

Rainwater Harvesting Using Porous Manhole Covers

Miss. Yogita Parihar¹, Mr. Omkar kengnalkar², Miss. Ayesha Shaikh³,

Mr. Atharva Dhangar⁴, Prof. Pratiksha Sanas⁵

^{1,2,3,4}Student, Dept. of Civil Engineering, Trinity Polytechnic, Kondhawa, Pune 1

⁵Assistant Professor, Dept. of Civil Engineering, Trinity Polytechnic, Kondhawa, Pune 2

Abstract—Rapid urban expansion and infrastructure development have led to a substantial increase in impermeable surfaces such as concrete roads, pavements, parking areas, and rooftops. These surfaces significantly reduce natural infiltration of rainwater into the soil, resulting in excessive surface runoff, urban flooding, and depletion of groundwater reserves. Conventional storm water drainage systems are primarily designed to convey water away quickly rather than conserve it. The present research proposes an innovative and decentralized solution titled “Rainwater Harvesting Using Porous Manhole Covers.” The system integrates groundwater recharge functionality directly into existing road drainage infrastructure by replacing conventional solid manhole covers with structurally safe porous concrete covers. The porous structure allows rainwater to pass through interconnected voids into an underlying filtration chamber and recharge pit. M25 grade pervious concrete specimens were cast and tested for compressive strength as per IS 516 (Part 1):2021. The average 7-day compressive strength was found to be 22.13 N/mm², confirming adequate load-bearing capacity. Runoff estimation using the Rational Method indicates that each installation can recharge approximately 45,000–60,000 liters annually under average rainfall conditions. The proposed system is economical, environmentally sustainable, easy to retrofit, and suitable for urban.

Index Terms—Rainwater harvesting, porous concrete, groundwater recharge, storm water management, pervious pavement, urban flooding.

I. INTRODUCTION

Water is one of the most critical natural resources supporting life, economic growth, and ecological balance. In India, a significant portion of annual rainfall is concentrated within a short monsoon period. Although the total rainfall volume is considerable, its uneven distribution and inadequate conservation result in seasonal water scarcity.

Rapid urbanization has altered natural hydrological cycles. Large areas of permeable soil have been replaced with impervious materials such as asphalt and cement concrete. These surfaces prevent infiltration and significantly increase surface runoff. During intense rainfall events, urban drainage systems often become overloaded, leading to waterlogging, traffic disruption, structural damage to roads, and public inconvenience.

Simultaneously, groundwater extraction through borewells has intensified due to increasing domestic and industrial demand. In many cities, groundwater levels are declining at an alarming rate. The contradiction between monsoon flooding and summer water scarcity indicates the urgent need for sustainable storm water management strategies.

Traditional rainwater harvesting techniques such as rooftop collection systems and recharge pits are effective but limited in coverage. Urban roads, which constitute a large percentage of impermeable surfaces, remain largely untapped for groundwater recharge.

This research introduces a novel approach that utilizes porous manhole covers as decentralized rainwater harvesting units. By modifying existing drainage infrastructure, rainwater falling on roads can be captured at the source and directed toward recharge systems. This dual-purpose design supports both drainage and conservation without requiring additional land acquisition.

A. State of development

Research on permeable pavements and porous materials has gained importance in recent decades. Studies on porous asphalt indicate that it reduces runoff velocity and improves water quality by filtering suspended particles. Similarly, pervious concrete has been widely investigated for use in parking lots, footpaths, and low-traffic roads. Pervious concrete is typically produced by eliminating fine aggregates,

creating interconnected voids ranging between 15% and 25%. These voids allow water infiltration while maintaining adequate compressive strength for light to moderate loading conditions.

Several researchers have reported that pervious concrete with 18–20% void ratio can achieve compressive strengths between 20–30 MPa, making it suitable for urban infrastructure applications. In addition to hydraulic performance, studies emphasize environmental benefits such as groundwater recharge and reduction in heat island effect.

However, most existing research focuses on pavement systems. Limited attention has been given to integrating permeability into smaller structural

elements such as manhole covers. Conventional manhole covers are solid and impermeable, preventing rainwater entry unless it flows through side openings. This study addresses this research gap by developing and evaluating a structurally reliable porous manhole cover capable of facilitating direct infiltration of rainwater into underground recharge systems

II. METHODOLOGY

The research methodology includes conceptual design, material selection, experimental testing, and runoff estimation.

