



REVOLUTIONISING URBAN PARKING: A COMPREHENSIVE EXPLORATION OF STACK-TYPE MULTI-LEVEL CAR PARKING SYSTEMS AND THEIR IMPLICATIONS FOR FUTURE PLANNING

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Abstract: As urbanisation accelerates globally, the demand for efficient parking solutions becomes increasingly critical. This research conducts a systematic literature review to comprehensively explore the transformative potential of stack-type multi-level car parking systems and their implications for future urban planning. The study fulfils three primary research objectives: evaluating the efficiency and space utilisation of stack-type systems, analysing their economic viability, and understanding their environmental impact. The results reveal that stack-type parking systems demonstrate superior efficiency metrics, economic viability, and reduced environmental impact compared to traditional structures. The comparative analysis underscores their transformative potential, while acknowledging structural complexities and scalability issues as challenges. The discussion delves into the implications for urban planning, recommendations for policymakers, and avenues for future research, emphasising the importance of public acceptance and smart technology integration. The conclusion highlights the need for continuous exploration, innovation, and interdisciplinary collaboration to successfully integrate stack-type parking solutions into the dynamic tapestry of future urban landscapes.

1. INTRODUCTION

Urban areas have struggled to keep pace with the rapid rise in vehicle ownership, resulting in congested streets and parking chaos. The traditional approach of horizontal parking spaces is becoming increasingly unsustainable, necessitating a paradigm shift in urban planning. Stack-type multi-level car parking systems, characterised by their vertical arrangement of vehicles, offer a transformative solution to this challenge. This research endeavours to unravel the intricacies of stack-type multi-level car parking, offering a nuanced understanding of its impact on urban landscapes.

2. LITERATURE REVIEW

A significant contribution to the discourse comes from Mirunalini et al. (2018), who conducted a comparative analysis of various multi-level parking systems. Their study, focused on efficiency and space utilisation, offered insights into the limitations of traditional systems. However, the analysis lacked a specific focus on stack-type parking, revealing a critical void in the literature.

Moreover, the study by Sawant et al. (2020) highlighted the environmental impact of conventional parking structures, drawing attention to the need for sustainable alternatives. Stack-type parking systems, with their vertical design and reduced footprint, present a promising avenue for addressing these concerns. This underlines the urgency of a detailed investigation into the ecological implications of stack-type solutions in urban settings.

To understand the public perception and acceptance of stack-type parking systems, the study by Chang & Phuc. (2020) becomes relevant. Their research, based on user experiences with multi-level parking, touches on the challenges faced by traditional designs. However, the specific nuances of stack-type systems remain unexplored, emphasising the necessity of this research to fill the existing gap.

The research conducted by Padiachy et al. (2015) on the economic viability of multi-level parking structures offers valuable insights into the financial considerations associated with parking solutions. Yet, the unique economic advantages and challenges of stack-type systems require dedicated attention in the literature.

2.1 Research Gap

Existing literature often highlights conventional parking issues but falls short in providing an in-depth analysis of stack-type multi-level systems. This research aims to bridge this gap by exploring the potential of stack-type parking to revolutionise urban parking dynamics.

2.2 Research Question

Our central research question is: How can stack-type multi-level car parking systems address the challenges of limited urban parking spaces and contribute to efficient urban planning?

2.3 Importance of the study

The significance of this study lies in its potential to reshape urban infrastructure, making it more adaptable to the burgeoning demands of modern cities. Stack-type parking systems have the potential to optimise space and alleviate the chronic issues associated with conventional parking structures.

2.4 Research Objectives

- To evaluate the efficiency and space utilisation of stack-type multi-level car parking systems.
- To analyse the economic viability and environmental impact of implementing stack-type parking.
- To understand the public perception and acceptance of stack-type parking solutions.

2.5 Scope and Limitation

While this research seeks to provide a comprehensive exploration, it is essential to acknowledge the limitations, including the contextual applicability of findings to diverse urban settings and potential challenges in implementation.

3. RESEARCH METHODOLOGY

This study employs a systematic literature review as the primary research method, aiming to comprehensively explore existing scholarly works related to stack-type multi-level car parking systems and their implications for future urban planning. A systematic review ensures a rigorous and transparent approach, minimising bias and providing a robust foundation for evidence-based conclusions (Jog et al., 2015).

3.1 Research Method and Design

The research design adheres to established guidelines for systematic literature reviews (Sunitha et al. 2010). This involves the systematic identification, selection, and critical appraisal of relevant studies to synthesise the existing knowledge on the topic. The process follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to enhance the transparency and reproducibility of the review (Rajasekhar, Maya & Panday, 2021).

3.2 Research Approaches

To find relevant literature, PubMed, IEEE Xplore, ScienceDirect, and Google Scholar will be widely searched. To find all relevant research, "stack-type parking," "multi-level parking systems," "urban planning," and similar phrases will be utilised. Boolean operators (AND, OR) will narrow the search and incorporate study topic dimensions.

Setting inclusion and exclusion criteria will filter the retrieved studies. Scholarly publications, conference papers, and reports published in English since 2000 are included to ensure relevance to urban planning

settings. Studies without actual data or not connected to stack-type multi-level auto parking systems will be eliminated.

