CURRENT RESEARCH JOURNAL OF HISTORY (ISSN: 2767-472X)

VOLUME: Vol.07 Issue04 2026
Page: - 01-06

RESEARCH ARTICLE OPEN ACCESS

Emergence of Computational Building Practices in Northwestern United States: Wood-Based Structures Within Automated Environments

Dr. Omar Al-Hakimi

Department of Artificial Intelligence King Fahd University of Petroleum and Minerals Dhahran, Saudi Arabia

Dr. Layla Al-Mansouri

Department of Computer Science Qatar University Doha, Qatar

Received: 08 February 2026 **Accepted:** 05 March 2026 Published**:** 01 April 2026

ABSTRACT

The transformation of architectural production in the Northwestern United States reflects a convergence of computational design methodologies, automated fabrication processes, and the resurgence of wood-based construction systems. This research examines how computational building practices are reshaping the material, economic, and socio-technical dimensions of construction, particularly through the integration of mass timber within automated environments. The study situates this transformation within broader historical trajectories of mechanization and digitalization, highlighting how emerging technologies such as Building Information Modeling (BIM), platform-based coordination systems, and data-driven fabrication pipelines are redefining the role of labor, material sourcing, and spatial production.

Drawing on interdisciplinary literature spanning architectural theory, digital labor studies, and control systems in built environments, this paper analyzes how automation interacts with regional ecological resources and industrial infrastructures. The Northwestern United States provides a unique context due to its historical reliance on timber economies and its contemporary position as a hub for digital innovation. The research identifies how computational workflows enable new forms of precision, scalability, and integration across design and construction phases, while also introducing new dependencies on data infrastructures and global supply chains.

The study further explores the implications of automation for labor restructuring, environmental sustainability, and regional economic development. While computational building practices promise efficiency and reduced material waste, they also raise concerns regarding labor displacement, technological centralization, and ecological externalities. Through critical analysis, the paper demonstrates that wood-based automated construction systems embody both opportunities and contradictions, particularly in balancing ecological benefits with industrial intensification.

The findings reveal that the integration of computational systems in timber construction is not merely a technological shift but a systemic reconfiguration of architectural production. The paper concludes by outlining future research directions, emphasizing the need for adaptive governance frameworks, equitable labor models, and sustainable material cycles to ensure that automated building practices contribute to resilient and inclusive development.

Keywords: Computational construction, automated fabrication, mass timber, digital architecture, building information modeling, labor transformation, regional development, sustainable materials.

INTRODUCTION

The evolution of construction practices in the Northwestern United States reflects a broader global transition toward digitally mediated production systems. Historically, the region has been characterized by a strong reliance on timber industries, supported by extensive forest resources and industrial processing infrastructures (Hirt, 1994; Loomis, 2016). However, the emergence of computational building practices has introduced new paradigms that integrate digital design, automated fabrication, and data-driven coordination into the construction process. This shift represents not only a technological advancement but also a transformation in the underlying logic of architectural production.

The integration of computational tools such as Building Information Modeling (BIM) and algorithmic design platforms has enabled unprecedented levels of precision and coordination across multiple stages of construction (Braun et al., 2022; Boeva et al., 2024). These tools facilitate the seamless translation of digital models into physical structures, thereby reducing inefficiencies and enabling complex geometries that were previously difficult to achieve. In parallel, automated fabrication technologies, including robotic assembly and prefabrication systems, have redefined the boundaries between design and construction, creating a continuous digital workflow (Kieran & Timberlake, 2004; Broadhurst et al., 2008).

Within this context, wood-based construction systems—particularly mass timber—have gained renewed prominence. Engineered wood products such as cross-laminated timber (CLT) offer structural capabilities comparable to traditional materials like steel and concrete, while also providing environmental benefits through carbon sequestration and reduced embodied energy (Lee, 2020). The integration of computational design with timber construction enables optimized material usage and enhanced performance, aligning with broader sustainability goals.

