Experimental Innovation & Investigation on Mortar Less Interlocking Concrete Block Wall System for Rapid Construction

Narayan Singh Apawat[1] and Vinod Kumar Modi[2]
[1]*M.Tech. Scholar, Kautilya Institute of Technology & Engineering, Jaipur*
[2]*Associate Professor, Kautilya Institute of Technology & Engineering, Jaipur*

Abstract: **Traditional masonry remains popular in developing nations like India and has evolved into advanced structural components due to interest from modern societies. To address the slow pace of conventional methods, scientists developed mortar-less interlocking wall systems, offering faster construction with less-skilled labor and cost savings. Interlocking blocks, an advanced version of traditional adobe blocks, gained prominence in Africa during the 20th century. In the 1970s and 1980s, dry-stack concrete blocks emerged, addressing speed, cost, and material efficiency, revolutionizing construction practices worldwide.**

Mortar-less interlocking masonry enables faster, cheaper, and durable construction but remains underutilized due to low awareness and market presence. To promote its adoption, government agencies and industry investors should implement this system in public housing projects, demonstrating commitment and raising public awareness of its benefits.

The study aims to evaluate the efficacy and standards of the mortar-less fast-stacking concrete block wall system in India, exploring its potential for repurposing within the construction sector. It seeks to assess advancements and methodologies in producing mortar-less fast-stacking concrete block wall systems with load-bearing capabilities. Additionally, the study intends to design a system that allows for easy disassembly and reuse at the end of the building's lifecycle

Keywords: **Mortar-less masonry, Interlocking concrete blocks, Fast-stacking wall systems, Dry-stack wall systems**

I. INTRODUCTION

The introduction discusses the evolution of mortar-less interlocking blocks, highlighting the transition from traditional masonry, which is prevalent in developing countries like India, to more advanced structural components. This shift is driven by the need for faster construction methods in the modern construction industry, as traditional practices are often time-consuming. Development of Interlocking Systems notes that scientists have developed various interlocking wall systems that eliminate the need for mortar, addressing the inefficiencies of conventional brickwork. These systems are designed to improve construction speed and reduce costs by allowing for quicker assembly with less skilled labor.

The mortar-less interlocking blocks can lead to robust, durable, and affordable housing solutions. However, despite their potential, these systems remain underutilized due to a lack of awareness among experts and limited market presence. It also points out that many older mortar-less systems created more problems than they solved, as they struggled to replicate the essential functions of mortar, such as joint sealing and flexural strength. The additional steps required for these systems often negated the cost savings they promised.

This summary encapsulates the key points from the introduction, providing a clear overview of the paper's focus on mortar-less interlocking blocks and their significance in modern construction., especially when buildings with different vibratory properties are closely spaced.

Objectives

1) To assess the efficiency and standards of the Mortar-less fast stacking Concrete Block wall system.
2) To evaluate advancements and methodologies for the production of Mortar-less fast stacking Concrete Block wall systems with load-bearing capabilities.
3) To devise a design for a Mortar-less fast stacking Concrete Block wall system that enables disassembly and reuse at the conclusion of the building's lifecycle.

II. LITERATURE REVIEW

In this study by Kumar & Patel, (2025) focused on the integration of mortar-less interlocking concrete blocks with modular construction systems. The research highlighted innovations such as using recycled concrete aggregates for block production, significantly improving sustainability. The design enhancements allowed disassembly and reuse, aligning with circular economy principles. These developments addressed environmental concerns while making the system more adaptable to various architectural designs. Ali et al. (2024) conducted detailed structural tests on mortar-less interlocking blocks under seismic conditions. The study confirmed their ability to withstand lateral loads with minimal structural damage, making them suitable for disaster-resilient housing. This research emphasized the importance of block geometry and connection strength in enhancing structural stability. Singh and Bhatt (2023) investigated the application of mortar-less interlocking blocks in public housing projects across India. Their findings showed a 40% reduction in construction time compared to traditional masonry techniques. The study also emphasized cost savings due to reduced labor requirements and elimination of wet materials, highlighting the system's potential in addressing housing shortages in developing nations.

Jayasuriya & Gunawardena (2022), Recent advancements in manufacturing technologies had improved the precision and strength of interlocking blocks. Innovations include the use of high-strength concrete and modular designs that facilitate disassembly and reuse, aligning with circular economy principles. These developments had expanded the potential applications of interlocking block systems in modern construction.

A. Desta et al. (2022) developed mortar-less masonry using interlocking hollow concrete blocks (IHCB) as an affordable construction alternative. A questionnaire survey was conducted, and 27 IHCB samples were tested experimentally. The results showed that IHCB was the most commonly used product in Hossana town for masonry work. Two block sizes (200x200x400 mm and 100x200x400 mm) were modeled, with a maximum density of 1222.73 kg/m3 and compressive strength of 2.39 MPa. It was found that IHCB had higher water absorption than the standard, requiring plastering for protection.

