BAPROLA

Resettlement Colony, West Delhi

STRUCTURAL ASSESSMENT

A Report on the Problems & Solutions

JUNE 2025

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Acknowledgements

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Executive Summary

Affordable housing is intended to enhance the quality of living of economically disadvantaged communities by providing a safe, resilient, and resource-efficient living environment. The Baprola Economically Weaker Section (EWS) Housing project in Delhi has faced major structural and design shortcomings that could lead to failures, raising concerns about its sustainability, resident well-being, and efficient use of economic resources.

Asha ki Kiran, a Self-Help Group (SHG) of residents, worked with architects and technical consultants at Alliance for an Energy Efficient Economy (AEEE) and Design Axis to conduct a structural assessment of the housing colony and identify problems and solutions.

This report identifies key issues, including rapid deterioration, seismic vulnerability, high repair costs, and poor design decisions, and provides recommendations to enhance future housing initiatives.

Key Issues

- **Rapid Structural Deterioration:** Within five years of occupancy, residents face issues like seepage, broken drainage and water supply infrastructure, and material failures, due to subpar construction practices, poor plumbing, and neglected maintenance.
- **Absence of Critical Seismic Features:** Located in Zone IV, the colony faces a high risk due to the lack of essential earthquake-resistant features. Existing site conditions of material degradation, structural cracks, water logging and poor drainage also significantly reduce resident safety and structural lifespan.
- **Loss of Investment and Resources:** The cost of repairing each dwelling is estimated at INR 80-100K, excluding site-level issues, providing an opportunity to bring better accountability in the use of economic resources in housing schemes.
- **Inadequate Design Decisions Related to Materials and Exterior Finishes:** Use of GI pipes (which corrode) for water supply, poorly waterproofed sunken toilets, and exposed brick façades create systemic failure points. The lack of passive design features exacerbates thermal stress and reduces the climate resilience of these housing units.

Key Recommendations

- **Strengthen Construction Quality & Seismic Resilience:** Buildings should adopt a column-beam-based frame structure as per the IS code and incorporate all required seismic bands (plinth, sill, lintel, roof, corner bands) and vertical reinforcements. Strong foundations should be designed as per the seismic zone, and lightweight and high-quality construction materials should be used.

- **Durable Material and Design Choices:** Long-term maintenance and repair costs can be avoided by using UPVC/CPVC pipes for internal and external piping to prevent corrosion, minimising or eliminating sunken spaces in toilets and kitchens to reduce the risk of water seepage and avoiding exposed brickwork façades. AAC blocks can be used instead of masonry infill for better insulation, enhancing thermal comfort and cost-effectiveness, and lowering the carbon footprint.
- **Improved Oversight and Accountability:** Developing more stringent Service Level Agreements (SLAs) for the Project Management Consultancy (PMC), highlighting the monitoring and supervision aspects required during all phases of construction, will lead to better accountability for quality construction and proper execution.
- **Capacity Building and Maintenance:** Mandatory training of masons in basic earthquake-resistant construction practices and regular inspection and maintenance, especially before monsoons, to check for dampness, cracks and waterlogging.

01

Introduction

Maintenance and repair of existing housing stock is a significant challenge in a country that has an official estimated housing shortage of 18.78 million homes and independent studies that indicate a demand between 29 to 50 million homes.[1] In a distressed and unaffordable housing market, any efforts towards ensuring that existing housing stock remains habitable, safe and resilient to climate change and disaster are critical, as is learning from the errors of past construction to build better in the future.

Low-income social housing in particular demands increased attention because the families living there do not have the means to afford additional enhancements at a unit or building level to increase their resilience if it becomes necessary. Resettlement colonies are one such prevalent form of social housing, where a government agency constructs new housing and resettles residents from informal settlements in the city into the new, formally planned housing stock, with the aim to improve their quality of life. Another important form is affordable housing built under social housing schemes like the Jawahar Lal Nehru National Urban Renewal Mission (JNNURM) or Rajiv Awas Yojana (RAY) and the ongoing Pradhan Mantri Awas Yojana (PMAY).

Over the last two decades, there has been significant construction under such social housing schemes. However, it has been observed that a majority of these flats remain vacant, with buildings deteriorating due to a lack of use, maintenance and security. During COVID, the new vertical announced for Affordable Rental Housing Complexes under the PMAY was a reaction and acknowledgement of extremely low rates of occupancy, offering subsidies and support to developers who were willing to take over existing unused vacant building stock built under schemes like JNNURM, repair and upgrade them and turn them into rental housing. In Delhi itself, the Delhi government constructed 35,744 houses with the Ministry of Housing and Urban Affairs (MoHUA) under JNNURM, from 2007 to 2017. However, only 4,833 of these have been allocated to beneficiaries, and 30,303 are vacant.[2]

The need for upgradation, maintenance, and repair becomes especially evident when occupied homes – where plumbing, sewerage and other systems are in use – are assessed. Studying the challenges that have come up in occupied resettlement colonies can give us insight into what can be improved in the construction process of future social housing. Additionally, with rising temperatures and the frequency of extreme climate events, it is important to understand how the existing housing stock fares under such conditions and what sort of maintenance, repairs, and upgrades would be required to make it adequate and resilient.

1 K. Valambhia, “Redefining strategies for India’s affordable housing challenges,” Mint, Feb. 3, 2024. [Online]. Available: https://www.livemint.com/industry/redefining-strategies-for-indias-affordable-housing-challenges-11706944997430.html.

2 A. Behal, “Govts in Delhi fail to deliver homes promised to hundreds in slums, 14 years after collecting up to Rs 1.4 lakh each,” Article 14, Oct. 2, 2024. [Online]. Available: https://article-14.com/post/govts-in-delhi-fail-to-deliver-homes-promised-to-hundreds-in-slums-14-years-after-collecting-up-to-rs-1-4-lakh-each-66fcb7d536cd8.

02

Pilot Project – Baprola

In keeping with its mandate to improve the quality of life of residents of JJ clusters, Delhi State Industrial and Infrastructure Development Corporation Ltd (DSIIDC) constructed an Economically Weaker Section (EWS) Housing Society in Baprola Phase II, approximately 25km from central Delhi. The project was planned and executed following the Rajiv Ratan Awas Yojana (RRAY) Guidelines under Jawahar Lal Nehru National Urban Renewal Mission (JNNURM). It was sanctioned in 2008 and completed in 2014 with approximately 2,144 Dwelling Units. The Delhi Urban Shelter Improvement Board (DUSIB) relocated the first batch of about 900 allottees there around 2014–15. These residents were from various Jhuggi Jhopri settlements located 10-15 km from Baprola, such as Punjabi Bagh and Jwalapuri.

However, **in less than five years since the completion** and the relocation of the first batch of allottees, issues of seepage, cracks in walls, peeling of bricks and overflowing drains have been reported by residents to various government authorities, including to DUSIB The emergence and prevalence of these issues in such a short duration necessitated a comprehensive assessment of the design and construction quality of the buildings and the site. This need was also raised by residents of the colony who were concerned about earthquake resilience and have actively been working through their SHG, Asha ki Kiran, on other challenges to improve their quality of life after resettlement.

This pilot project aims to assess the built conditions of Baprola Resettlement Colony-Phase II in West Delhi, with an aim to expand to other resettlement colonies. It builds on a 2022 report by the Delhi Housing Rights Task Force,[3] which presented a preliminary evaluation of issues in construction quality and maintenance. The design and construction of Baprola is similar to other resettlement colonies, such as the one in Bawana, and the learnings from here will be applicable to other sites.

This project will involve a structural and constructional audit of the resettlement site, assessing issues at multiple scales: dwelling unit, building, and the resettlement colony. The report will highlight structural and construction process flaws, suggest possible repairs, retrofits and maintenance measures, and will recommend improved practices for future projects.

3 "Assessment of quality of construction at the Baprola RRAY resettlement colony: a report," India Housing Report, March 2022. [Online]. Available: https://indiahousingreport.in/wp-content/uploads/sites/10/2022/05/Baprola-Report_DHRTF.pdf.

03

Site Study

Asha ki Kiran, AEEE, and Design Axis collaborated to assess the construction-related issues of Baprola Resettlement Colony-Phase II, with a team comprising residents, architects, a structural engineer, and built environment researchers.

