); Hartmann and Briskorn (2010)
	Favourable temperature windows for paving	Certain construction operations are sensitive to ambient temperature, solar radiation, and humidity. Asphalt paving, concrete pours, epoxy coatings, and waterproofing applications can all benefit from the more stable nighttime conditions that reduce the risk of premature setting, thermal cracking, or surface defects, providing a quality-driven and productivity-based case for night work.	Procore (2023); Lazari et al. (2024)
	Concurrent activity parallelism	Night shifts enable simultaneous execution of activities that share space or access during the day, allowing parallel progress streams that cannot be achieved within a single daytime shift window.	Lazari et al. (2024); Gomez Sanchez et al. (2023)
	Reduced third-party interference	Night working minimises interference from adjacent businesses, pedestrians, utility works, and delivery traffic that disrupt productivity during daytime operations, enabling more efficient site logistics and uninterrupted work sequences.	Procore (2023); Singh et al. (2024)
Social and Stakeholder Drivers	Community pressure for rapid completion	Sustained disruption to access, noise, and amenity generates political and public pressure to minimise project duration by concentrating working hours into extended shifts.	Zohrehvandi et al. (2024); Singh et al. (2024)
	Political Visibility of Infrastructure Delivery	High-profile construction projects, whether infrastructure, landmark buildings, or regeneration schemes, attract political attention and media scrutiny, creating pressure for visible progress and early completion that translates into decisions to extend productive hours into night shifts.	Zohrehvandi et al. (2024); Herroelen (2005)
	Minimising total duration of community disruption	Even where night work generates noise, concentrating the total construction period through extended hours may be preferable to communities and authorities than a prolonged programme at reduced daily intensity.	NYC DEP (2023); Zohrehvandi et al. (2024)

What Table 1 reveals is that night shift adoption is rarely a single, clear-cut decision. Some drivers are reactive, some are imposed by access constraints, and some reflect genuine technical advantages. What all eleven share is that they tend to be acted upon without any structured analysis of whether night working will actually deliver the expected benefit, or what it will cost in safety, environmental, and financial terms.

3.3 Challenges of Night Shift Operations in Construction Projects

If the drivers in Table 1 explain why teams choose night working, the challenges in Table 2 explain why it so often falls short of expectations. The literature identifies fourteen challenges, which cluster consistently into four categories regardless of project type, even if their severity varies by context. Table 2 presents these with the references that document each one.

Table 2: Challenges of night shift operations across construction projects

Category	Challenge	Description and Planning Implication	Key References
Human Factors Challenges	Worker fatigue and circadian disruption	Night work disrupts circadian rhythms and impairs alertness, reaction time, and decision quality. Accident risk elevates progressively with consecutive nights worked. These risks can be anticipated at the planning stage if fatigue parameters are embedded within scheduling tools.	Heng et al. (2024); Dinges et al. (2023); Wagstaff and Sigstad Lie (2011); HSE HSG256 (2006); OSHA (2024)
	Elevated occupational accident and injury risk	Empirical evidence confirms that incident rates are consistently higher on evening and night shifts than day shifts. Construction workers face compounded risk due to physically hazardous tasks performed under conditions of reduced alertness and visibility.	Dong et al. (2015); Singh et al. (2024); Wagstaff and Sigstad Lie (2011); HSE HSG256 (2006); National Safety Council (2024); OSHA (2024)
	Long-term worker health consequences	Sustained night shift exposure is associated with chronic health conditions including sleep disorders, cardiovascular disease, and metabolic disorders, with long-term workforce wellbeing and availability implications beyond immediate accident risk.	Hanif et al. (2024); Heng et al. (2024); Wagstaff and Sigstad Lie (2011)
	Supervision, quality assurance and shift continuity	Senior technical staff and client representatives are less available at night, reducing capacity for real-time problem resolution and quality inspection. Shift handover requirements add coordination overhead routinely underestimated in planning, increasing the risk of quality nonconformance.	Singh et al. (2024); Heng et al. (2024); Dinges et al. (2023); Anwer et al. (2021)
Technical and Operational Challenges	Productivity variability and night-time performance degradation	Night operations systematically deliver lower unit productivity than daytime working. Reduced natural light, physiological fatigue, and material temperature sensitivity combine to undermine output rates. Duration halving assumptions in planning overstate achievable schedule compression.	Anwer et al. (2021); ElRayes and Moselhi (2001); Barraza (2011); Halpin and Riggs (1992); Martinez (2010)
	Resource constraints and shared equipment management	Night shift extension does not create new resources; it extends existing ones already shared across concurrent projects in contractor portfolios. Resource contention limits practical schedule compression, and supplementary resource mobilisation carries significant cost premiums.	Hartmann and Briskorn (2010); Gomez Sanchez et al. (2023); Weglarz et al. (2011); Lazari et al. (2024)
	Stochastic uncertainty and planning unreliability	Night operations introduce greater variability in productivity, equipment availability, and material delivery than daytime working. Deterministic scheduling tools cannot represent this elevated	Barraza (2011); Yuan et al. (2024)

