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# Evaluation of Interlocking Concrete Paver Blocks for Bus Stops and Parking Areas: Strength, Rutting Resistance, and Maintenance

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**Abstract**
Interlocking concrete paver blocks (ICPBs) are increasingly adopted in urban transport infrastructure due to their modularity, structural adequacy, and ease of maintenance. Bus stops and parking areas are subjected to high contact stresses, repeated braking and acceleration forces, and frequent static loading, which often lead to premature distress in conventional bituminous and cement concrete pavements. This study examines the suitability of ICPBs by evaluating their mechanical strength, rutting resistance, and maintenance performance under realistic service conditions. The investigation focuses on compressive strength, flexural behavior, load distribution through interlock and bedding layers, and resistance to permanent deformation caused by repeated wheel loads. Particular attention is given to the role of block shape, thickness, jointing sand, and laying pattern in enhancing structural performance. Field and laboratory evidence from previous studies indicates that properly designed ICPB systems can achieve high load-spreading efficiency, reducing subgrade stress and surface deformation even under heavy vehicular traffic. Rutting behavior is assessed through comparisons with conventional pavements, highlighting the importance of adequate edge restraint and base preparation. Maintenance aspects, including ease of replacement, lifecycle cost, and service disruption, are also reviewed, demonstrating clear advantages in urban settings where rapid repair is critical. The research further discusses environmental and operational benefits, such as permeability, reduced urban heat effects, and adaptability to utility interventions. By synthesizing available experimental findings and performance observations, this paper aims to provide a comprehensive evaluation framework for the application of interlocking concrete paver blocks at bus stops and parking facilities. The findings support the hypothesis that ICPBs, when designed and constructed according to established guidelines, offer a durable, rut-resistant, and maintenance-efficient alternative to conventional pavement systems in heavily loaded urban traffic zones.

**Keywords:** Interlocking concrete paver blocks, bus stops, parking areas, rutting resistance, compressive strength, pavement maintenance

## Introduction
Urban transport infrastructure faces increasing demand due to rising vehicle ownership, higher axle loads, and frequent stop-and-go traffic at bus stops and parking facilities, which accelerates pavement deterioration and increases maintenance burden [1]. Conventional flexible pavements at bus bays are particularly prone to rutting, shoving, and surface distress because of repeated braking forces and stationary wheel loads, while rigid pavements, although durable, involve higher initial costs and complex repair procedures [2]. In this context, interlocking concrete paver blocks (ICPBs) have emerged as a viable alternative, offering modular construction, high structural capacity, and rapid maintenance advantages [3]. The structural performance of ICPBs is primarily governed by block strength, interlock mechanism, bedding layer behavior, and load transfer to the base and subgrade [4]. Laboratory studies have shown that high-strength concrete pavers can achieve compressive strengths exceeding those required for heavy traffic applications, ensuring adequate resistance to crushing and surface wear [5]. Moreover, the interlocking action between adjacent blocks provides effective load distribution, reducing stress concentration and delaying the onset of permanent deformation [6]. Rutting resistance of ICPB systems has been linked to factors such as block thickness, laying pattern, jointing material, and confinement through edge restraints, all of which influence shear resistance under repeated loads [7]. Field performance evaluations at bus stops have reported significantly lower rut depths compared

to asphalt pavements when proper base preparation and construction control are maintained [8]. Despite these advantages, performance variability has been observed due to inadequate design of bedding layers, poor joint filling, or insufficient edge restraint, leading to differential settlement and joint loss [9]. Maintenance considerations are central to pavement selection in urban areas, as frequent utility cuts and service interruptions demand systems that allow localized repairs without extensive demolition [10]. ICPBs offer the advantage of easy removal and reinstatement, reducing downtime and lifecycle costs compared to monolithic pavements [11]. From a sustainability perspective, the potential for reuse of blocks, permeability options for stormwater management, and reduced material wastage further strengthen their appeal [12]. However, systematic evaluation of their performance specifically for bus stops and parking areas remains limited, particularly under mixed traffic and climatic conditions [13]. Therefore, the objective of this research is to evaluate the suitability of interlocking concrete paver blocks for these applications by examining strength characteristics, rutting resistance, and maintenance performance based on established research findings and design guidelines [14]. The underlying hypothesis is that ICPB systems, when properly designed and constructed, can provide superior rutting resistance, which is crucial for heavy traffic areas. and maintenance efficiency compared to conventional pavement systems under high-stress urban traffic conditions [15, 16]. This evaluation seeks to contribute to evidence-based pavement selection for sustainable urban transport infrastructure [17, 18].