The screening method includes title screening, abstract examination, and full-text evaluation. Two independent reviewers will evaluate each study's eligibility, and disagreements will be handled via discussion to guarantee inter-rater reliability.

To evaluate evidence quality and bias, chosen papers will be critically appraised using standardised procedures (Bedair et al. 2021). This technique improves synthesised results and identifies literature constraints.

4. ANALYSIS OF DATA

The analysis of data in this study involves a meticulous examination of the synthesised findings from the systematic literature review. The key themes, methodologies, and outcomes of the selected studies are subjected to a rigorous analysis to derive meaningful insights into the efficiency, economic viability, and environmental impact of stack-type multi-level car parking systems.

4.1 Efficiency and Space Utilisation

Table 1 presents a summary of studies assessing the efficiency and space utilisation of stack-type parking systems in comparison to traditional multi-level structures.

Study	Efficiency Metrics	Space Utilisation
Bedair et al. (2021)	Turnaround time, Occupancy rate	Reduced footprint, Increased capacity
Jog et al. (2015)	Throughput, Average parking time	Vertical design optimization, Space maximisation

The comparative analysis indicates that stack-type parking systems demonstrate superior efficiency metrics, such as reduced turnaround time and increased throughput, contributing to enhanced space utilisation in urban environments.

4.2 Economic Viability

Table 2 synthesises findings related to the economic viability of stack-type parking systems, including construction costs, maintenance expenses, and long-term financial sustainability.

Study	Construction Costs	Maintenance Expenses	Financial Sustainability
Mirunalini et al. (2018)	Comparable construction costs	Lower maintenance costs	Long-term cost-effectiveness and viability

The data suggest that stack-type parking systems, while exhibiting comparable construction costs, offer a potential advantage in terms of lower maintenance expenses, contributing to their economic viability and sustainability over time.

4.3 Environmental Impact

Environmental considerations are crucial in the analysis of stack-type parking systems. Table 3 summarises the findings related to the environmental impact of these systems, including carbon emissions, energy consumption, and overall ecological footprint.

Study	Carbon Emissions	Energy Consumption	Ecological Footprint
Padiachy et al. (2015)	Reduced carbon footprint	Energy-efficient design	Minimal ecological impact

The analysis indicates that stack-type parking systems contribute to a reduced carbon footprint, incorporating energy-efficient design principles and minimising their ecological impact.

4.4 Comparative Analysis

A comprehensive comparative analysis, as shown in Table 4, highlights the strengths and weaknesses of stack-type parking systems compared to conventional multi-level structures.

Study	Strengths	Weaknesses
Salau et al. (2021)	Enhanced efficiency and space utilisation	Initial implementation costs, Public acceptance
Sawant et al. (2020)	Increased capacity, Reduced footprint	Structural complexity, Limited scalability

This comparative analysis provides a nuanced understanding of the advantages and challenges associated with stack-type parking systems.

4.5 Synthesis of Key Themes

The synthesis of key themes from the analysed data reveals that stack-type multi-level car parking systems offer a promising solution to urban parking challenges. Their efficiency, economic viability, and reduced environmental impact position them as a transformative option for future urban planning.

5. RESULT AND DISCUSSION

This section presents a detailed analysis of the findings derived from the systematic literature review, addressing the research objectives outlined in the study.

5.1 Fulfilment of Research Objectives

Turnaround time, occupancy rate, throughput, and average parking time show that stack-type parking facilities outperform multi-level structures. Vertical design optimization and lower footprint boost space utilisation, meeting the first study aim.

The comparison of construction costs, maintenance costs, and long-term financial sustainability shows that stack-type parking systems have similar development costs but lower maintenance costs. Economic viability supports the second research goal.

Stack-type parking systems have a low carbon footprint and ecological effect, according to statistics on carbon emissions, energy usage, and ecological footprint. This meets the third research goal.

5.2 Comparative Analysis and Discussion

Comparative investigation reveals stack-type parking facilities are more efficient and space-efficient than conventional structures. Stack-type systems solve urban parking problems with shorter turnaround time, improved throughput, and vertical architecture.

Competitive construction and maintenance costs support stack-type parking systems' long-term cost-effectiveness and sustainability (Objective 2). Despite early installation expenses, stack-type systems may be economically viable for urban planners due to their long-term financial advantages and decreased environmental effect.

Stack-type parking systems are ecologically friendly due to their low carbon emissions, energy efficiency, and ecological effect.

6. CONCLUSION

In conclusion, the results and discussion section substantiate the fulfilment of the research objectives, offering a nuanced understanding of stack-type multi-level car parking systems. The efficiency gains, economic viability, and reduced environmental impact position these systems as transformative solutions for urban planning. The identified weaknesses provide valuable insights for policymakers and urban planners to address challenges and pave the way for the successful integration of stack-type parking systems into future urban landscapes.

6.1 Suggestion or recommendation

Future implementations of stack-type parking systems could benefit from the integration of smart technologies. Automated parking systems, real-time monitoring, and data-driven optimization can enhance the overall efficiency and user experience. Research and development efforts should explore the potential of smart technologies in further refining stack-type parking solutions.

6.2 Future Scope

Future research can delve into advancements in structural engineering to address the identified weaknesses, such as complexities and scalability issues. Innovations in materials, design, and construction methodologies could pave the way for more adaptable and scalable stack-type parking structures.

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