



A Review On Architecture In Transition

HISTORY, SUSTAINABILITY, AND DIGITAL INNOVATION IN THE BUILT ENVIRONMENT

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Abstract: Architecture has evolved significantly in response to cultural, environmental, and technological changes. This research examines architectural transition focusing on history, sustainability, and digital innovation in the built environment. Traditional architecture emphasized cultural identity and craftsmanship, while modern architecture focuses on functionality and efficiency. Sustainable architecture reduces environmental impact through energy-efficient designs and eco-friendly materials. Digital technologies such as Building Information Modeling and computer-aided design improve architectural accuracy and performance. The study uses literature review and comparative analysis. Results show that integration of sustainability and digital innovation improves building efficiency and environmental performance. Future architecture will depend on the integration of historical knowledge, sustainable practices, and digital innovation.

Index Terms - Architecture evolution, Sustainable architecture, Digital architecture, Built environment, Smart buildings, Green buildings, BIM, Digital innovation

Introduction:

Architecture is a representation of human civilization and cultural development. Throughout history architecture has evolved in response to social needs and technological progress. Traditional architecture emphasized craftsmanship, ornamentation and cultural symbolism. Buildings were constructed using locally available materials such as stone, wood and brick. Modern architecture focuses on functionality, simplicity and efficiency. The introduction of reinforced concrete, steel and glass enabled the construction of taller and more flexible structures. In recent decades architecture has experienced significant transformation due to environmental concerns and technological development. Sustainable architecture and digital design technologies are transforming the built environment.

Literature review:

C.E.Dickerson, Senior Member, IEEE, and M.K. Wilkinson (2024) The authors state that systems engineering has long lacked the rigorous scientific and mathematical foundations characteristic of traditional engineering disciplines, and they argue that category theory can provide this foundation when suitably extended. They introduce CoR (Category of Relations), an enriched algebraic logic that expands the traditional category of relations by incorporating logical dependencies such as subset relations and implication, rather than relying solely on equality of compositions. According to the authors, engineering design problems can be formally expressed as relational compositions between objective and design spaces, where requirements are transformed into compliant solution sets using inverse relations and relational homomorphism. Through examples such as aircraft drag analysis and a radar system case study, they demonstrate how single and multi-objective, multi-attribute design problems can be structured and solved symbolically using relational algebra. They further contend that existing modelling languages like SysMLv2 lack sufficient expressiveness to represent interrelations between

relations, and that CoR provides a structured framework with graphical, structural, and algebraic views that function as mathematical blueprints for system architecture. Overall, the authors claim that CoR establishes a rigorous yet practical foundation for advancing next-generation systems engineering methodologies, tools, and digital design environments.

Zepnep YAVUZ and Mehmet Taygun YILDIRIM (2020) The author analyses the relationship between contemporary architectural annexes and historical buildings by examining international charters, design theories, and visual perception principles alongside selected case studies. The study argues that new additions should correspond to the historical structure in terms of scale, mass, proportion, colour, texture, rhythm, hierarchy, balance, and spatial organisation, while preserving the dominance, silhouette, and cultural value of the old building. Through the evaluation of different types of interventions—roof completions, façade arrangements, connection spaces, circulation additions, extensions, and new buildings within historic settlements—the author finds that imitation has largely lost importance, and “respectful” and “contrast” approaches are now more common. Respectful designs tend to maintain harmony by aligning with the old building’s proportions and light–shadow relationships, whereas contrast approaches often produce iconic forms that may enhance urban identity but risk overpowering the historical context. The study also highlights that contemporary concepts such as transparency, flexibility, urban integration, and sustainability can positively support the continuity and functionality of heritage structures when applied sensitively. Ultimately, the author concludes that a successful new annex must balance contextual sensitivity with contemporary expression, allowing the historical building to retain its integrity while enabling the new structure to reflect the architectural spirit of its own time.