Guanyu Xie et al. (2022) studied on mortar-less interlocking brick walls highlighted their efficiency and reduced labor skill requirements, though their seismic performance remains less understood. Research involved laboratory shaking table tests and numerical modeling to investigate their behavior under seismic loading. Findings indicated that interlocking walls primarily experience rocking responses with damage at the bottom corners, differing from the diagonal shear failure typical of conventional masonry. Comparisons with concrete masonry unit (CMU) walls showed interlocking walls had higher seismic resistance, with inter-brick friction as the main energy dissipation mechanism. The walls were found to be significantly influenced by vertical ground motion but less sensitive to velocity pulses due to their high natural frequency.

Ahmad Aswad et al. (2022) examined various configurations of ICBs, incorporating recycled concrete aggregate (RCA) and other additive materials to enhance sustainability and performance. Studies compared the compressive strength outcomes of RCA mixtures, analyzing factors such as RCA replacement levels, water-to-cement (w/c) ratios, and mix proportions. These investigations demonstrated the potential of RCA-enhanced ICBs to maintain structural integrity while reducing environmental impact. Additionally, researchers discussed several methods and techniques that had been developed to improve the mechanical behavior of ICBs, ensuring their suitability for modern construction.

Haque et al. (2021) evaluated the environmental and economic impacts of using interlocking blocks. The study demonstrated that mortar-less systems reduce material waste by 25% and labor costs by 30% compared to traditional masonry. It also explored the system's role in reducing the carbon footprint of construction activities, emphasizing its contribution to sustainable building practices.

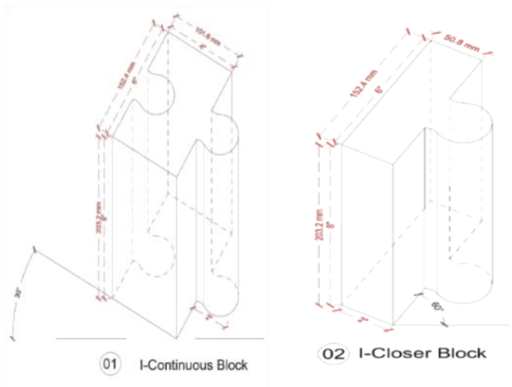
Francia H. Tomenio and Elias L. Tomenio (2020) designed of mortarless interlocking hollow blocks for non-load bearing walls was presented in the paper. The compressive strength was determined and compared to the ASTM and PTSS standards for CHB. The construction cost was also evaluated. Three designs of the mortarless interlocking hollow blocks were used: the straight block (45 cm x 10 cm x 20 cm with a hollow dimension of 7.5 cm x 5 cm x 18.1 cm), the corner block (10 cm x 10 cm x 20 cm), and the L-shaped block (30 cm x 10 cm x 20 cm with a hollow dimension of 7.5 cm x 5 cm x

18.1 cm). The radius of the tongue and groove was 3 cm. The compressive strength of the mortarless interlocking hollow blocks was found to exceed the ASTM and PTSS standards using a t-test. It was also found that the cost for laying out the mortarless interlocking hollow blocks was lower than the cost for installation and plastering of commonly used CHB.

Kim et al. (2020) discussed barriers to the widespread adoption of mortar-less interlocking systems, including low awareness among construction professionals and limited market availability. The study recommended government intervention and the establishment of standardized guidelines to address these issues, enabling broader implementation. Cheng et al. (2019) analyzed the load-bearing capabilities of interlocking concrete blocks. The research showed that advancements in block geometry and material composition have made these systems suitable for both residential and commercial applications. Design innovations, such as hollow cores for rebar insertion, were found to enhance the system's structural performance. Azizi et al. (2018) conducted field studies to evaluate the performance of mortar-less interlocking blocks in real-world construction projects. Their research highlighted the system's effectiveness in reducing construction time and costs. However, the study also pointed out the need for further research into standardization and compatibility with building codes.

III. METHODOLOGY

The purpose of this project is to develop a design for load-bearing interlocking concrete blocks that can be disassembled and reused repeatedly. The repurposing of buildings is made easier by this design. The design of blocks employs incremental innovation. Here are some sketches that I have made of the one-of-a-kind concrete block that interlocks.