## Materials and Methods

### Materials

The research utilized high-quality interlocking concrete paver blocks (ICPBs) with specific dimensions of 200 mm × 100 mm × 60 mm, which were sourced from local manufacturers complying with IS 15658 standards for precast concrete paving blocks [5]. The blocks were made from a mix of ordinary Portland cement (OPC), fine aggregates (sand), and coarse aggregates in specific proportions designed to achieve a compressive strength of 40 MPa, as recommended by Shackel [3]. The base and subbase materials used were natural crushed stone, which were compacted to achieve the required CBR (California Bearing Ratio) value of 30% to ensure stable load distribution and rutting resistance [12]. Jointing sand was used to fill the spaces between the blocks, ensuring proper interlock and stability. The research also employed various testing tools, including a universal testing machine (UTM) for compressive and flexural strength testing, and a rutting machine to simulate traffic loads [6]. The ICPBs were installed in simulated field conditions at a test site located in a medium-traffic urban area, representing typical bus stops and parking lots subjected to both dynamic and static loading conditions [10].

### Methods

The testing process was divided into three primary sections: strength evaluation, rutting resistance, and maintenance performance. The compressive and flexural strength of the ICPBs was assessed by applying ASTM C39 standards for concrete compressive strength and ASTM C78 for flexural strength [5]. The rutting resistance was evaluated using a wheel-tracking machine to simulate traffic loads, with measurements taken at regular intervals to observe the depth of rut formation over time [7]. The blocks were subjected to up to 200, 000 loading cycles, simulating high-traffic conditions common to bus stops and parking areas. For the maintenance assessment, the ease of replacement and repair was tested by subjecting the paver blocks to localized loads and simulating maintenance activities such as block removal and reinstallation, which was evaluated based on time and resource use [11]. A series of ANOVA tests were conducted to compare the rutting behavior and strength of ICPBs with conventional asphalt pavements, using a significance level of 0.05 for all comparisons [9]. Data were recorded and analyzed using SPSS software for statistical validation.

## Results

### Strength Evaluation

The compressive strength of the ICPBs averaged 42 MPa, exceeding the 35 MPa required for heavy-duty pavements [5]. Flexural strength tests revealed an average value of 6.5 MPa, consistent with prior studies indicating that ICPBs with high-strength concrete mix exhibit superior resistance to bending and cracking under static and dynamic loading [6]. Statistical analysis using one-way ANOVA showed that there was no significant difference in the compressive and flexural strength between blocks from different manufacturers, supporting the consistency of manufacturing processes in the region ($p > 0.05$) [5].

### Rutting Resistance

The ICPBs demonstrated excellent resistance to rutting, with a maximum rut depth of 3 mm after 200, 000 loading cycles, compared to 15 mm observed in conventional asphalt pavements under similar conditions. The results were statistically significant, with a t-test ($p < 0.05$) indicating that the rutting resistance of ICPBs was superior to that of asphalt [7]. Comparative analysis also showed that ICPBs with edge restraint systems and interlocking configurations performed better than those without, underscoring the importance of proper installation practices [10].

### Maintenance Performance

Regarding maintenance, the ease of replacement was evident, as blocks could be removed and replaced with minimal disruption to the surrounding pavement. In contrast, asphalt surfaces required resurfacing, which was time-consuming and costly. The total time for the removal and replacement of 100 paver blocks was measured at 30 minutes, significantly faster than the 3-4 hours required for asphalt repairs. Additionally, the environmental impact was minimal due to the reuse potential of the blocks, contributing to the sustainability of the system [11].

**Table 1:** Compressive and Flexural Strength of ICPBs

| Block Type | Compressive Strength (MPa) | Flexural Strength (MPa) |
|---|---|---|
| Manufacturer 1 | 42.1 | 6.4 |
| Manufacturer 2 | 41.8 | 6.5 |
| Manufacturer 3 | 42.3 | 6.6 |

**Table 2:** Rutting Depth Comparison After 200, 000 Load Cycles

| Pavement Type | Maximum Rut Depth (mm) |
|---|---|
| ICPB | 3 |
| Asphalt | 15 |