Abdullah. KH. E. Jafar (2025) The author explains that old architecture was deeply rooted in cultural, religious, and political contexts, emphasising grandeur, symmetry, ornamentation, and skilled craftsmanship, with structures built from locally available materials like stone, wood, and brick. These buildings symbolised power, faith, and identity but relied on labor-intensive construction methods and often lacked environmental efficiency. In contrast, new architecture is shaped by technological progress, globalisation, and changing social needs, prioritising minimalism, open spaces, functionality, and structural innovation through materials such as steel, glass, and reinforced concrete. The paper further stresses that sustainability has become central to modern design, incorporating green building certifications, renewable energy systems, smart technologies, and energy-efficient planning to reduce environmental impact. Additionally, contemporary architecture promotes inclusivity, accessibility, and adaptability within urban environments, responding to evolving societal demands. The author concludes that while traditional architecture preserves cultural heritage and artistic richness, modern architecture reflects innovation and environmental consciousness, and the integration of both approaches may lead to more resilient and meaningful built environments in the future.

Sajjad Nazidizaji and Hossein Safari (2012) The authors argue that traditional engineering disciplines rely on well-established mathematical structures, whereas systems engineering has often depended on intuitive or semi-formal modelling methods. To bridge this gap, they model systems as structured compositions of functions and binary relations between design spaces and objective spaces, where requirements are represented as relational constraints and transformed into feasible design specifications through inverse mappings and relational composition. After introducing the category REL, in which morphisms are binary relations rather than just functions, they demonstrate that real engineering problems require more than equality-based commutative diagrams; therefore, they extend REL into CoR by incorporating logical dependencies such as subset, implication, and sub-commutative relations within the calculus of relations. Through detailed case studies—including aircraft drag modelling and a multi-objective radar system design problem involving detection range and radiation safety constraints—the paper shows how complex engineering constraints can be expressed as composition diagrams and solved algebraically while preserving relational homomorphism between requirements and design solutions. It further introduces schemata in CoR as mathematical blueprints that integrate structural, graphical, and algebraic relational views of systems, enabling consistency, traceability, and constraint-driven design. Ultimately, the work proposes CoR as a practical yet rigorous foundation for next-generation model-based systems engineering methodologies and digital tools, enhancing the mathematical expressiveness

of modelling standards such as SysMLv2 and supporting symbolic problem-solving in engineering practice.

Anada Tiwari and Harsh Mehta (2025) According to the author, Udaipur's identity is not defined merely by its historical significance but by a structured visual language formed through the repetition of architectural motifs, harmonious spatial composition, and the interaction between built forms and natural elements. The author explains that features such as jharokhas, domes, arches, ghats, palace façades, and white marble surfaces operate as consistent visual symbols that create recognition, unity, and aesthetic coherence across the city. Lakes and their reflections are described as active visual agents that enhance depth, symmetry, and emotional appeal, transforming architecture into a dynamic scenic experience. Survey findings reinforce that viewers strongly associate Udaipur with its pastel colour palette, symmetry, intricate detailing, and reflective landscapes, proving that its visual identity emerges from the integrated system of form, colour, texture, light, and environmental harmony rather than from isolated monuments alone.

Literature survey:

From the review of the above papers, several important conclusions can be drawn regarding architectural design and its evolution. Architecture has continuously evolved with changes in technology, culture, and environmental requirements. Traditional architecture emphasised craftsmanship, ornamentation, and cultural symbolism, while modern architecture focuses on functionality, innovation, and sustainability. The studies confirm that visual identity in cities is strongly influenced by architectural elements such as façades, domes, arches, spatial composition, and the relationship between built structures and natural surroundings. It is also observed that when contemporary buildings are attached to historical structures, the new design should respect the scale, materials, and character of the existing heritage structures to maintain visual harmony. Furthermore, analytical methods and reverse engineering approaches help architects understand the design principles used in successful buildings and improve architectural creativity and design quality. Modern architectural practices also emphasize sustainable design, efficient materials, and advanced technologies to create environmentally responsible and adaptable buildings. Therefore, integrating traditional knowledge, modern technology, and systematic design analysis can significantly improve the quality and sustainability of future architectural developments.

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