Despite these advancements, the transition toward automated building environments raises critical questions regarding labor, governance, and ecological impact. The increasing reliance on digital platforms and automation has significant implications for labor structures, potentially displacing traditional construction workers while creating new forms of digital labor (Arantes, 2019; Benanav, 2020). Moreover, the centralization of computational infrastructures introduces new forms of dependency and control, raising concerns about equity and accessibility in the construction industry.

The Northwestern United States serves as a particularly relevant case study due to its unique intersection of technological innovation and natural resource availability. The region's proximity to major technology hubs, combined with its historical expertise in timber production, creates a fertile environment for the development of computational building practices (Levenda & Mahmoudi, 2019). This convergence highlights the interplay between digital economies and material landscapes, illustrating how technological advancements are embedded within specific geographical and socio-economic contexts.

The primary objective of this research is to analyze the emergence of computational building practices in the Northwestern United States, with a focus on wood-based structures within automated environments. The study aims to identify the key drivers of this transformation, examine its implications for labor and sustainability, and evaluate the challenges associated with integrating digital technologies into traditional construction systems.

The scope of the research encompasses theoretical, technical, and practical dimensions of computational construction. By synthesizing insights from architecture, engineering, and socio-economic studies, the paper seeks to provide a comprehensive understanding of how automation is reshaping the built environment. The significance of this research lies in its potential to inform future policy and design strategies, ensuring that technological advancements contribute to sustainable and equitable development.

LITERATURE REVIEW

The literature on computational building practices reveals a complex interplay between technological innovation, material transformation, and socio-economic restructuring. Early studies on mechanization in architecture emphasize the historical continuity between industrial production and contemporary digital fabrication (Giedion, 1970). This perspective highlights how automation represents an extension of long-standing efforts to standardize and optimize construction processes.

Recent research has focused on the role of digital platforms and data-driven systems in reshaping construction practices. Braun et al. (2022) argue that the transition from digital design to data assets represents a fundamental shift in value creation, where information becomes a central resource in the construction process. Similarly, Boeva et al. (2024) analyze the platformization of the built environment, emphasizing the political and economic implications of centralized digital infrastructures.

Event-triggered and automated control systems, although primarily studied in engineering contexts, provide valuable insights into the coordination mechanisms underlying computational construction (Nowzari et al., 2019; Heemels et al., 2013). These studies highlight how decentralized systems can achieve coordinated behavior through adaptive control strategies, offering parallels to the coordination of distributed construction processes.

The integration of timber construction within automated environments has been explored in both technical and socio-economic contexts. Lee (2020) examines the environmental benefits of mass timber, while Duvernay (2022) and Elias (2022) highlight the economic opportunities associated with expanding timber production. These studies underscore the potential of wood-based systems to support sustainable development, particularly in regions with abundant forest resources.

At the same time, critical perspectives emphasize the challenges associated with automation and digitalization. Arantes (2019) and Benanav (2020) analyze the impact of automation on labor, arguing that technological advancements often lead to increased precarity and inequality. Irani (2015) further highlights the hidden labor involved in maintaining digital systems, drawing attention to the often-overlooked human contributions behind automated processes.

Environmental considerations also play a central role in the literature. Ensmenger (2018) and Cubitt (2017) explore the ecological implications of digital technologies, emphasizing the resource-intensive nature of data infrastructures. These studies challenge the assumption that digitalization inherently leads to sustainability, highlighting the need for a more nuanced understanding of environmental impact.

The literature also identifies significant research gaps. While there is extensive research on digital construction technologies and timber systems, there is limited integration of these perspectives within a unified framework. Furthermore, existing studies often focus on either technical or socio-economic dimensions, without adequately addressing their interdependencies.

This research seeks to address these gaps by providing a comprehensive analysis of computational building practices in the Northwestern United States, integrating technical, environmental, and socio-economic perspectives.

