
# *Rapport de veille n° 66*

## BIM

**31/12/2024**

**Objectif :** *L'utilisation du BIM en phase de conception et de ses potentiels applications pour la prévention des risques*

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

# Table des matières

# 1. Article scientifique

**Focus : BIM et maquette numérique**
Salles Propres, novembre-décembre 2024, n°147, pp.31-47
Ce focus regroupe 3 articles sur le thème du BIM : les spécificités du BIM pour les installations de salles propres neuves et rénovées ; BIM : limites et bonnes pratiques d'utilisation ; les nouveaux outils BIM dans la conception des salles propres.

**Health and Safety Challenges in Bridge Construction: A Comprehensive Review of Workplace Accidents [PDF]**
F KONSTANDAKOPOULOU – Engineering World, December 2024, 6:277-290
DOI:10.37394/232025.2024.6.30
The construction of bridges is a critical component of infrastructure advancement; however, it is accompanied by considerable occupational risks. This review article investigates the common types, underlying causes, and repercussions of global accidents in bridge construction projects. The study of data derived from diverse case studies, industry analyses, and scholarly publications identifies prevalent risk factors, including falls from heights, equipment malfunctions, and structural failures. The discussion extends to the ramifications of these incidents on worker safety, project schedules, and financial implications. Additionally, the paper assesses existing safety measures and their efficacy in risk reduction. It also emphasizes innovative technologies and best practices that hold the potential for improving safety conditions in bridge construction. By integrating this information, a thorough insight into the industry's challenges and suggestions for strategies for enhancing safety protocols are provided. This research is vital in minimizing occupational hazards and
fostering safer work environments in bridge construction initiatives.

**Integrating Building Information Modelling (BIM) and Artificial Intelligence (AI) Technologies to Improve the Planning and Control Process of Construction Projects**
M Makhsusy, A Amirkardoust, D Sedaghat Shayegan - Civil and Project, 2024
DOI : 10.22034/cpj.2024.490357.1328
This research deals with the feasibility of integrating building information modeling (BIM) and artificial intelligence (AI) technologies to improve construction project planning and control processes. Examining successful construction projects shows that it is necessary to modify traditional planning methods; Because by using newer technologies such as BIM and AI, it is possible to reduce planning errors and thus affect project success. This research analyzes the advantages and different potentials of BIM and AI integration compared to traditional methods, discusses some useful BIM and AI tools for planning, and explains the possibility of their integration; Finally, the challenges of implementing these tools and suggestions for overcoming obstacles and future development are discussed. The result is that using BIM and AI integration tools can bring countless benefits (such as speeding up planning, more accurate forecasts, optimizing resources, and reducing risk) to the planning process. However, studies are still needed to facilitate the use of these technologies through adaptation, development of standard approaches, and education of construction industry stakeholders.

**Survey on the use of BIM methodology for railway 3D modeling**

A Malta, T Farinha, AJM Cardoso, M Mendes - Discover Applied Sciences, 2024, Volume 6, 657

DOI : https://doi.org/10.1007/s42452-024-06316-z

This article explores the development of Augmented Reality (AR) models for railway projects, as illustrated in Fig. 1, with particular emphasis on interoperability between different systems and platforms. The historical development of Building In- formation Modeling (BIM) is traced from its origins in computer-aided de- sign (CAD) to its recent applications in diverse fields. Significant milestones and the evolution of BIM into project lifecycle management are highlighted. Fundamental aspects such as Level of Development (LOD) and Industry Foundation Classes (IFC) file types are reviewed. The integration of BIM with machine learning and AR has enormous po- tential to improve asset management and decision-making in railway projects. The importance of interoperability when integrating AR into railway projects using BIM methodology, highlighting tools and models that ensure seamless operation across various platforms and software systems, is discussed. Stan- dards such as ISO 19650 and ISO 16739 are fundamental in this context. Studies that demonstrate the advantages of BIM in railway projects, in- cluding cost control, error detection and better maintenance planning, are reviewed. The challenges and opportunities associated with integrating BIM into rail are discussed, including the importance of technological advances in promoting increasingly efficient, collaborative and sustainable maintenance projects. This research is important for advancing the study and development of integration and compatibility with new technologies, specifically in the con-text of the use of BIM methodologies in railways, particularly in locomotives and carriages, and the application of AR, making a significant contribution to the fields of computer engineering, maintenance engineering and others.