		uncertainty, producing plans whose reliability is lower than for equivalent daytime programmes.	
	Material and process temperature sensitivity	Temperature, humidity, and dew point conditions at night can compromise a range of construction processes including asphalt compaction, concrete curing, mortar setting, epoxy application, and steel welding, introducing technical quality risks across multiple project types that require additional monitoring and control.	Procore (2023); Lazari et al. (2024); Singh et al. (2024)
Regulatory and Environmental Challenges	Environmental compliance and noise regulation	Regulatory frameworks impose lower night-time noise thresholds, permit requirements, and activity restrictions near residential receptors. Non-compliance risks enforcement action, community escalation, and work stoppages that can eliminate the schedule benefit sought.	NYC DEP (2023); Procore (2023); Li et al. (2020); Ding et al. (2023); CDM Regulations (2015)
	Permit complexity and approval lead times	Night working in urban environments requires advance permit applications, noise management plans, and community consultation processes that introduce lead times and administrative burdens not accounted for in standard scheduling.	NYC DEP (2023); Procore (2023); Ding et al. (2023)
	Light pollution, emissions and broader environmental impact	Artificial lighting generates light pollution affecting adjacent residents. Extended equipment operation increases fuel consumption, particulate emissions, and carbon dioxide output. These impacts are subject to growing regulatory scrutiny and community sensitivity.	Li et al. (2020); Ding et al. (2018); NYC DEP (2023)
Financial Challenges	Premium labour rates and overtime cost escalation	Night work attracts unsocial hours allowances and overtime rates typically adding fifteen to forty percent to base labour costs, frequently underestimated or omitted from acceleration cost analyses such that the true cost only emerges after operational commitment.	Yuan et al. (2024); Zohrehvandi et al. (2024); Senouci and Al-Derham (2008)
	Indirect cost escalation from night operations	Site lighting infrastructure, enhanced security, additional welfare provision, temporary noise barriers, low-noise equipment premiums, and ongoing environmental monitoring collectively add substantial indirect costs structurally absent from standard daytime cost models.	Yuan et al. (2024); NYC DEP (2023); Procore (2023)
	Ineffective acceleration and sunk cost risk	Where resource constraints, productivity differentials, or regulatory complications prevent night operations from delivering intended schedule compression, premium costs incurred represent sunk cost with no project benefit. The absence of pre-decision analysis makes this outcome common and difficult to reverse.	Lazari et al. (2024); Hartmann and Briskorn (2010); Zohrehvandi et al. (2024)

The challenges in Table 2 do not operate independently. Fatigue erodes productivity, which undermines the schedule gain that justified the premium labour cost in the first place. Resource contention limits how much compression is achievable. And a noise enforcement notice can stop night operations entirely, wiping out whatever schedule benefit had been accumulated. How severely each challenge bites will vary depending on the project type, location, and regulatory context, which is precisely why a configurable decision support framework is needed rather than a one-size-fits-all rule.

3.4 The SSDSS Conceptual Framework

3.4.1 Shift Strategy Scenarios

Five shift regime scenarios are evaluated across project types: a standard single daytime shift (S1) as the baseline; a double shift (S2) extending productive hours to sixteen per day; an extended single shift with rest periods (S3); a selective night shift limited to activities where access constraints or technical requirements mandate it (S4); and a phase-based hybrid that applies different regimes to different construction phases (S5), reflecting the varying resource profiles and night-working sensitivity of activities such as excavation, structural works, fit-out, and commissioning.

3.4.2 Seven-Module Architecture

The SSDSS processes each of the five scenarios through seven sequential modules, moving from data gathering through to a ranked, auditable recommendation. Table 3 sets out what each module does and which challenge cluster it addresses.