METHOD

Theoretical Foundations of Computational Construction

Computational construction is grounded in the integration of algorithmic design, data-driven decision-making, and automated fabrication. The theoretical foundation draws from control theory, systems engineering, and architectural theory, emphasizing the role of feedback loops and adaptive systems in coordinating complex processes (Nowzari et al., 2019). These principles enable the synchronization of multiple agents within a construction environment, ensuring efficiency and consistency.

Digital Design and Automation Frameworks

The adoption of BIM and parametric design tools facilitates the creation of highly detailed digital models that serve as the basis for automated fabrication. These models enable real-time updates and coordination across different stakeholders, reducing errors and improving efficiency (Braun et al., 2022). The integration of cloud-based platforms further enhances collaboration, enabling distributed teams to work seamlessly.

Wood-Based Construction in Automated Systems

Mass timber systems represent a key application of computational construction. The use of prefabricated components allows for rapid assembly and reduced waste, while digital tools enable precise customization. The environmental benefits of timber construction are complemented by its compatibility with automated fabrication processes (Lee, 2020).

Labor Transformation and Socio-Economic Impacts

Automation reshapes labor dynamics by reducing the need for manual labor while increasing demand for digital skills. This transition creates both opportunities and challenges, particularly in terms of workforce adaptation and equity (Benanav, 2020).

Environmental and Material Considerations

The integration of computational systems with timber construction offers potential sustainability benefits. However, the environmental impact of digital infrastructures must also be considered, highlighting the need for holistic approaches to sustainability (Cubitt, 2017).

RESULTS

The analysis reveals that computational building practices significantly enhance efficiency and precision in construction processes. The integration of digital design tools with automated fabrication systems enables the seamless translation of complex architectural models into physical structures. This capability reduces material waste and construction time, particularly in the context of prefabricated timber systems.

A key finding is the central role of data in coordinating construction activities. Digital platforms facilitate real-time communication and decision-making, enabling adaptive responses to changing conditions. This capability is particularly important in environments characterized by uncertainty, such as fluctuating material availability or variable site conditions.

The study also identifies the growing importance of timber as a sustainable construction material. Mass timber systems not only reduce carbon emissions but also support regional economies by leveraging local resources. However, the scalability of these systems depends on the availability of advanced manufacturing facilities and skilled labor.

Another significant finding is the impact of automation on labor dynamics. While automation reduces the need for traditional construction labor, it creates new opportunities in areas such as digital modeling, data analysis, and system management. This shift highlights the need for targeted education and training programs to support workforce transition.

Finally, the research underscores the importance of integrating environmental considerations into computational building practices. While digital technologies offer efficiency gains, their environmental impact must be carefully managed to ensure sustainable outcomes.

DISCUSSION

The findings highlight the transformative potential of computational building practices, while also revealing significant challenges. The integration of digital technologies and timber construction represents a promising pathway toward sustainable development, but it requires careful coordination across multiple domains.

From a theoretical perspective, the study reinforces the relevance of systems-based approaches to construction. The ability to coordinate distributed agents through digital platforms aligns with principles of control theory, suggesting new opportunities for optimizing construction processes.

However, the socio-economic implications of automation cannot be overlooked. The displacement of traditional labor and the concentration of technological expertise raise concerns about inequality and access. These issues must be addressed through inclusive policies and education initiatives.

Environmental considerations also play a critical role. While timber construction offers significant sustainability benefits, the environmental impact of digital infrastructures must be taken into account. This dual perspective highlights the need for integrated approaches that consider both material and digital systems.

CONCLUSION

This research demonstrates that the emergence of computational building practices in the Northwestern United States represents a fundamental transformation in architectural production. The integration of digital design, automated fabrication, and timber construction creates new opportunities for efficiency, sustainability, and innovation.

However, this transformation also introduces significant challenges, particularly in terms of labor, governance, and environmental impact. Addressing these challenges requires a holistic approach that integrates technical, social, and ecological perspectives.

Future research should focus on developing adaptive frameworks that support equitable and sustainable development, ensuring that the benefits of computational construction are widely distributed.