**Automated identification of hazardous zones on construction sites using a 2D digital information model**

J Cho, J Shin, J Jang, TW Kim - Automation in Construction, Volume 170, February 2025

DOI : https://doi.org/10.1016/j.autcon.2024.105922

Construction sites are high-risk environments owing to the dynamic changes and improper placement of temporary facilities, requiring comprehensive safety management and spatial hazard analyses. Existing construction site layout planning (CSLP) studies have limitations in identifying hazardous zones and accommodating the flexibility stakeholders require. This paper introduces a site information model framework to define digital objects and relationships in the CSLP, proposing methods to identify automatically unsafe spaces by considering facility hazards and visibility. By establishing ontological relationships and developing algorithms to quantify risk in unoccupied spaces, the framework identifies unsafe spaces in alignment with the perceptions of safety practitioners. Case studies at four sites demonstrated the reliability of the framework with a high precision, recall, and an F1-score of 0.945. This framework allows safety practitioners to evaluate systematically and improve site layouts during the preconstruction phase. Future integration with scheduling information could enhance the spatiotemporal hazard analysis and contribute to safer construction sites.

**BIM adoption predictors for health and safety management among construction SMEs**

N Sila, JN Agumba, OJ Adebowale - Construction Innovation, 2024

DOI : https://doi.org/10.1108/CI-04-2024-0100

Health and safety (H&S) management remains a significant global challenge in the construction industry. Small and medium enterprises (SMEs) particularly struggle to comply with H&S regulations, resulting in high accident records. To address this poor performance, experts suggest that SMEs adopt H&S management technologies, particularly building information modeling (BIM), due to their potential to improve H&S practices. This study aims to determine the key predictors of construction SMEs' intentions to adopt BIM for H&S management. The study also explores the potential impact of selected demographic variables on

construction SMEs' adoption intentions. Quantitative research was used using a questionnaire distributed to 357 randomly sampled SMEs. The questionnaire collected data regarding SMEs' intention to adopt BIM for H&S management. Binary logistic regression analysis was used to analyze the research data. The findings reveal specific "relative advantages", which include "BIM for H&S management will be preferable to the manual use of the H&S file" and "BIM for H&S management will make it easier to comply with H&S regulations" as significant predictors of the intention to adopt BIM for H&S management. The study also underscores the significance of educational qualifications and professional affiliation as predictors of BIM adoption.

**Exploring the Intersection of Building Information Modeling (BIM) and Artificial Intelligence in Modern Infrastructure Projects [PDF]**

RO Ajirotutu, AB Adeyemi, GO Ifechukwu, TC Ohakawa… - International Journal of Science and Research Archive, 2024, 13(02), 14 p.