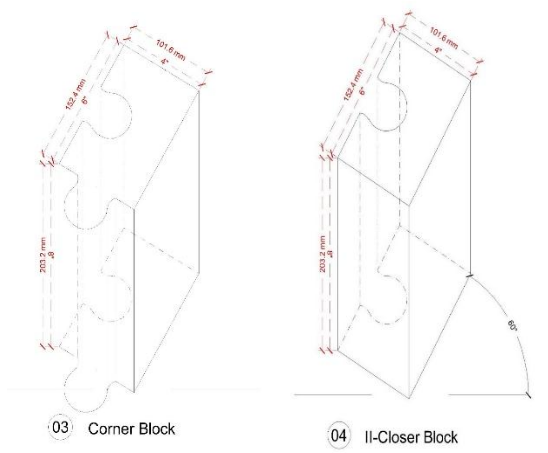


Fig 1 New Developed Mortar-Less Interlocking Wall Block

Table 1: Cost analysis of newly Invented Mortar-less interlocking Concrete Block

Ratio	0.40:1:2.27:1.65				
	Water	Admixture	Cement	Dust/Fly Ash/M-sand	Coarse Aggt
	M30 Mix Trial No.1	0.012	M30 Mix Trial No.2	M30 Mix Trial No.3	M30 Mix Trial No.4
	With 6 mm(80 %) and 10 mm(20 %) CA, & Fly Ash		With 6 mm(80 %) and 10 mm(20 %) CA, & Stone Dust	With 6 mm(80 %) and 10 mm(20 %) CA, & M-Sand	With 6 mm(80%) and 10 mm(20%) CA, & River Sand
OPC Cement Qty (kg/m3)	430	5.16	430	430	430
Cost of Cement Rs./Kg	7.5		7.5	7.5	7.5

Cement Cost Rs.	3225		3225	3225	3225
FA Qty	977.15		977.15	977.15	977.15
Cost of FA Rs./Kg	1		0.3	0.3	0.7
FA Cost Rs.	977.15		293.145	293.145	684.005
Coarse Agg Qty/Kg	711.01		711.01	711.01	711.01
Cost of CA Rs./Kg	0.7		0.7	0.7	0.7
Coarse Aggt Cost Rs.	497.707		497.707	497.707	497.707
Admixture Qty/Kg	5.16		5.16	5.16	5.16
Cost of Admixtire Rs./Ltr	165		165	165	165
Admixture Cost Rs.	851.4		851.4	851.4	851.4
Total Amount Rs./m3	5551.257		4867.252	4867.252	5258.112
Finishing Quality	Fine Finish		Fine Finish	Rough	Rough

IV. RESULTS AND DISCUSSION

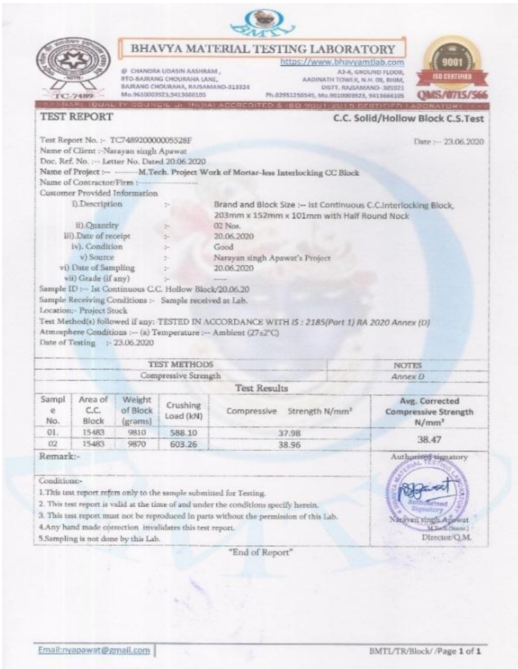
In mortar-less construction, wall alignment stability depends purely on the locking mechanism, while mortar joints are needed in conventional building. Wall height and length must be regulated. An efficient locking system with certain block designs may be needed to align the dry bonded wall horizontally and vertically. Rooms over 2.5 meters tall and 3 meters long with walls without a substantial opening. Mortaring and beams will be needed to straighten.

The performance of the interlocking mortar-less system's joint can be affected by the actions of the contact surface and the dry joint under compressive loading at long period. To prevent this action, we can apply any epoxy materials like silicon on the dry joints. Also, we can apply this epoxy to prevent rainy water percolation and dampness.

The newly designed demountable concrete block was compared to current varieties. This comparison between the existing block and the newly developed block assessed the developed block's conformity with demountable block criteria.