REFERENCES

1. A. T. Anderson, “Operation breakthrough housing in the pacific northwest,” Pacific Northwest Quart., vol. 112, no. 4, pp. 161–170, 2021.

2. P. F. Arantes, The Rent of Form: Architecture and Labor in the Digital Age. Minneapolis, MN, USA : Univ. of Minnesota Press, 2019.

3. “Autodesk.” Mackenzie. Accessed: Jan. 14, 2023. [Online]. Available: https://mackenzie.inc/project/autodesk

4. D. Beekman and D. Gutman, “Snoqualmie tribe says Forterra misled it, feds in $20M grant application,” Seattle Times, Sep. 30, 2022. Accessed: Oct. 17, 2022. [Online]. Available: https://www.seattletimes.com/seattle-news/times-watchdog/snoqualmie-tribe-says-forterra-misled-it-feds-in-20-million-grant-application/

5. A. Benanav, Automation and the Future of Work. London, U.K. : Verso, 2020.

6. K. Braun, C. Kropp, and Y. Boeva, “From digital design to data-assets: Competing visions, policy projects, and emerging arrangements of value creation in the digital transformation of construction,” Historical Social Res., vol. 47, no. 3, pp. 81–110, 2022, doi: 10.12759/hsr.47.2022.27.

7. Y. Boeva, K. Braun, and C. Kropp, “Platformization in the built environment: The political techno-economy of building information modeling,” Sci. Culture, vol. 33, no. 2, pp. 146–173, 2024, doi: 10.1080/09505431.2023.2237042.

8. R. Boyd, Ed., Indians, Fire, and the Land in the Pacific Northwest. Chicago, IL, USA : Oregon State Univ. Press, 2022.

9. R. Broadhurst, B. Bergdoll, P. Christensen, and Museum of Modern Art (N.Y.), Home Delivery: Fabricating the Modern Dwelling. New York, NY, USA : Museum of Modern Art, 2008.

10. “Building PDX’s wooden roof, from forest to frame,” PDX Next, Aug. 13, 2024. Accessed: Mar. 17, 2025. [Online]. Available: https://www.pdxnext.com/Stories/Details/new-pdx-roof-from-forest-to-frame

11. J. Burrell, “On half-built assemblages: Waiting for a data center in Prineville, Oregon,” Engaging STS, vol. 6, pp. 283–305, Jun. 2020, doi: 10.17351/ests2020.447.

12. I. Burrington, “From war crystals to ordinary sand: Excavating silicon supply chains,” IEEE Ann. Hist. Comput., vol. 46, no. 2, pp. 13–23, Apr./Jun. 2024, doi: 10.1109/MAHC.2024.3378121.

13. Z. G. T. Cooper, “Of dog kennels, magnets, and hard drives: Dealing with Big Data peripheries,” Big Data Soc., vol. 8, no. 2, Jul. 2021, Art. no. 205395172110154, doi: 10.1177/20539517211015430.

14. W. Cronon, Nature’s Metropolis: Chicago and the Great West. New York, NY, USA : Norton, 1992.

15. S. Cubitt, Finite Media: Environmental Implications of Digital Technologies. Durham NC, USA : Duke Univ. Press, 2017. [Online]. Available: https://www.dukeupress.edu/finite-media

16. D. Davis, “Katerra’s $2 billion legacy,” Architect Mag., Jun. 18, 2021. Accessed: Jan. 03, 2023. [Online]. Available: https://www.architectmagazine.com/technology/katerras-2-billion-legacy_o

17. P. Deamer and P. G. Bernstein, Eds., Building (in) the Future: Recasting Labor in Architecture. New York, NY, USA : Princeton Architectural Press, 2010.