A site study was conducted through observation of multiple buildings, key water and drainage infrastructure, common areas and interiors of dwelling units, interaction with the residents, and collecting photographic evidence to further examine the underlying problems. Each building has four floors and 16 dwelling units, with four units per floor.

The team focused on four points, namely:

1. Identifying the problems faced by the residents.
2. Mapping the construction-related issues and reasons thereof.
3. Suggesting solutions to address the problems.
4. Making suggestions for better outcomes of such projects in the future.

Before delving into the issues, here is a brief overview of the site, the construction technique and the materials used there:

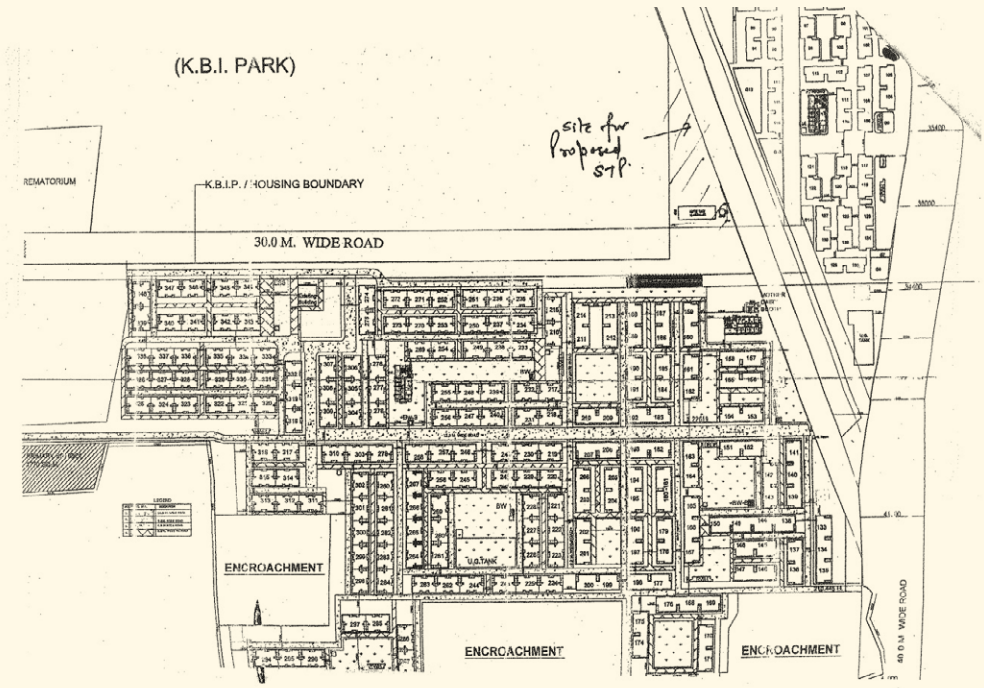

Figure 1: Site Plan

3.1 Construction Technique & Materials

A. Foundation

The foundations consist of spread footings, made up of brick masonry under load-bearing and partition walls (Figure 2). The continuous strip footing serves as a level base on which the wall is built. It is wide enough to distribute the load evenly onto the subsoil, ensuring the ground can support the structure without excessive settlement.

The materials used are Plain Concrete Cement (PCC) on a compacted earth base and conventional clay bricks of 230×115×75 mm size with Cement Sand Mortar.

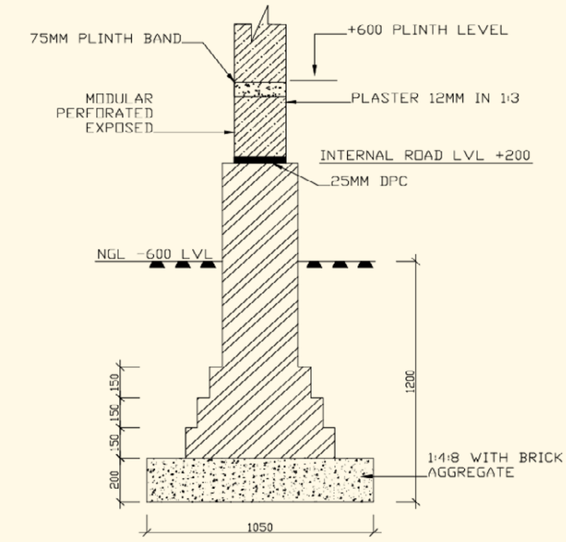

Figure 2: Foundation

B. Superstructure

The superstructure consists of load-bearing walls with vertical reinforcement bars passing through the holes of modular bricks (Figure 3). These bars have been provided at selected locations to provide some resistance against earthquakes (Figure 4).

The walls are 200mm thick load-bearing brick walls using modular mechanised perforated bricks with a combination of Fal-G bricks (grey coloured). Sunshades and steps for stairs are precast Reinforced Concrete Cement (RCC).

Modular Mechanised Perforated Bricks: Most of the conventional bricks manufactured in the country have dimensions of 230x115x75mm. To bring modularity in construction, the bricks incorporated have modular sizes, which have **nominal dimensions of 200×100×100mm and actual size of 190×90×90 mm.** The main advantages of using modular bricks are:

- They allow for more carpet area, since the wall thickness is reduced
- A saving of about 10% in the quantity of bricks and about 22% in the consumption of mortar
- Reduction in the consumption of clay and coal (for burning)

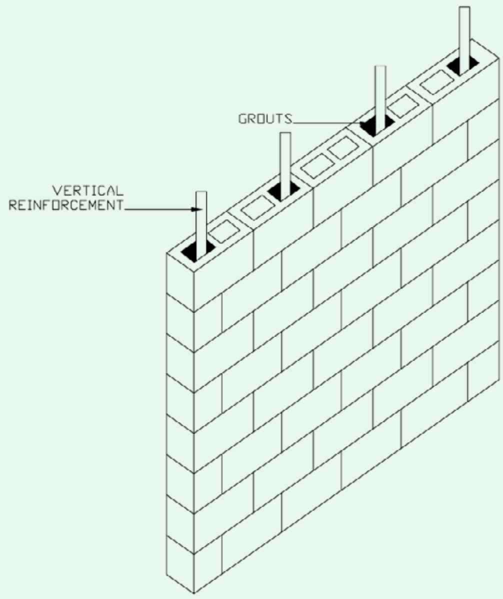

Figure 3: Walling Technique

Fal-G: A cementitious material with a composition of **flyash 70%, lime 15%, and calcinated gypsum 15%. A compressive strength of 50 to 60 kg per sqcm** is expected to be achieved from these bricks. They can be **manufactured in modular sizes** to enable brick and mortar savings.

C. Intermediate Slabs & Roofing

The roofing system consists of precast RCC planks that are 60 mm thick and supported over partially precast RCC joists of 150 mm width and 150 to 200 mm depth with stirrups projecting out on the top. To provide for the tee-beam effect with the joist, the plank is made partly 30 mm thick. A 100 mm wide tapered concrete fillet is provided for strengthening the haunch portion during handling and erection.