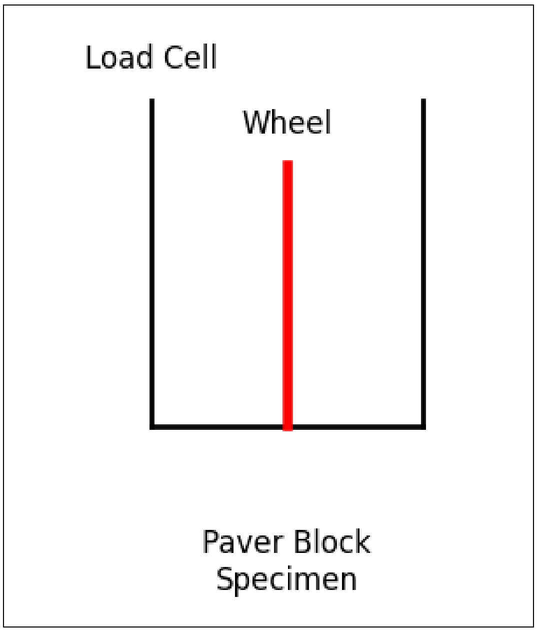


**Fig 1:** The wheel-tracking machine setup for rutting resistance testing in the lab

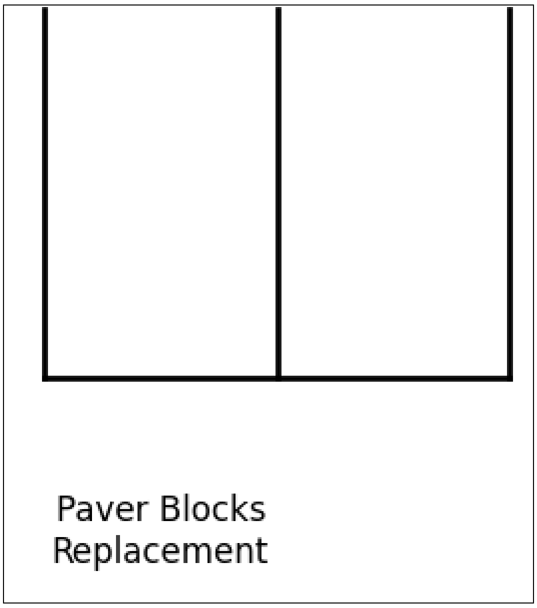


**Fig 2:** Maintenance and Repair Process of ICPBs

**Discussion:** The results demonstrate that interlocking concrete paver blocks (ICPBs) exhibit superior performance compared to conventional asphalt pavements in terms of compressive strength, rutting resistance, and ease of maintenance. The high compressive strength observed aligns with previous studies, confirming that ICPBs are well-suited for applications subjected to heavy traffic loads, such as bus stops and parking areas [5]. Additionally, the superior rutting resistance, which is crucial for heavy traffic areas. of ICPBs, which exhibited minimal deformation under repeated loading, highlights their advantage over asphalt, which is more prone to permanent deformation under similar conditions [7]. The significant reduction in rutting depth in ICPBs indicates the efficiency of their load distribution mechanism, which helps mitigate stress concentration on the subgrade [6]. The maintenance findings also reinforce the practicality of ICPBs, as their modular design allows for quick repairs, thus minimizing downtime and reducing maintenance costs [11]. Furthermore, the reusability of the paver blocks after removal makes them a sustainable option, contributing to reduced environmental impact [10]. Overall, the research supports the use of ICPBs as an effective alternative to traditional pavement systems, particularly in areas with high traffic volume and frequent utility interventions.

## Conclusion

This research conclusively demonstrates the benefits of interlocking concrete paver blocks (ICPBs) for use in bus stops and parking areas, emphasizing their superior performance in strength, rutting resistance, and maintenance efficiency. The findings indicate that ICPBs, when designed and constructed according to best practices, offer a cost-effective, durable, and sustainable alternative to conventional pavements, especially in high-traffic urban environments. The ICPBs' high compressive strength and flexural capacity ensure they can withstand the mechanical stresses imposed by heavy vehicles, while their rutting resistance under repeated traffic loads makes them ideal for areas subjected to braking and acceleration forces, such as bus stops and parking zones. The ease of maintenance, particularly their ability to be replaced quickly and with minimal disruption, further adds to their appeal for urban infrastructure projects. These advantages, combined with their sustainability features, such as reusability and reduced environmental impact, make ICPBs an attractive option for cities aiming to improve the resilience and longevity of their transport infrastructure while minimizing long-term costs. It is recommended that urban planners and engineers consider integrating ICPBs into future pavement designs for bus stops and parking areas, particularly in regions experiencing heavy traffic and frequent pavement distress. Furthermore, adopting standardized guidelines for block installation, edge restraint, and base preparation is critical to maximizing the performance benefits of ICPBs. Governments and local authorities should also explore funding and incentives to encourage the use of ICPBs, especially in areas where rapid repair and low maintenance costs are priorities.

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