DOI: https://doi.org/10.30574/ijsra.2024.13.2.2421

The integration of Building Information Modeling (BIM) and Artificial Intelligence (AI) is revolutionizing infrastructure development, offering innovative solutions for design, construction, and operational challenges. This study explores the synergy between BIM and AI, examining their conceptual framework, impact on sustainability and decision-making, and the challenges associated with their integration. Through a comprehensive review of recent literature and industry practices, the study elucidates the transformative potential of these technologies in modern infrastructure projects. The findings reveal that BIM and AI enhance project efficiency, resource management, and stakeholder collaboration by leveraging AI's predictive analytics and automation alongside BIM's digital modeling capabilities. These technologies enable precise resource allocation, dynamic risk mitigation, and sustainable energy solutions, aligning infrastructure projects with global environmental goals. However, challenges such as data interoperability, high implementation costs, and ethical concerns remain significant barriers to their widespread adoption. The study underscores the need for industry-wide data standards, advanced cybersecurity frameworks, and targeted workforce upskilling to address these challenges. Future trends identified include the integration of generative AI, blockchain technology, and the Internet of Things (IoT) into BIM systems, promising to further enhance the scope and functionality of these technologies. These advancements hold the potential to redefine infrastructure practices, driving innovation and sustainability. In conclusion, BIM and AI represent a paradigm shift in infrastructure development, fostering efficiency, sustainability, and resilience. It is recommended that stakeholders invest in research, adopt ethical AI practices, and build collaborative ecosystems to fully realize the benefits of these technologies. By addressing identified challenges and embracing emerging trends, BIM and AI can become foundational tools in achieving sustainable and technologically advanced infrastructure solutions.

**Smart Construction Management Using AI [PDF]**

AR Mohammed - International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, Vol. 12, Issue 11, November 2024

DOI: 10.17148/IJIREEICE.2024.121103

Smart construction management harnesses artificial intelligence (AI) to address inefficiencies and challenges in modern construction projects, enhancing scheduling, resource allocation, and decision-making processes. By leveraging AI technologies such as machine learning (ML), natural language processing (NLP), and computer vision, construction managers can optimize workflows, monitor progress in real-time, and predict potential issues before they occur. This research explores how AI-driven tools transform key aspects of construction management, from improving safety and quality control to reducing costs and delays. Case studies highlight the practical applications of AI, including predictive maintenance, dynamic task adjustments, and automated

inspections, demonstrating significant improvements in project outcomes. Despite its benefits, the adoption of AI in construction faces challenges such as data integration, high implementation costs, and the need for specialized skills. The paper discusses potential solutions to these challenges and outlines future opportunities for AI in smart construction management.

**Agent-based simulation framework for enhanced construction site risk estimation and safety management**

T Sorbi, V Getuli, P Capone, FP Rahimian - ournal of Information Technology in Construction, Volume 29, 2024, pp. 1219-1238

DOI : 10.36680/j.itcon.2024.054

Despite ongoing efforts to boost safety through new regulations and technologies, the construction industry still grapples with significant safety and accident issues. Construction sites are complex and dynamic environments, teeming with workers, vehicles, and machinery engaged in various activities. This complexity often leads to unpredictable hazardous events, making safety management a challenging task heavily reliant on the experience of safety managers. This paper introduces a framework to aid safety managers in risk assessment by developing an advanced simulation system. The system merges 4D Building Information Modeling (BIM) Simulation with 3D Agent-Based Modeling and Simulation (ABMS) within a game engine environment. This integration allows for the simulation of various entities (agents) and their interactions on a construction site, offering a detailed view of potential hazards. The proposed system features an automatic Prevention through Design (PtD) method. This method predicts hazards by analyzing the likelihood of occurrence, vulnerability, and exposure values during the planning phase. It simulates agent behaviors, records interactions leading to hazardous events, and visualizes these interactions as hazard exposure heatmaps in the 4D BIM model. The model reflects various site configurations over time, helping safety managers to strategically organize activities and workspaces to minimize risks. The framework follows the ISO 31000:2018 risk definition and addresses the complexity of construction site systems and their risk management issues. It discusses the key components of the framework, including the rules of agent behavior based on game theory, management of BIM data for 3D scenario creation, and a detection and visualization system for monitoring agent interactions. Overall, this framework seeks to enhance risk assessment effectiveness in the construction industry by leveraging BIM and advanced simulation techniques to provide valuable insights for improving site safety management.