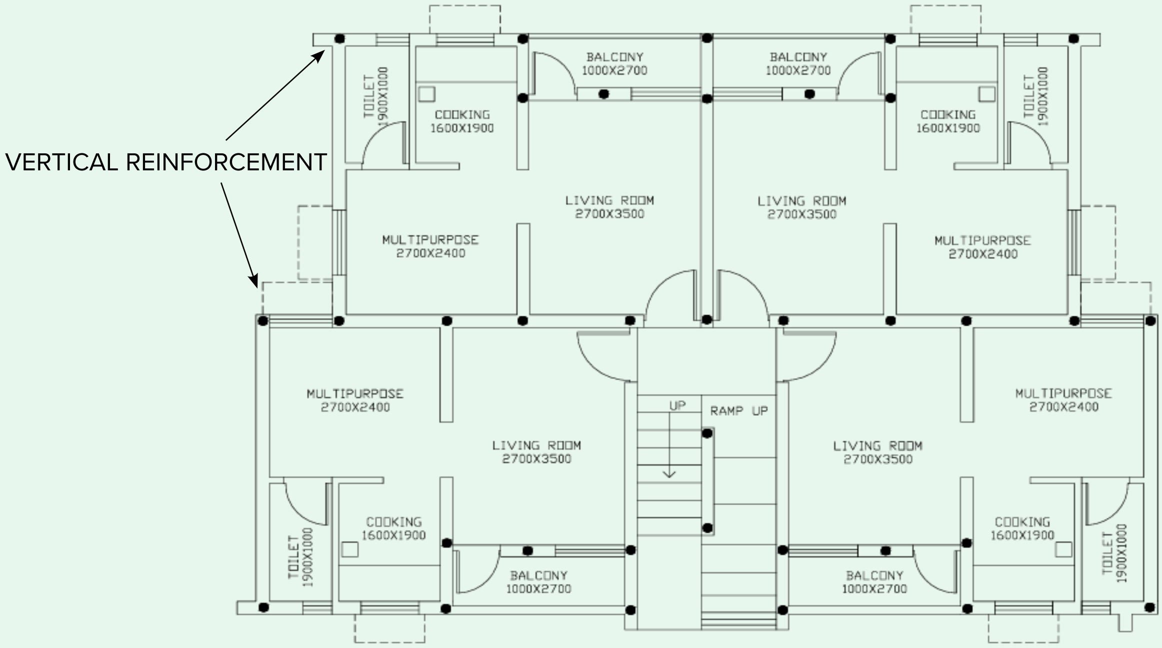

Figure 4: Vertical Reinforcement in Walls

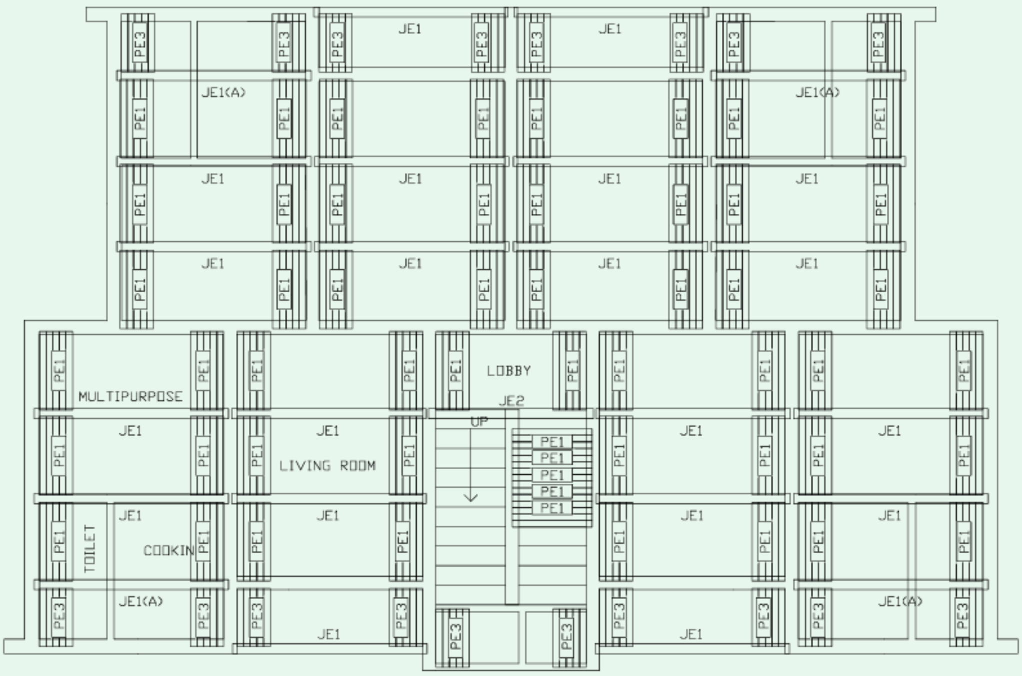

Figure 5: Intermediate Slab and Roofing Structure Plan

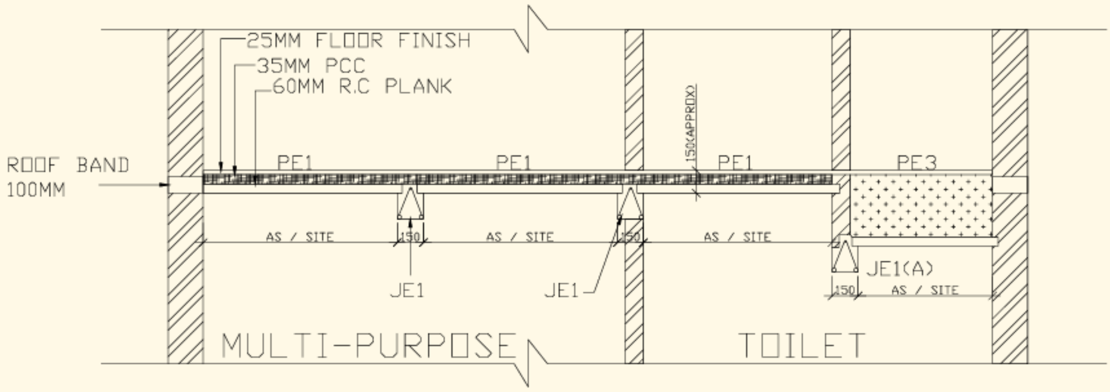

Figure 6: Typical Section showing joist & plank arrangement

3.2 Construction & Maintenance Issues Identified

Concrete/masonry constructions require proper care in the form of regular maintenance. The building blocks in this colony seem to have remained without due maintenance for several years. Water stagnation, paint peeling, plaster break-off, fungus growth, cracking of external rendering and cover concrete are common and widespread. Penetration of moisture into reinforced concrete and masonry components has led to corrosion, further damaging the construction.

The main issues observed by the technical team can be listed as follows:

- Deterioration and peeling off of facade bricks
- Moisture/dampness in the toilets and kitchens
- Broken water supply and broken sewer and drainage pipes
- Moisture/dripping water, and fungal growth on internal and external walls
- Blocked stormwater drains
- Uncovered drains and trenches, and overflow
- Broken/missing pavers, steel windows, and manhole covers

Other specific challenges brought up by the residents include:

- Problem of manually bringing drinking water supplied by the Delhi Jal Board tankers.
- Water for flushing and washing not reaching 2nd (low pressure) and 3rd floors (not reaching at all).

04

Pre-Repair Assessment Methodology

Before attempting any repair procedure, it is necessary to have a planned approach to investigate the condition of masonry, concrete, and reinforcement. Just as durable building construction requires an understanding of structural engineering, material science, and environment/exposure conditions, repair jobs also require the same level of attention in these areas.

This will require a thorough technical inspection and an understanding of the behaviour of the structural components that need repair. Inspection calls for detailed mapping of affected areas, documentation of the type and location of symptoms and their history and photographic evidence. It may also include environmental factors, which are likely to accelerate the damage. The existence of concealed pipes, water lines, and wet areas requires special attention. Comprehensive inspection data helps in making an effective strategy for repair and rehabilitation.

The three distinct stages are to be recognised while taking up a repair job.

- The first stage involves documentation of damage, its type and extent, prognosis of the repaired structure, and recommendations on repair methodology.
- The second stage requires preparation of detailed drawings, sketches, execution guidelines and notes, material and works specifications and tender documents. The tender documents should adequately cover various elements to the extent possible.
- The third stage is the actual execution of repairs. This is a specialised job and only those who have the necessary expertise and resources in terms of tools and plants should be engaged. The supervising engineer(s) must have a good understanding of the procedures and provide attentive supervision.

This pilot study covers the first stage, with findings that the next two stages can build on.

05

Analysis of Issues On Site

The issues on the site fall into four categories:

1. Seepage
2. Drainage
3. Water Supply & Pressure
4. Safety & Security

The prevalence of these issues can be connected with poor quality of construction and ignored maintenance.

5.1 Seepage – Building Level Challenges

Problems

- In all blocks, without fail, the internal and external walls, especially in the kitchen and toilet zone, have a major seepage problem
- The seepage is causing dampness on the walls, resulting in flaking of paint inside the dwelling unit and deterioration of bricks on the facade



Figure 7: Seepage and moisture on interior walls, ceiling, toilet in a home

Causes

- Poor quality plumbing work inside toilets and kitchens
- Broken sewer and rainwater pipes
- Rusting of GI water supply pipes when exposed on the exterior

Figure 8: Deterioration of ceiling due to seepage

Figure 9: Seepage on external walls, deterioration of bricks

The diagrams below show the areas of damage in the internal and external walls of the building blocks, through the floor plan and elevation of a standard block. The diagrams show that the majority of damage has been sustained in the toilet and kitchen areas, both internally and externally.