Table 3: SSDSS module architecture and purpose

Module	Function	Description	Challenge Addressed
Module 1	Project characterisation	Captures activity structure, resource pools, cost parameters, seasonal and weather data, traffic management windows, environmental permit conditions, and safety benchmarks.	Establishes multidimensional input base for all subsequent modules
Module 2	Feasibility and constraint screening	Applies hard constraints from labour law, union agreements, noise permits, and occupational health regulations, eliminating non-compliant scenarios before detailed analysis.	Addresses regulatory and human factors challenge categories
Module 3	Resource-constrained scheduling	Implements multi-mode RCPSP modelling each shift regime as a distinct execution mode with resource consumption, duration, productivity factor, and cost parameters across shared resource pools.	Addresses resource constraints and productivity challenges
Module 4	Stochastic simulation	Applies Monte Carlo simulation to propagate uncertainty through productivity, weather, equipment availability, and supply chain variables, producing probabilistic completion and cost profiles.	Addresses stochastic uncertainty and planning unreliability
Module 5	Safety and fatigue risk assessment	Embeds empirically grounded fatigue risk parameters for evening and night scenarios and enforces constraints on consecutive shift exposure and mandatory recovery time as planning rules.	Addresses all human factors challenge cluster
Module 6	Environmental compliance assessment	Evaluates noise generation against regulatory thresholds, identifies required mitigation measures, and incorporates mitigation costs into the scenario financial profile.	Addresses regulatory and environmental challenge cluster
Module 7	Multicriteria decision ranking	Integrates all module outputs into a configurable multicriteria decision analysis structure, ranking scenarios by weighted objectives reflecting project-specific priorities.	Integrates all challenge clusters into auditable ranked recommendation

Everything feeds into Module 7, which uses an AHP-TOPSIS engine to rank the five shift scenarios against four weighted objectives: schedule performance, cost efficiency, safety risk, and environmental compliance (Saaty 2008; Zavadskas and Turskis 2011). The decision-maker receives six outputs: probabilistic schedule profiles for each scenario, a full-cycle cost comparison, quantified safety risk scores, an environmental compliance assessment, a ranked scenario table with sensitivity analysis, and an auditable record of how the recommendation was reached. The outputs are designed to connect with BIM-based project management environments, supporting accountability to clients, regulators, and communities.

3.4.3 SSDSS Parametrisation for Offsite and Hybrid Construction

While the seven-module architecture applies across all project types, offsite and hybrid delivery requires distinct parametrisation. First, factory output cadence governs module delivery windows: Module 3 must synchronise with the manufacturing programme so that night installation shifts are triggered only when completed modules are confirmed available. Second, crane-share constraints are more acute in modular projects competing for specialist heavy-lift cranes; Module 3 must represent crane availability as a shared cross-project resource. Third, the tight sequence dependency between module setting and follow-on structural connections, MEP commissioning, and waterproofing amplifies the consequences of fatigue errors or noise enforcement stoppages, making Modules 5 and 6 particularly critical in OSC contexts (Li et al. 2025; Yuan et al. 2024; NYC DEP 2023). These parametric differences inform data inputs, constraint thresholds, and MCDM weight profiles without altering the underlying framework architecture.

3.4.4 Framework Contribution to Construction Practice

The SSDSS replaces intuitive shift decisions with structured AHP-TOPSIS analysis aligned with UK HSE HSG256 and CDM 2015 obligations (Saaty 2008; Zavadskas and Turskis 2011), representing an initial conceptual contribution with software prototyping and retrospective validation as the next research phases.

4. CONCLUSION AND PERSPECTIVES

Night shift operations are among the most consequential and least analytically supported decisions in construction project management. Current practice is systematically inadequate: deterministic scheduling tools cannot represent the productivity, safety, resource, and regulatory dimensions that determine whether night working will deliver its intended benefits. Eleven drivers across three categories and fourteen challenges across four categories, identified in structured tables, collectively demonstrate the complexity that existing tools cannot address. The SSDSS framework responds through a seven-module architecture that treats shift regime as a primary decision variable, places worker safety at the centre of planning, ensures environmental compliance is evaluated before commitment, and produces auditable recommendations across all project types.

Future research should formalise the SSDSS module logic, develop a software prototype, and validate it retrospectively against completed projects. Professional bodies should develop standardised shift strategy guidance applicable across project types, universities should incorporate it into construction management curricula, and clients should require structured shift strategy analysis in project planning submissions.

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