**Formalizing virtual construction safety training: a schematic data framework enabling real-world hazard simulations using BIM and location tracking [PDF]**

K Speiser, J Teizer - ournal of Information Technology in Construction, December 2024, Vol. 29, pp. 980-1004

DOI: 10.36680/j.itcon.2024.043

Virtual construction safety training (VCST) as an active training method has considerable potential to be more effective than existing passive learning methods. VCST can also become equivalent to or part of on- the-job training once the system has been tested and is comparable to real-world training methods. However, including such real-world scenarios is commonly integrated into VCST by experts creating made-up scenarios. This approach requires considerable resources from different domains and may not represent the scenarios with sufficient realism, risking the relevance of and efforts spent on creating the training system. Despite several existing approaches to integrate real-world data, no formalization of the relevant Data Modeling (DM) concepts, their relations, and their functionalities within VCST have been published. Such a formalization, however, can ease the creation of training developers and enable them to simulate scenarios from real-world construction sites. This research proposes that VirtualSafeConDM formalize such concepts using existing ontologies. VirtualSafeConDM is developed using an existing data schema development method based on the

Linked Open Term methodology. It comprises four steps: (a) Specification of requirements as Competency Questions (CQs), (b) knowledge acquisition and conceptualization from existing ontologies such as IfcOwl or a hazard ontology, (c) implementation in a C# library for the game engine Unity, and (d) the evaluation of the proposed VirtualSafeConDM. The evaluation contains a manifold qualitative approach. The consistency of the VirtualSafeConDM is evaluated through consistency checks. The extendibility and clarity are evaluated using a qualitative criteria-based method. Last, the usability and coverage are evaluated using a task-based method of answering the CQs. This task-based evaluation approach includes the creation of a real-world hazard-integrated virtual training environment (RHI-VTE) based on a metro renovation project in Germany. The authors recreated a task where a worker and several machines were active. The case study demonstrates that VirtualSafeConDM connects to real-world data sources using an as-built Building Information Modeling (BIM) model and Real-Time Location System (RTLS) data to expose trainees to hazards based on historical real-world construction activities. This integration formalizes hazard entities, allowing for comprehensive behavior analysis. Secondly, VirtualSafeConDM ensures efficient knowledge transfer across construction domains and use cases.

**The Present and Future of Smart Construction Technologies**

MJ Skibniewski - Engineering, 2024

DOI : https://doi.org/10.1016/j.eng.2024.12.024

The construction industry is undergoing a profound transformation, driven by the integration of advanced technologies that enhance productivity and economic efficiency [1]. To date, smart or intelligent construction has been developing within the framework of Industry 4.0, with the collection of automation and information technologies intended to accomplish the objectives of this transformation being known as “Construction 4.0” [2]. Smart/intelligent construction technologies encompass a range of innovations, including building information modeling (BIM), the Internet of Things (IoT), robotics, and professional decision support based on artificial intelligence (AI). This article explores the current state of these technologies in the construction sector and anticipates future developments and their implications worldwide.

**Transforming construction: digital twin technology for site monitoring and optimization in Denmark [PDF]**

M Jradi - Smart Construction. 2024(3):0015

DOI : https://doi.org/10.55092/sc20240015

Digital twin (DT) technology is revolutionizing the construction industry by creating real-time digital replicas of physical assets, enabling enhanced monitoring, optimization, and decision-making. In Denmark, the integration of DTs aligns with national objectives for sustainability and digital innovation, supported by collaborative efforts among research institutions, government, and industry stakeholders. Despite significant progress, several challenges persist, including integrating diverse data sources, ensuring cybersecurity, and managing implementation costs. Addressing these barriers is critical to scaling DT adoption and maximizing its potential in construction applications. This paper anticipates significant advancements, such as AI-driven predictive analytics, integration with circular economy practices, and the establishment of open standards to ensure seamless interoperability. The findings demonstrate how Denmark's DT initiatives are reshaping the construction landscape, offering practical insights into overcoming barriers and advancing sustainability goals. In conclusion, Denmark’s proactive adoption of DT technology serves as a blueprint for leveraging innovation to create smarter, more sustainable construction practices, setting a benchmark for global efforts in this domain.