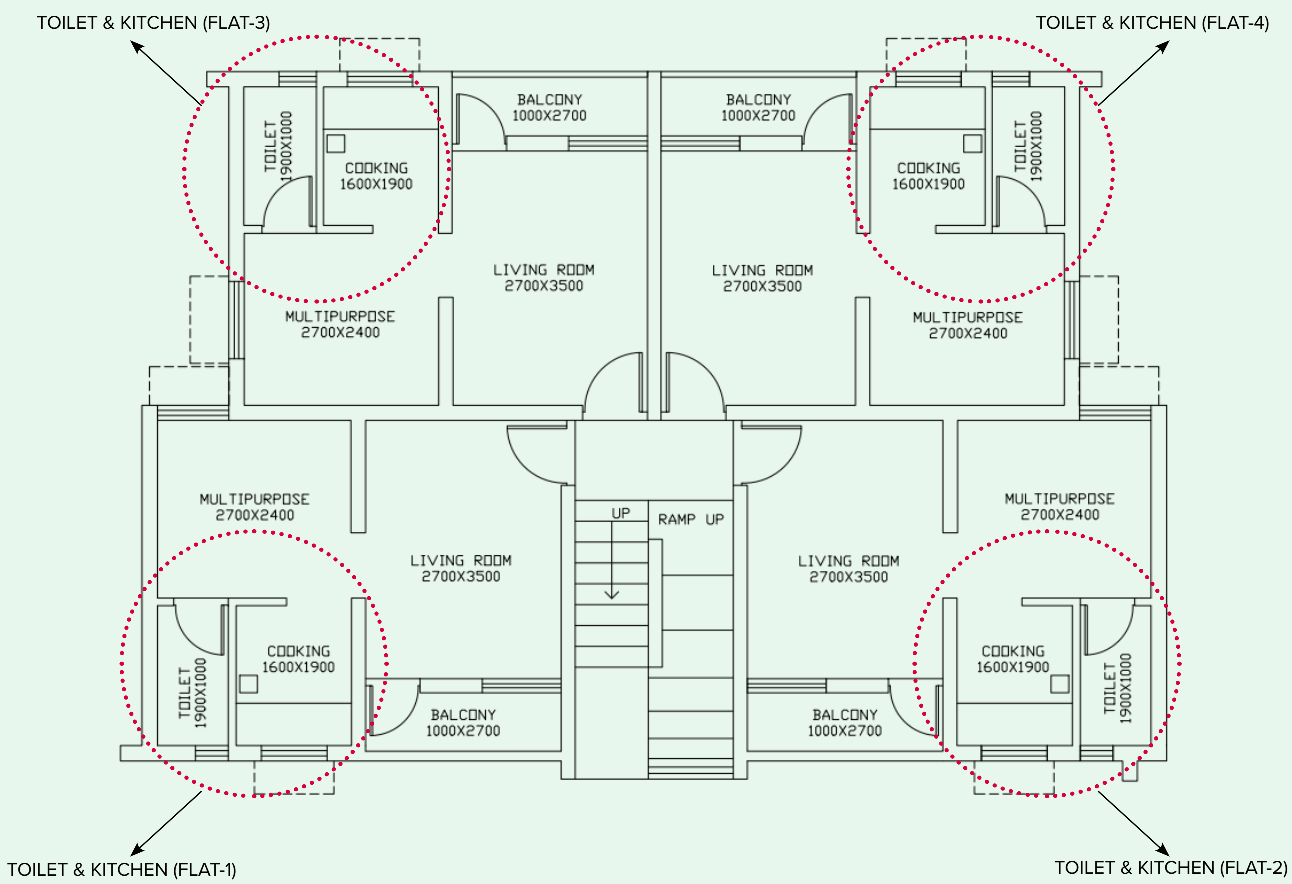

Figure 10: Block plan showing affected areas inside flats

MAJOR DAMPNESS ON EXTERNAL WALLS OF TOILET & KITCHEN AREAS

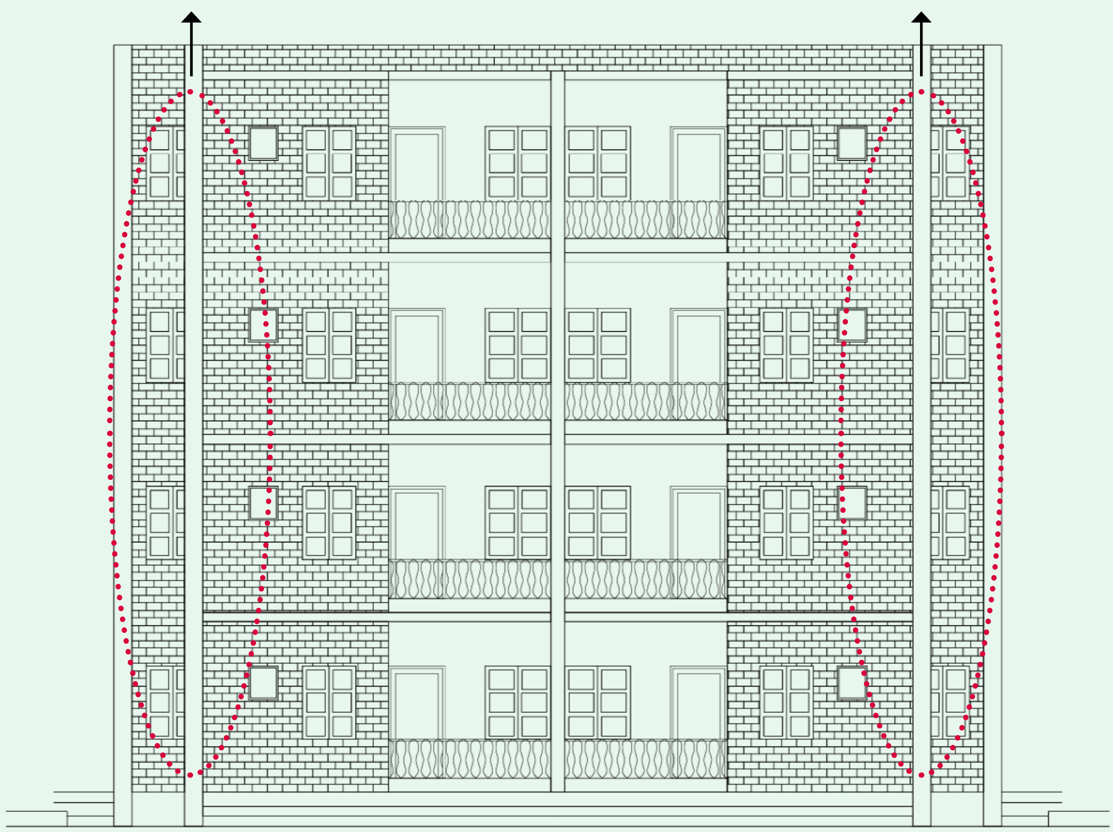

Figure 11: Block elevation showing affected wall surfaces

5.2 Drainage – Site Level Challenges

Problems

- Sewage overflowing on the roads
- Overflowing rainwater drains
- No proper disposal of waste and garbage

Causes

- Choked sewer lines and stormwater drains
- Broken and/or absent manhole/drain covers
- Seemingly non-functional septic tanks
- Pumps of septic tanks stolen

The proposed STP observed on the site plan (Figure 1) from the tender drawings was also never built.

Figure 12: Overflowing sewage and storm water drains, missing/broken drain covers

5.3 Water Supply & Pressure

Problems

- Water not reaching the third floor
- Low water pressure on the second floor
- Terrace water tanks lying unused

Causes

- Low water pressure from bore well(s) located in the area occupied by CISF
- Water supply steel pipes stolen

People who could afford it have set up their own motors (Figure 11) to bring water up to the third floor, but this has been done in an ad hoc manner and is not a feasible universal solution.

