Proceedings of the 10th International Conference On Civil Structural and Transportation Engineering (ICCSTE 2025)
July, 2025 | Imperial College London Conference Center, London, United Kingdom
Paper No. 330
DOI: 10.11159/iccste25.330

Towards Sustainable Construction: A Simulation-Driven Evaluation of a 3D-Printed Building for DGNB Certification

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Extended Abstract

Green Buildings (GB) as a pathway to sustainability have emerged as a key solution to address the environmental impact of buildings throughout their lifecycle. GB certification systems offer a performance framework to achieve sustainability based on pre-assumed parameters during the construction and operation phases. This paper examines a case study of the German Sustainable Building Council (DGNB)'s New Construction International system as a certification body for a 3D-printed research building. The key towards evaluating certification criteria includes the three sustainability pillars: environmental, economic, and sociocultural quality [1]. Multiple simulation software programs were used to assess different aspects of building design to verify certification prior to construction initiation. Thermal simulation utilized DesignBuilder integrated with EnergyPlus to assess envelope performance, specifically cooling demand under hot and arid conditions. Visual comfort and accessibility were evaluated through DIAlux Evo with scene-specific lighting simulation and ISO 21542 compliance walkthroughs, verifying principles of inclusive design being matched [2]. A Life Cycle Costing (LCC) analysis was performed using an interconnected Excel tool. Calculating the cost of construction, whole life cost, and maintenance projections introspective of the economic conditions of the region were also part of this study. Project results provide an evaluation of holistic building potential to be DGNB certified, suggesting optimization strategies based on results to ensure performance improvement across all required categories [3]. Calculated results reveal enhanced performance in thermal comfort with 0 unmatched cooling hours achieved, indicating optimal indoor temperatures. Adaptive comfort standards revealed through simulation alignment with ASHARE 55 confirming high occupant satisfaction potential [4]. Analysis conducted on Computational Fluid Dynamics (CFD) confirmed efficient air circulation with improvements recommended for solar shading along exposed façades. Muscat's Extreme summers show peak cooling demands through energy simulation reports with the projected Energy Usage Intensity (EUI) being 355.77 kWh/m^2/year. Visual comfort simulation showed compliance with uniformity and emergency lighting requirements for each building zone. Initial LCC revealed that 71% of the cost stem from initial construction procedure. Renewable energy integration reduces the long-term operational costs net impact by 42% enhancing overall economic feasibility. Assessment towards material procurement found that over 95% of construction components were locally sourced, minimising transport emissions according to DGNB. The 3D printed concrete mix utilised incorporates CEMEX D.fab additives that reduce embodied carbon to 320 CO_2 eq/m^3 for the same standard mortar volume [5]. This demonstrates the value of simulation-based planning towards DGNB certification in hot climate zones like Oman Moreover, the project aligns with the United Nations Sustainable Development Goals (SDGs) [6] and supports the strategic objectives of Oman Vision 2040 [7], particularly in promoting sustainable urban development, innovation in construction technologies, and responsible resource management.

Keywords: Green building, German Sustainable Building Council. Life cycle costing, 3D printed building, United Nations Sustainable Development Goals, Oman Vision 2040

References

[1] D. T. Doan, A. Ghaffarianhoseini, N. Naismith, T. Zhang, A. Ghaffarianhoseini, and J. Tookey, "A critical comparison of Green Building Rating Systems," Building and Environment, vol. 123, pp. 243-260, 2017. [Online]. Available: https://doi.org/10.1016/j.buildenv.2017.07.007

[2] I. T. Steffan and M. A. Klenovec, "EU Standardization. Mandate 420 - Accessibility in the Built Environment Following a Design for All Approach," in Proc. 20th Congress of the International Ergonomics Association (IEA 2018), Advances in Intelligent Systems and Computing, vol. 824, S. Bagnara, R. Tartaglia, S. Albolino, T. Alexander, and Y. Fujita, Eds. Cham: Springer, 2019. [Online]. Available: https://doi.org/10.1007/978-3-319-96071-5_154

[3] A. Z. Hamedani and F. Huber, "A comparative study of DGNB, LEED and BREEAM certificate systems in Urban Sustainability," WIT Transactions on Ecology and The Environment, 2012. [Online]. Available: https://doi.org/10.2495/sc120111

[4] A. Baghaei Daemei, A. K. Limaki, and H. Safari, "Opening Performance Simulation in Natural Ventilation Using Design Builder (Case Study: A Residential Home in Rasht)," Energy Procedia, vol. 100, pp. 412-422, 2016. [Online]. Available: https://doi.org/10.1016/j.egypro.2016.10.196

[5] M. D. Shaharul, S. Abu Bakar, N. Mat Saad, M. D. U. Hossain Uzir, and S. Shah Alam, "A conceptual model for the adoption of Green Building Technology in the construction industry," Journal of Sustainability Science and Management, vol. 19, no. 2, pp. 228–241, 2024. [Online]. Available: https://doi.org/10.46754/jssm.2024.02.012

[6] S. Goubran, T. Walker, C. Cucuzzella, and T. Schwartz, "Green building standards and the United Nations' Sustainable Development Goals," Journal of Environmental Management, vol. 326, p. 116552, 2023. [Online]. Available: https://doi.org/10.1016/j.jenvman.2022.116552

[7] A. Amoatey, A. Al-Nadabi, M. Chen, M. R. Nikoo, A. Al-Maktoumi, A. Al-Hinai, and A. Izady, "Transition to sustainable hydrogen energy in Oman: Implication for future socio-economic transformation and environmental well-being," Environment, Development and Sustainability, 2024. [Online]. Available: https://doi.org/10.1007/s10668-024-04657-8