## 2. Conférence / ouvrage / thèse

**Multi-level and collaborative planning and control of construction sites using BIM and Lean (Planification et contrôle multi-niveaux et collaboratifs des chantiers de construction à l'aide de la BIM et du Lean)**

M Sheikhkhoshkar – Thèse, Université de Lorraine, 2024, 293 p. (En anglais)

HAL : https://hal.univ-lorraine.fr/tel-04813923v1

La gestion efficace des projets de construction est essentielle en raison de leur complexité inhérente et des implications financières substantielles. À cet égard, la planification et le contrôle des projets jouent un rôle crucial dans la réussite de l'exécution des projets, nécessitant des décisions basées sur les données et les connaissances pour naviguer dans ces complexités et garantir des résultats positifs. Malgré la présence de divers systèmes de planification et de contrôle, une planification et un contrôle inefficaces restent des causes majeures de faible productivité, de dépassements de budget et de retards dans les projets de construction. L'intégration des systèmes de planification et de contrôle existants peut remédier à ces problèmes en agrégant les avantages de chacun. Cependant, un écart significatif subsiste en raison de l'absence d'un cadre intégré et multi-niveaux combinant différentes méthodes de planification et métriques de contrôle à travers divers niveaux d'échéancier, tirant parti des forces de chacun pour offrir une solution plus efficace. De plus, il existe une insuffisance de systèmes basés sur les données et les connaissances qui répondent aux besoins spécifiques et aux applications des équipes de projet en matière de planification et de contrôle, proposant des solutions multi-niveaux optimisées. Cette étude vise à combler cette lacune en développant d'abord un cadre intégré et multi-niveaux pour la planification et le contrôle des projets. Ensuite, elle développe et met en œuvre un système d'aide à la décision (SAD) basé sur les données et les connaissances, qui exploite une base de connaissances construite à partir des expériences des experts. Ce système propose des solutions multi-niveaux et intégrées pour la planification et le contrôle des projets de construction, améliorant à la fois les cadres théoriques et les applications pratiques. Le SAD développé simplifie le processus de prise de décision en posant des questions simples et pertinentes adaptées aux besoins de l'équipe de projet, suggérant ainsi les approches les plus appropriées pour la planification et le contrôle des projets. Le cadre et le système d'aide à la décision développés ont été validés en les appliquant à une étude de cas de rénovation et en recevant des retours positifs de la part des experts. Enfin, une directive méthodologique détaillée a été élaborée pour faciliter la mise en œuvre du système de planification et de contrôle multi-niveaux recommandé par le SAD pour les projets de rénovation. Cette directive offre des instructions claires et étape par étape pour assurer une adoption simple et une intégration efficace dans les pratiques de gestion de projet. Cet outil polyvalent peut être appliqué à divers types de projets durant la phase de préconstruction, déterminant les stratégies de planification et de contrôle les plus efficaces en fonction des exigences fonctionnelles de l'équipe de projet.

**Construction Site Risk Assessment Through Digital Twins for Safety Optimization**

ASEP Zitiello, M Nicolella - In: Calabrò, F., Madureira, L., Morabito, F.C., Piñeira Mantiñán, M.J. (eds) Networks, Markets & People. NMP 2024. Lecture Notes in Networks and Systems, vol 1189. Springer, Cham, pp. 348-357

DOI : https://doi.org/10.1007/978-3-031-74723-6_30

The organization of construction sites involves analyzing and managing all activities necessary for the realization of a project, aiming to reduce time and enhance safety. Standardizing construction site risk assessment processes is difficult due to the diverse morphologies and construction types of civil works. The results of research highlight the importance of digitization, particularly through Building Information Modeling,

in organizing construction sites, for both new and historical buildings. This approach helps address issues that may arise with traditional methods. This research specifically focuses on safety checks at construction sites, performed using a new application that simulates activities in a three-dimensional manner.