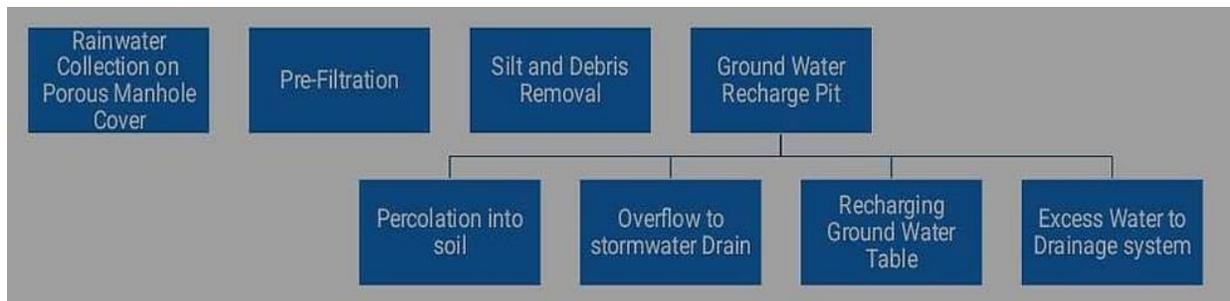


Fig 1 Work Flow chart

A. Conceptual Design

The proposed porous manhole cover consists of:

- Circular diameter: 600 mm
 - Thickness: 100 mm
 - Designed for medium traffic load
 - Void ratio: 18–22%
 - Installed above a filtration chamber and recharge pit
- A graded filtration layer consisting of coarse aggregate, gravel, and sand is provided below the cover to prevent clogging and allow sediment settlement.

B. Materials Used

- Ordinary Portland Cement (OPC 53 Grade)
- Coarse aggregate (10–12 mm)
- Water-cement ratio: 0.35
- No fine aggregates
- Optional superplasticizer for workability

C. Casting and Testing

Concrete cubes of 150 mm × 150 mm × 150 mm were cast and cured for 7 days and 28 days. Compressive

strength testing was conducted as per IS 516 (Part 1):2021.

D. Runoff Estimation

The Rational Method was used:

$$Q = CIAQ = C I A Q = CIA$$

Where:

$$C = 0.85 \text{ (concrete surface)}$$

$$I = 75 \text{ mm/hr (average rainfall intensity)}$$

$$A = 100 \text{ m}^2 \text{ (sample catchment area)}$$

$$\text{Calculated peak runoff: } 0.00177 \text{ m}^3/\text{s}$$

Estimated annual recharge per unit: 50,000 liters (based on 700 mm annual rainfall)

III. RESULT AND DISCUSSION

A. Compressive Strength.

Table 2 Compressive Strength Results

Age	Strength (N/mm ²)
7 Days	22.13
28 Days	31.5 (average)

The results indicate that porous concrete achieved adequate structural capacity for light and medium vehicular load

B. Hydraulic Performance

Observed infiltration rate: 3.8 mm/sec
this rate effectively prevents surface ponding during moderate rainfall events.

C. Performance Evaluation

The porous manhole cover demonstrated:

- Efficient surface runoff capture
- Reduced water stagnation
- Improved recharge efficiency
- Structural stability under load

D. Environmental and Economic Benefits

- Reduction in urban flooding risk
- Increased groundwater table levels
- Decreased dependence on tanker water
- Low installation cost

Easy retrofitting in existing infrastructure

IV. ADVANTAGES AND PRACTICAL IMPLICATIONS

The system offers several practical benefits:

- Dual functionality (drainage + recharge)
- Minimal structural modification required
- Suitable for urban roads and parking areas
- Scalable and cost-effective
- Supports sustainable development goals

Municipal authorities can adopt this system as part of smart city initiatives and climate-resilient infrastructure planning.

V. LIMITATIONS AND FUTURE SCOPE

Although promising, the system requires periodic maintenance to prevent clogging. Future research can focus on:

- Long-term durability assessment
- Optimization of void ratio
- Self-cleaning surface treatments
- Integration with sensor-based monitoring

Field-scale pilot implementation is recommended for performance validation under varying rainfall conditions.

VI. CONCLUSIONS

The present study demonstrates that porous manhole covers provide an innovative, practical, and sustainable solution for decentralized rainwater harvesting. Experimental results confirm that M25 grade porous concrete maintains sufficient compressive strength while enabling effective water infiltration. Each installation has the potential to recharge approximately 50,000 liters annually under average rainfall conditions.

By integrating harvesting functionality into existing drainage infrastructure, the proposed system reduces urban flooding, enhances groundwater recharge, and promotes sustainable water management practices. With proper maintenance and implementation, porous manhole covers can significantly contribute to long-term water security in urban areas.

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