Figure 13: Motor installed by resident

Figure 14: Water tanks unused on terrace

5.4 Safety & Security

Due to lack of security and maintenance on site, several problems arise because items get damaged or stolen from the building. Water supply pipes, pumps of septic tanks and sewers, GI water pipes for filling tanks and electric meter box covers have been broken or stolen. From unoccupied flats, windows and grills have also been stolen, which will cause problems for new allottees.

While safety and security are not construction-related issues, they stem from the lack of maintenance in the colony, which creates an atmosphere of neglect. The existing Resident's Welfare Association (RWA) has not been addressing these issues, and efforts by active and engaged women in the community to set up a more effective RWA have not succeeded yet.

Figure 15: Electric meter boxes exposed because covers stolen

Figure 16: Windows & grills stolen from unoccupied flats

06

Technical Portrayal of Seepage Problems & Details for Repair Work

Without breaking open the toilet and kitchen areas in the occupied flats, which would significantly disrupt the daily life of residents, determining the exact cause of seepage is difficult. However, we can estimate what the major causes might be. The following problems could be occurring in the kitchen and toilet areas, as per our understanding and observation of issues outlined in 5.1:

1. Water seepage through the concrete block corner due to high-pressure wastewater from the open drain pipe

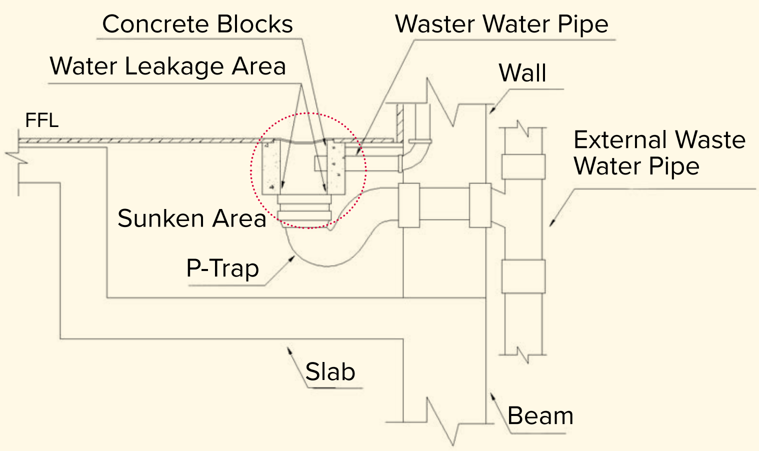

Figure 17: Water seepage through the concrete block corner due to high pressure waste water from the open drain pipe

2. Improper floor and dado tile junction and tiles/stone joint leading to seepage

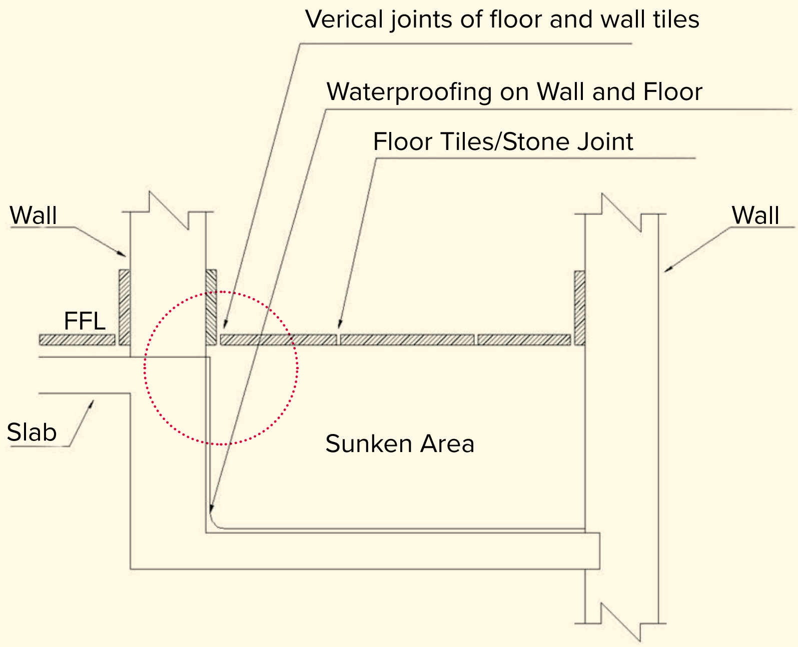

Figure 18: Improper floor and dado tile junction and tiles/stone joint leading to seepage

3. Improper joint between the WC and P-trap resulting in seepage

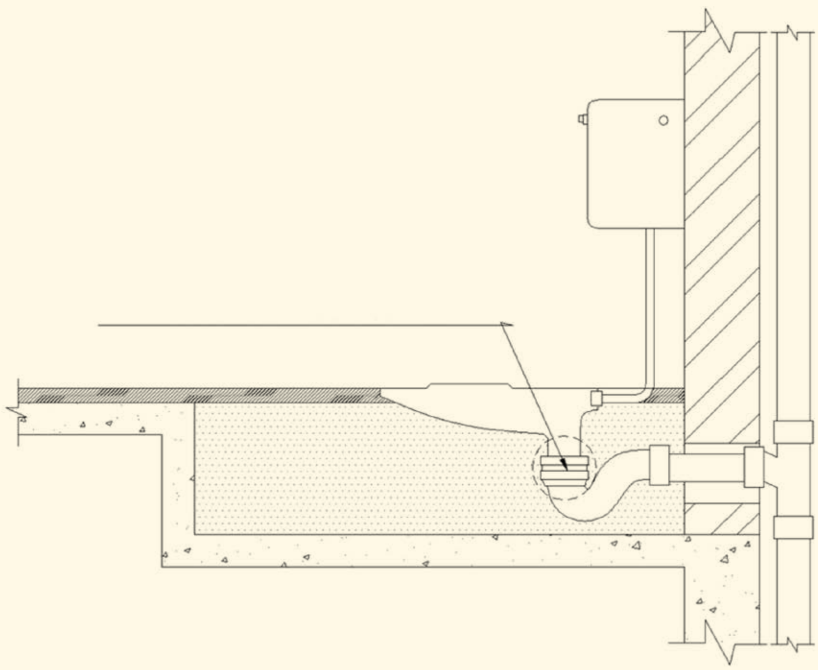

Figure 19: WC and P-Trap improper joint leading to seepage

4. Water supply in the dwelling units is through GI pipes, which corrode easily

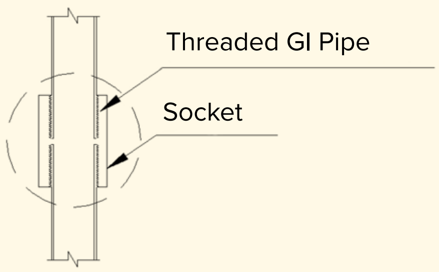

Figure 20: Galvanising gets off the threaded GI pipe leading to corrosion of the pipes

To solve these issues, the following repairs would be required:

1. Using a hopper system to ensure zero seepage

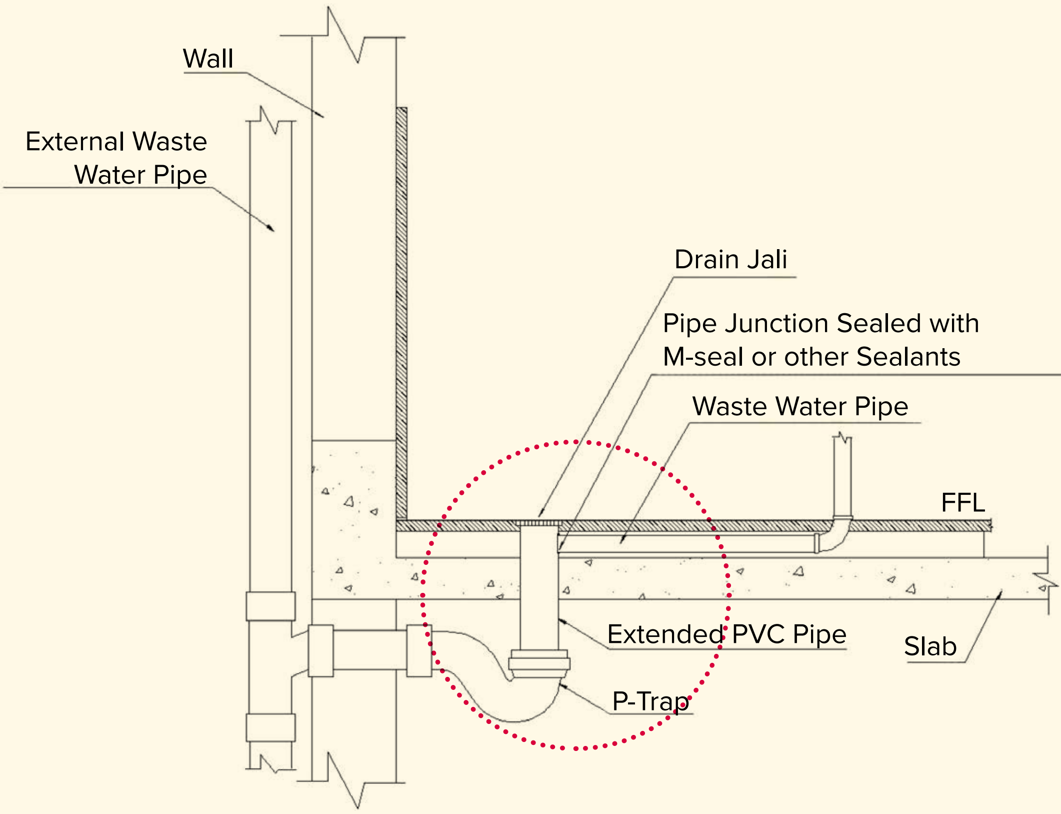

Figure 21: Hopper system ensuring zero seepage

2. Properly placed tiles junction to minimise seepage through the floor

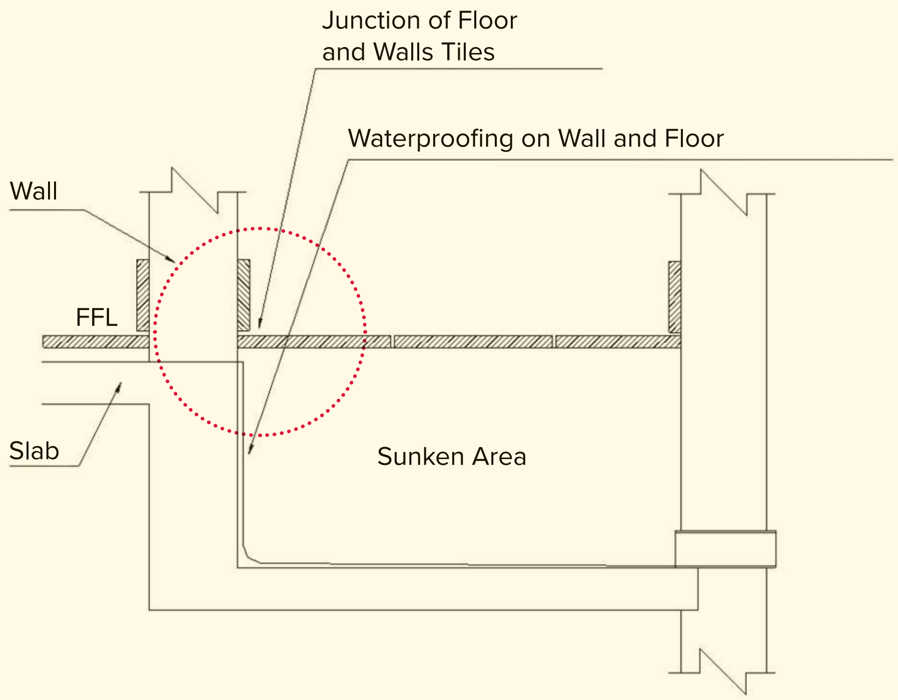

Figure 22: Ideal tiles junction for minimizing chances of water seepage through floor

3. Treatment of sunken areas

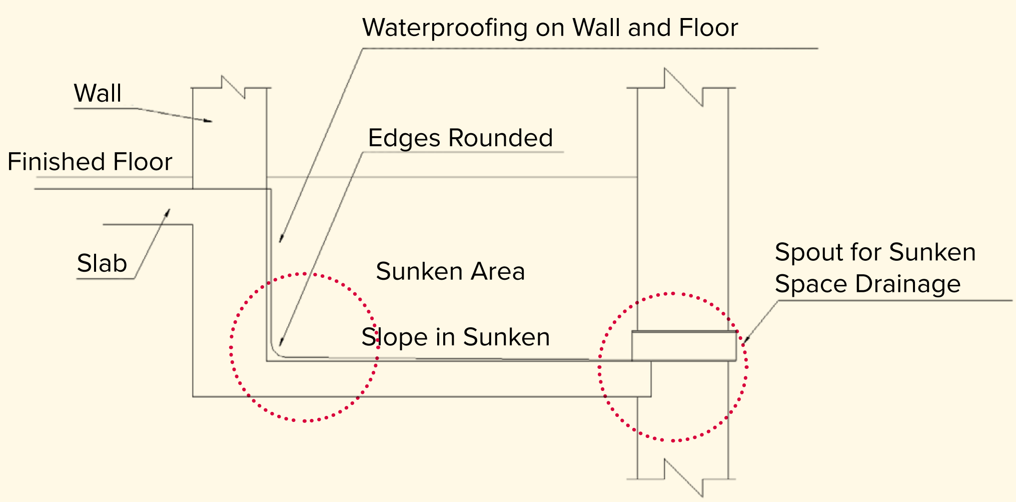

Figure 23: Treatment of sunken areas

07

Overall Repairs & Approximate Costs

The overall repairs can be broadly divided into three parts:

Internal Areas

1. Breaking open the toilet and kitchen floors, and plumbing work
2. Proper waterproofing of sunken spaces in toilets and kitchens
3. Redoing plumbing work with UPVC & CPVC pipes
4. Redoing tiling/flooring work on floors and walls
5. Refixing chinaware and CP/PTMT bathroom fittings wherever required

Ideally, these repairs should be done for all units in a building at once, since issues of water seepage are interconnected across floors. For example, if there is seepage in the toilet on the second floor, the flat below will suffer as well.

External Walls Repairs

1. Repairing damaged bricks either through replacement or repair with plaster/micro-concreting
2. Painting repaired-brick surfaces. Plastering the walls till the second floor is necessary, while the third floor can be plastered if there is a risk of water seepage from the terrace

Site-Level Works

1. Bore well pumps' capacity augmentation. Fresh bore wells are required if the water table has been depleted. The best solution will be to provide a piped supply from external sources to avoid further depletion of the groundwater table
2. Repair and regular maintenance by the government authorities of storm and wastewater drains

We approximate the cost below for the building-level work, based on the cost of repairing the internal areas and external walls for each dwelling unit within a building.

Approximate Cost Estimation per Dwelling Unit (DU)

S. No.	PARTICULARS	COST in INR PER DU
1.	Breaking open the Sunken and Planks for toilet and kitchen	10,000 - 15,000
2.	Breaking the existing plumbing	5,000
3.	Water-proofing	9,000 - 11,000
4.	Backfilling	2,000
5.	PCC	3,000
6.	Plumbing (sewer and drainage)	20,000 - 23,000
7.	Chinaware (WC)	5,000 - 7,000
8.	Flooring	12,500
9.	Tiling on walls	7,500 - 8,500
10.	Plaster outside	4,000 - 5,000
11.	Painting	2,000 - 3,000
	Total	**80,000 - 95,000**

Disclaimer: The actual cost of repairs can be found out only with a detailed analysis of each and every block and dwelling unit. The cost might vary as well if bulk orders are given for multiple dwelling units being repaired together, which is the ideal case, since issues of seepage cause damage across floors. This will also depend on the quotes to be submitted by the contractors and the overheads, such as the fee of the Construction Agency/PMC and the contingency charges to be levied by the PMC, which shall be extra. The repairs per dwelling unit can cost approximately INR 80,000 – INR 95,000 (excluding overheads) on the basis of the above calculations (as per costs in 2025), but this may change as per the final assessment of the site and as per factors mentioned above.

For external, site-level work, it is a lengthy process to ascertain the cost of repairs, which run into tens of crores. The government must consider the costs of internal and external work and ascertain a feasible way of undertaking them.