**Safety Management And Competency-Based Learning Trough Building Information Modeling In Construction Project Management**

T Mandičák, M Spišáková - ICERI2024 Proceedings, 2024

DOI : 10.21125/iceri.2024.0448

Safety management and competence enhancement should be based on reliable information that supports decision-making in the management of construction projects. The process of increasing knowledge and Competency-based Learning through the use of selected digital technologies can be one of the key performance indicators. Risk management at work through simulation and the use of building information modeling should contribute to better results based on Competency-based Learning of project managers. Research focused on the use of these technologies and their impact on increasing the skills, knowledge and decisions of managers are the subject of this research. The basic hypothesis of the research was to verify the claim that Competency-based Learning through Building Information Modeling technology has an impact on the level of safety. The research was carried out in Slovakia, Slovenia and Croatia. 199 respondents representing the construction project took part in the research. Correlation analysis was used to examine the impacts on the safety of construction projects.

**Research on Risk Management of Engineering Projects Based on Building Information Model (BIM) Technology**

Y Bian, Q Liao, Y Shi, X Zhang – In Proceedings of ICEMGD 2024 Workshop: Innovative Strategies in Microeconomic Business Management, 2024

DOI : https://doi.org/10.54254/2754-1169/115/2024BJ0224

With the rapid development of the construction industry, the application of BIM technology has gradually become key to improving the efficiency of construction management. This paper, focusing on the issues existing in the risk management of engineering projects, conducts research and discussion based on BIM technology. Through in-depth analysis of the application of BIM technology in the risk management of engineering projects, combined with case studies, the advantages and roles of BIM technology in risk management are explored. The research results show that the application of BIM technology can effectively improve the efficiency and accuracy of engineering project risk management, reduce the possibility of risk occurrence, and provide important support for the smooth implementation of engineering projects. This paper also discusses the specific application of BIM technology in risk management and analyzes and proposes solutions to the challenges that may be encountered in the implementation process. Through the research of this paper, BIM technology provides good ideas and methods for the risk management of engineering projects and has a certain reference value for improving the management level of engineering projects and ensuring the smooth implementation of engineering projects.

**Evaluating Barriers, Benefits, And Mitigation Strategies For Safety Equipment In The Construction Industry [PDF]**

SD Datta, S Mazumder, S Hossain, P Goon - 7th International Conference on Advances in Civil Engineering (ICACE2024), 12-14 December 2024, CUET, Chattogram, Bangladesh, 8 p.

https://icace2024.cuet.ac.bd

Construction accidents and the construction industry are two sides of the same coin. Every year, workers die or

get injured due to inevitable reasons such as electrocution, falling from heights, being struck by heavy items, and suffocation. The objective of this paper is to identify the importance and usability of safety equipment to mitigate barriers, discuss the benefits and barriers of using smart safety equipment, and make suggestions for overcoming the challenges at construction sites all over Bangladesh. The study was done in three stages. First, a detailed literature review was conducted to identify potential barriers and benefits of construction accidents. The data was used to generate a Likert scale questionnaire, followed by a survey of construction sites throughout Bangladesh, where about 150 people responded to fill out the forms. The elements influencing construction site safety performance were found by a questionnaire survey, which was assessed using RII criteria and validated using the Cronbach alpha test. The result shows that uncertainty about the safety equipment platform (RII = 0.938), fear of the negative impact on the business and low success due to the investment of time to learn new technology (RII = 0.905), and the initial high cost of safety equipment (RII = 0.897) are the topmost barriers affecting construction safety. On the other hand, the topmost benefits of construction safety are decreased life and health risk (RII=0.985), decreased physical injuries (RII = 0.977), and improved productivity (RII = 0.969). In addition, significant mitigation strategies for barriers include implementing various safety equipment and innovative technologies like RTLS, BIM and VCS systems can be implemented in construction fields. The paper's findings will help overcome the barriers, and the benefits can be ensured. Moreover, the health risks to workers will be greatly reduced by taking measures.