Table 2 Mix Proportion (IS : 10262 – 2019)

	Actual Quantities reqd. for the mix per 1 m³ of Concrete					W/C = 0.4	
	Water (kg)	Cement (kg)	Admixture (kg) 1.2%	Crusher Sand	Coarse Aggregate		
	189.84	430.00	5.16	977.15	6 mm (kg) (80%)		10 mm (kg) (20%)
					568.81		142.20
Slump = 45 mm							
Water	Cement	F.A.	C.A.	0.40	1.00	2.27	1.65
	Actual Quantities reqd. for the mix per 1 Bag of Cement					W/C =0.40	
	Water (kg)	Cement (kg)	Admixture (kg)C*(Ad/C)	Crusher Sand	Coarse Aggregate		
	20.00	50.00	0.60	113.62	6 mm (kg) (80%)		10 mm (kg) (20%)
					66.14		37.58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TEST REPORT — C.C. Solid/Hollow Block C.S.Test

Test Report No. :- TC748920000005528F — Date :-- 23.06.2020
Name of Client :-Narayan singh Apawat
Doc. Ref. No. :-- Letter No. Dated 20.06.2020
Name of Project :-- ———M.Tech. Project Work of Mortar-less Interlocking CC Block
Name of Contractor/Firm :-----------------
Customer Provided Information
i).Description :- Brand and Block Size :-- Ist Continuous C.C.Interlocking Block, 203mm x 152mm x 101mm with Half Round Nock
ii).Quantity :- 02 Nos.
iii).Date of receipt :- 20.06.2020
iv). Condition :- Good
v) Source :- Narayan singh Apawat's Project
vi) Date of Sampling :- 20.06.2020
vii) Grade (if any) :- ----
Sample ID :-- Ist Continuous C.C. Hollow Block/20.06.20
Sample Receiving Conditions :- Sample received at Lab.
Location:- Project Stock
Test Method(s) followed if any:-TESTED IN ACCORDANCE WITH *IS : 2185(Part 1) RA 2020 Annex (D)*
Atmosphere Conditions :-- (a) Temperature :-- Ambient (27±2°C)
Date of Testing :- 23.06.2020

TEST METHODS	NOTES
Compressive Strength	*Annex D*

Test Results

Sample No.	Area of C.C. Block	Weight of Block (grams)	Crushing Load (kN)	Compressive Strength N/mm²	Avg. Corrected Compressive Strength N/mm²
01.	15483	9810	588.10	37.98	38.47
02	15483	9870	603.26	38.96	

Remark:-

Conditions:-
1.This test report refers only to the sample submitted for Testing.
2. This test report is valid at the time of and under the conditions specify herein.
3. This test report must not be reproduced in parts without the permission of this Lab.
4.Any hand made correction invalidates this test report.
5.Sampling is not done by this Lab.

Authorised signatory
Narayan singh Apawat
Director/Q.M.

"End of Report"

Email:nyapawat@gmail.com — BMTL/TR/Block/ /Page 1 of 1

Fig 2 NABL Lab Test Report of New Developed Mortar-Less Interlocking Wall Block As Below

Table 3 Feature evaluation of New interlocking block invented

Criteria		New block invention
Primary A	Facilitates separation of units for reuse	++
	Load bearing block	++
	Mortar Joints-No cement	++
Secondary B	Protects outdoor pollution	+
	Simple, easy, and fast in construction	+
	Reduces equipment and skill labourers	+
	Uses less energy	+
	Environmentally friendly	+

V. CONCLUSIONS

These conclusions collectively underscore the advantages of using mortar-less interlocking blocks in construction, particularly in the context of sustainability, efficiency, and structural integrity.

Adhesive Use: The study concludes that adhesive material is only necessary for the initial course of wall construction, as the blocks are designed to be dry-stacked, which simplifies the building process and reduces material costs.

Reusability of Blocks: The mortar-less, dry-stacked interlocking blocks allow for easy disassembly at the end of a building's life cycle, promoting the reuse of concrete blocks. This feature is particularly beneficial for sustainable construction practices in India.

Interlinking Technology: The research highlights that the use of tongue and groove technology enhances both horizontal and vertical interlinking of the blocks, resulting in a robust wall structure with an interlinking depth of fifty millimetres.

Structural Integrity: The study finds that the interrelated nature of the demountable concrete blocks contributes to a twenty percent increase in wall robustness, ensuring that the structures remain solid and durable over time.

Health and Safety: Strong wall connections formed by the interlocking blocks prevent deterioration and protect inhabitants from harmful pollutants, enhancing the overall safety of the building.

Construction Efficiency: The paper emphasizes that block laying without mortar is a quick and straightforward method, allowing workers to adapt to new technologies with minimal training. This efficiency can significantly reduce labour costs and construction time.

Energy and Resource Savings: The innovative block design requires less energy for construction compared to traditional mortar-based blocks, contributing to a more sustainable building process.

Market Potential: The findings suggest that the Indian construction industry could benefit from adopting these new demountable concrete blocks, as they can minimize waste and accelerate construction processes, making them a viable alternative to conventional methods.

Future Research: The study indicates that further independent research is needed to validate the potential for lower production costs of the new interlocking blocks compared to standard concrete blocks.

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