08

Disaster Risk Assessment

This section delves into the disaster resilience of the colony, which is a combination of its building design, construction quality, and the material degradation and site issues detailed above.

Hazard Profile

Baprola is located on the southwestern edge of Delhi, an area classified under Seismic Zone IV, which has a high probability of earthquake-induced damage, as per IS 1893:2016. Poor construction quality, no maintenance, ignorance of developing failures/faults, ignorance of masonry considerations, and inadequate infrastructure further exacerbate its vulnerability to earthquakes.

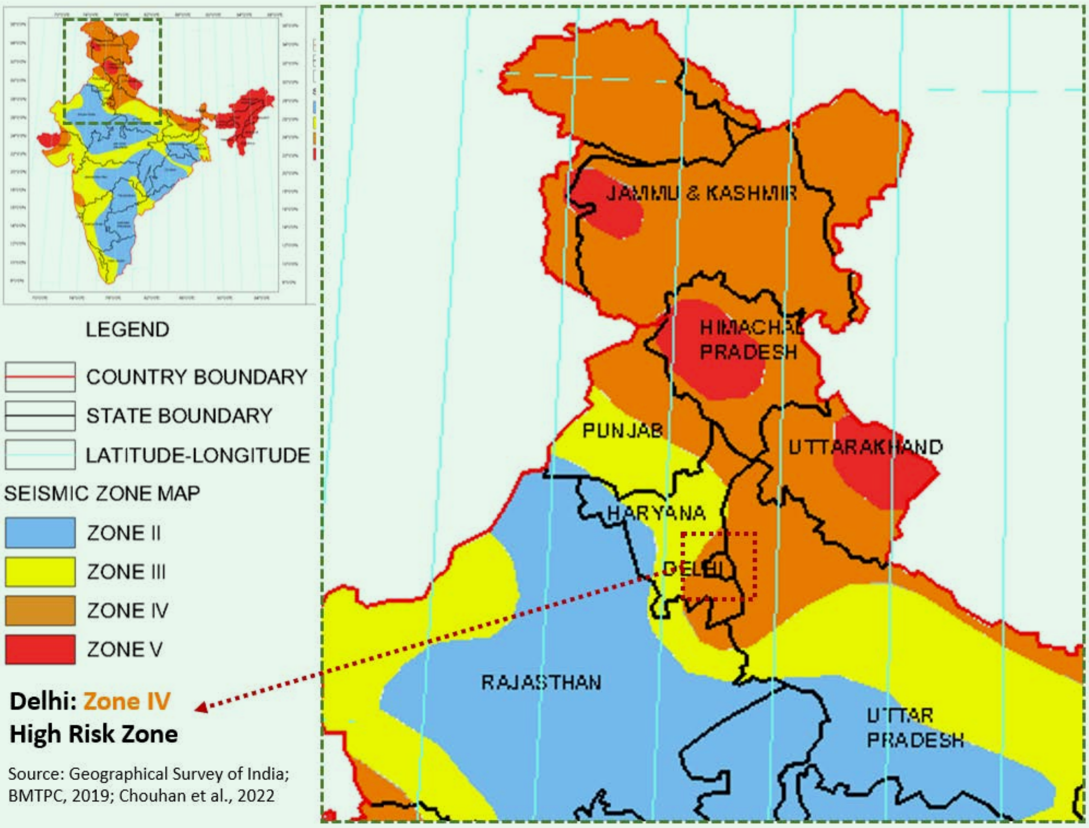

Figure 24: Seismic Map of India (adapted from BMTPC, 2019) - Baprola, Delhi

Seasonal waterlogging, moisture retention, and poor drainage infrastructure also expose the colony to problems like water overflow, dampness, and deterioration. Environmental stresses such as extreme heat events, rising humidity, and pollution contribute to the faster deterioration of buildings.

Deficiencies Observed in Existing Buildings

The colony's buildings are G+3 load-bearing brick masonry structures exhibiting multiple signs of structural distress and environmental wear. Only plinth and lintel bands are present, with no sill band or roof band as recommended for high seismic zones.

Key deficiencies include:

- Cracks near openings, indicating stress concentration and seismic vulnerability
- Delamination of plaster in interior walls and brick peeling in exterior walls, caused by moisture ingress and poor-quality materials
- Damp walls, fungal growth, and indoor moisture accumulation, reflecting insufficient waterproofing and drainage
- Poor quality construction and material degradation
- Cracks in the walls

These conditions, if left unaddressed, may lead to significant damage or collapse in the event of an earthquake or heavy rainfall. The figures below depict some of these issues and additional concerns that need to be addressed for earthquake resilience.

Figure 25: Issues to be addressed for earthquake resilience

Vulnerability Assessment

Method: Rapid Visual Screening

To assess the seismic vulnerability of the building, the Rapid Visual Screening (RVS) methodology was employed, based on the adapted version of FEMA P-154 and IITK-BMTPC guidelines (2005) tailored for Indian conditions. RVS involves a non-intrusive, visual evaluation of key structural and architectural parameters that affect the building's performance during seismic events.

Each component, such as walls, openings, roof type, earthquake bands, overhangs, parapet walls, and potential pounding effect, is evaluated on a binary risk scale[4], and assigned a Safety Index Score ranging from 0 (low risk) to 1 (high risk)[5]. The higher the score, the greater the vulnerability of that component in seismic conditions.

Result

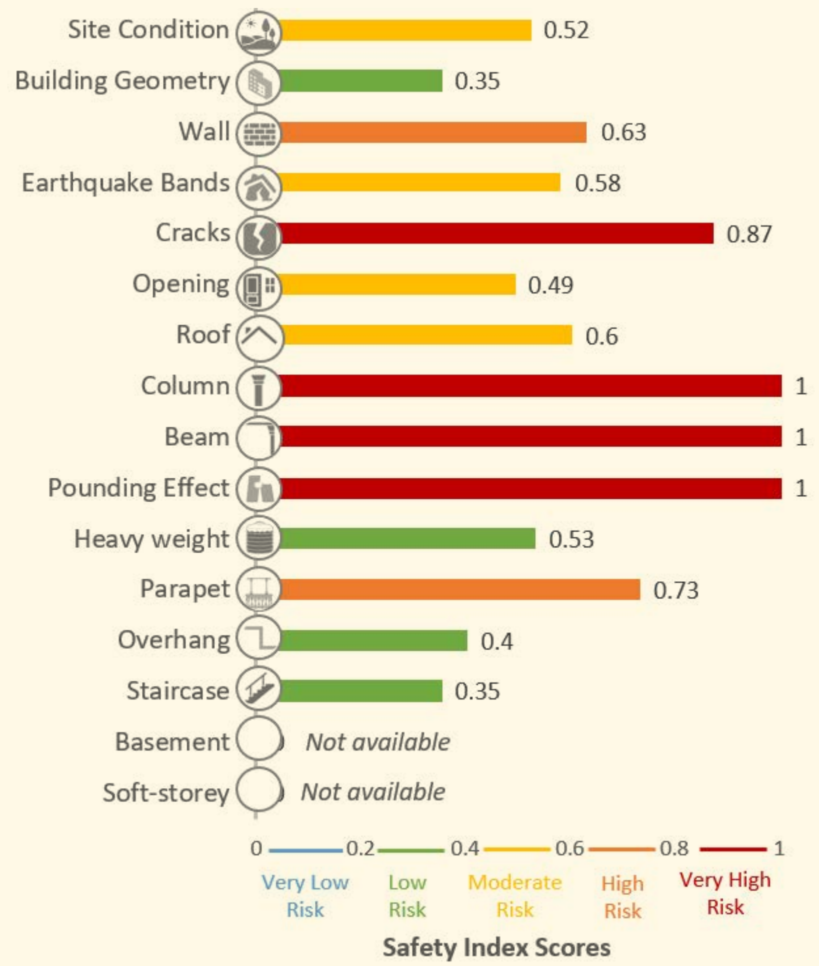

Figure 26: Safety Index Scores of Building Components

Based on the field assessment, the building's seismic vulnerability was evaluated through component-wise scoring, as illustrated in the accompanying figure (Figure 26). The assessment indicates high risk in components such as walls, due to excessive dampness and structural cracks, columns and beams, due to their absence, and parapets, due to their poor condition.