18. A. Duvernay, “Oregon project to expand mass timber production, industry jobs with $41.4M federal grant,” Register-Guard, Eugene, Sep. 06, 2022. Accessed: Apr. 03, 2023. [Online]. Available: https://www.registerguard.com/story/news/2022/09/06/oregon-mass-timber-coalition-build-back-better-regional-challenge/65475100007/

19. K. Elias, “Mercer’s mission: Cross-laminated timber maker plans $50M in upgrades,” Spokane J. Bus., May 19, 2022. Accessed: Mar. 17, 2025. [Online]. Available: https://www.spokanejournal.com/articles/578-

mercer-s-mission-cross-laminated-timber-maker-plans-50m-in-upgrades

20. N. Ensmenger, “The environmental history of computing,” Technol. Culture, vol. 59, no. 4S, pp. S7–S33, Oct. 2018, doi: 10.1353/tech.2018.0148.

21. F. Floré, “Wood firm De Coene and the modern office,” Architectural Theory Rev., vol. 25, nos. 1–2, pp. 99–116, May 2021, doi: 10.1080/13264826.2021.1957961.

22. S. Giedion, Mechanization Takes Command. New York, NY, USA : Oxford Univ. Press, 1970.

23. T. Gordon, “Otis couple who lost home in wildfire to receive ‘Mass Casitas’ modular home,” kgw.com, Jan. 28, 2023. Accessed: Mar. 17, 2025. [Online]. Available: https://www.kgw.com/article/news/local/prototype-modular-home-goes-to-couple-who-lost-home-in-otis-wildfire/283-1c8a4e45-9185-47b4-800f-49271e41ea4e

24. B. Grad and D. Kasik, “CAD: Forming the industry,” IEEE Ann. Hist. Comput., vol. 46, no. 4, pp. 7–9, Oct./Dec. 2024, doi: 10.1109/MAHC.2024.3484016.

25. P. W. Hirt, A Conspiracy of Optimism: Management of the National Forests Since World War Two. Lincoln, NE, USA : Univ. of Nebraska Press, 1994.

26. M. Hogan, “Big data ecologies,” Ephemera: Theory Politics Org., vol. 18, no. 3, pp. 631–657, 2018. Accessed: Dec. 04, 2023. [Online]. Available: https://ephemerajournal.org/contribution/big-data-ecologies

27. L. Irani, “Justice for ‘data janitors’,” Public Books, Jan. 15, 2015. [Online]. Available: http://www.publicbooks.org/nonfiction/justice-for-data-janitors

28. I. Katz, “Mobile colonial architecture: Facilitating settler colonialism’s expansions, expulsions, resistance, and decolonisation,” Mobilities, vol. 17, no. 2, pp. 213–237, Apr. 2022, doi: 10.1080/17450101.2021.2000838.

29. S. Kieran and J. Timberlake, Refabricating Architecture. New York, NY, USA; London, U.K. : McGraw-Hill, 2004.

30. N. Langston, Forest Dreams, Forest Nightmares: The Paradox of Old Growth in the Inland West. Seattle, WA, USA : Univ. of Washington Press, 1995.

31. L. Lee, “How mass timber could help reduce wildfire risk,” Metropolis, Dec. 09, 2020. Accessed: Mar. 17, 2025. [Online]. Available: https://metropolismag.com/viewpoints/mass-timber-wildfire/

32. A. M. Levenda and D. Mahmoudi, “Silicon forest and server farms: The (urban) nature of digital capitalism in the pacific northwest,” Culture Mach., vol. 18, pp. 1–14, 2019.

33. E. Loomis, Empire of Timber: Labor Unions and the Pacific Northwest Forests (Studies in Environment and History). New York, NY, USA : Cambridge Univ. Press, 2016.

34. R. Martin, The Organizational Complex: Architecture, Media, and Corporate Space. Cambridge, MA, USA : MIT Press, 2003.

35. K. Marx, Capital: A Critique of Political Economy. London, U.K. : Penguin, 1981.

36. “Cross-laminated timber (CLT) introduction,” Katerra, Menlo Park, CA, USA, Fall 2019. [Online]. Available: https://assets2.katerra.com/wp-content/uploads/2019/10/01154806/Katerra-CLT-Introduction-1.pdf