Moderate risk is identified due to the lack of essential earthquake-resistant features, particularly the absence of a continuous required number of earthquake bands (eg, sill bands and door-window bands), which are mandatory in masonry buildings constructed in Zone IV. As per IS Code 4326:1993, Clause 8.4, masonry buildings located in high to very high seismic zones (such as Zone IV) must incorporate all earthquake bands. Additional concerns include roof dampness and site conditions such as waterlogging and poor drainage, which can compromise the building's foundation and reduce its overall lifespan.

With an **average safety index score of 0.60,** the building is categorised as highly vulnerable, primarily due to the absence of critical seismic features and visible signs of material deterioration.

4 S. Chouhan and M. Mukherjee, "Design and application of a multi-hazard risk rapid assessment questionnaire for hill communities in the Indian Himalayan region," Natural Hazards and Earth System Sciences, vol. 23, no. 4, 2023, doi: 10.5194/nhess-23-1267-2023.

5 S. Ruggieri, D. Perrone, M. Leone, G. Uva, and M. A. Aiello, "A prioritization RVS methodology for the seismic risk assessment of RC school buildings," International Journal of Disaster Risk Reduction, vol. 51, 2020, doi: 10.1016/j.ijdrr.2020.101807.

09

Retrofitting Measures

The assessment of Baprola's buildings highlights a critical need for seismic risk mitigation. The high vulnerability indicated by the RVS, combined with poor construction quality and environmental degradation, poses serious threats to life and property. Systematic retrofitting of existing structures, adherence to seismic codes, and awareness among local builders and residents are essential to minimise disaster risk and enhance community resilience.

To enhance the seismic resilience of the existing masonry structure in accordance with IS Code 13935:2009, it is strongly recommended to carry out a Detailed Vulnerability Assessment (DVA). Based on the observed conditions and risk assessment, the following retrofitting and improvement measures should be considered under the expert's supervision:

1. **Provision of Earthquake Bands:** Install the required number of continuous earthquake bands (plinth, sill, roof, door, and window bands) with proper anchorage and reinforcement. These bands should be provided at all critical junctions and around openings to enhance the structural integrity of the masonry.
2. **Wall Strengthening and Crack Treatment:**
   a. Stitch existing cracks using cement grouting for superficial cracks and structural epoxy injections for deeper structural cracks.
   b. Apply a retrofitting mesh on both sides of the walls for added confinement.
   c. Re-plaster the interior walls with cement mortar mixed with waterproofing additives to prevent further moisture ingress.
3. **Drainage and Site Improvement:**
   a. Construct or improve peripheral drainage systems around the building to prevent waterlogging and reduce foundation weakening.
   b. Regrade the site or install slope correction measures to direct water away from the structure.
4. **Foundation Strengthening (if necessary):** If signs of settlement or foundation distress are observed, consider underpinning techniques or soil stabilisation methods to ensure a stable base.
5. **Non-Structural Retrofitting (NSR):** Secure all non-structural elements like parapets to the structural frame properly.
6. Remove or centrally position and anchor heavy objects like water tanks on rooftops to minimise the risk of them shifting or falling during earthquakes.

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Key Findings & Recommendations for Future Projects

To summarise, the key findings of the structural assessment of existing affordable housing stock are as follows:

- **Rapid Structural Deterioration:** Within five years of occupancy, residents face issues like seepage, broken drainage and water supply infrastructure, and material failures, due to subpar construction practices, poor plumbing, and neglected maintenance.
- **Absence of Critical Seismic Features:** Located in Zone IV, the colony faces a high risk due to a lack of essential earthquake-resistant features. Existing site conditions of material degradation, structural cracks, waterlogging, and poor drainage also significantly reduce resident safety and structural lifespan.
- **Loss of Investment and Resources:** The cost of repairing each dwelling is estimated at INR 80-100K, excluding site-level issues, providing an opportunity to bring better accountability in the use of economic resources in housing schemes.
- **Inadequate Design Decisions Related to Materials and Exterior Finishes:** Use of GI pipes for water supply (which corrode), poorly waterproofed sunken toilets, and exposed brick façades create systemic failure points. Lack of passive design features exacerbates thermal stress and reduces the climate resilience of these housing units.

The specific recommendations for future projects are as follows:

- **Making column and beam structures as per the current IS codes to make buildings safe and earthquake-resistant**

  Buildings should adopt column-beam-based frame structures as per the IS code. All the beam-column and beam-beam joints should be centric and strong. Openings are the weaker point in a building. Thus, they should be strengthened with reinforcements and grills. And if going for Brick Masonry construction, all required seismic bands (plinth, sill, lintel, roof, corner, door and window bands) should be incorporated.

- **Anchoring projections and parapets and ensuring connections**

  Parapets, window overhangs, and other projections must be firmly anchored to the main structure. Overhangs above the window should be less than 450mm. Avoid cantilevered overhangs unless they are structurally supported and reinforced. Ensure proper roof-wall and parapet-wall connections.

- **Detailed soil and context study required**

  Conduct soil testing to determine bearing capacity and design site-specific foundations based on soil conditions and expected ground motion. Plinth height should also be as per the local flood height.

- **Avoid exposed brickwork façades for easy repair and maintenance**

  Exposed brickwork requires more maintenance due to frequent wear and tear from environmental factors, resulting in higher operational costs for the building.

- **UPVC/CPVC pipes to be used in internal and external piping**

  It is advisable to use CPVC/UPVC over GI pipes for water and waste movement in the building, as GI pipes are vulnerable to rusting.

- **Sunken spaces to be minimised/eliminated in toilets and kitchens**

  Sunken spaces are vulnerable to water seepage if waterproofing is not done, a proper slope is not provided, or the tile joints are not grouted properly. It is also necessary to provide a water spout in the sunken to let the wastewater move out of the sunken to the external drain.

- **Use of Autoclaved Aerated Concrete (AAC) blocks to achieve better thermal insulation and reduce the carbon footprint compared to traditional red bricks**

  AAC blocks are a good alternative for traditional bricks as infill in an RCC-framed structure, as they are lightweight, making them a better masonry material in earthquake-prone areas. They have better insulation properties, which enhance thermal comfort and improve energy efficiency. They have lower embodied energy compared to traditional bricks, meaning less energy is required for their production. The AAC bricks also provide superior sound insulation, reducing sound transmission.

- **Fixing the responsibility of good construction with the contractor and PMC, and improving accountability**

  PMC and contractors play a major role in proper construction and streamlining the construction process for smooth execution. It is important to develop more stringent SLAs highlighting the monitoring and supervision aspect during all phases of construction for the PMC, to minimise errors and have better accountability for quality construction and proper execution.

- **Mandatory training of masons and regular maintenance checks**

  Mandatory training of masons in basic earthquake-safe construction practices and regular inspection and maintenance, especially before monsoons, to check for dampness, cracks and waterlogging.

Addressing these critical issues will help create safe, comfortable, and cost-effective housing solutions while maximising the impact of resources utilised. By adopting better construction practices, sustainable materials, and climate-responsive designs, future EWS housing projects can avoid similar pitfalls and provide long-term benefits to residents.

11

Our Work – A Larger Housing Context

The Baprola pilot is a wake-up call: current housing practices risk entrenching thermal discomfort, decay, and resource inefficiency while also normalising a risk to life. We need to build on it to shift India's affordable housing agenda toward safety, durability, affordable comfort, and disaster resilience. This study and its findings contribute to AEEE's broader research and policy work and strengthen the case for AEEE's ongoing work on the following convergent efforts towards shifting the policy landscape:

1. **Thermal Comfort for All:** Promoting passive and low-energy design strategies to ensure year-round comfort in low-income homes, aligned with the India Cooling Action Plan (ICAP).
2. **Low-Embodied Carbon Materials:** Replacing traditional bricks with AAC blocks, fly-ash bricks, or other alternatives to improve thermal performance and reduce lifecycle emissions.
3. **Eco-Niwas Samhita (ENS) Implementation:** Building regulatory frameworks and city-level pilots (eg, Ahmedabad) to demonstrate that energy efficiency in housing is both affordable and scalable.
4. **Policy and Financing Innovation:** Supporting mainstreaming of climate-resilient housing through building codes, fiscal incentives, and tools like green certifications or cost-benefit analyses.

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