INFORMAL HOUSING: REDUCING DISASTER VULNERABILITY THROUGH SAFER CONSTRUCTION

BOOK 1: SITUATION ANALYSIS

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INTRODUCTION

This report is the first of 2 reports under this study and presents a **Situation Analysis** of informal housing in Mumbai, with a focus on the types of construction methods and practices. The team’s core emphasis is on identifying building systems, materials used, the associated costs and the issues and opportunities that these present.

While slums in Mumbai have been the subject of much study, little documentation exists on current construction practices. As a first step, the team conducted a survey of 10 settlements in Mumbai. Each settlement is distinct in terms of occupational patterns, demographic make-up and location. However, the survey reveals a consistency across all settlements in the palette of materials used for construction, the quality of the labor pool available, and the sources of materials and costs associated with construction.

Three predominant types of construction systems have been identified - **dry, wet and hybrid**. These types are based on materials used, the methods of assembly, the time involved for construction and the associated costs.

In general, the following are the distinguishing characteristics for each construction system –

A. **Dry building system** –
- Materials require little to no water for assembly;
- Homes may be built within accelerated time frames;
- Associated costs are low;
- Materials are easy to salvage/replace, in case of damage to the house;
- This is the typical choice of construction system for a household new to a slum community.

B. **Wet building system** –
- Materials require the use of water for assembly;
- Time frame for construction is typically longer than time frame for dry building systems;
- Associated costs are higher than for dry building construction system;
- Materials are not easy to salvage/replace in case of damage to the house;
- This is the typical choice of construction for households with established presence in a slum community.

C. **Hybrid building system** –
- Combination of the Dry and Wet system
- Materials require some water for assembly;
- Hybrid systems are faster and cheaper to build than wet systems, but are more expensive and time consuming than dry systems;
- Usually an outcome of incremental expansion, with wet on the ground level and dry on the top;
- Dry components are easy to salvage/replace;
- A typical choice for households with established presence in a slum community, but with limited means; also a typical choice for households seeking to expand their homes vertically.

To test the validity of these assumptions, the team selected three of the ten surveyed sites for detailed studies. This selection was made on the basis of the willingness of the community to work with the team. The selection of sites is also diverse in terms of location and demographic make-up, while still displaying consistency in construction systems.
As part of the detailed site studies, the team carried out the following steps –
• Interviews with local community leaders;
• Interviews with select residents to ascertain occupation, income, household composition, costs of construction and length of tenure;
• Photo-documentation and measure drawings of homes in the communities;
• Detailed discussions with local petty contractors and tradespersons;
• A public workshop in one of the communities (Shivaji Nagar) organized by the local community leaders to solicit input from residents in a public forum.

Chapter 2 provides a snapshot of the 10 settlements covered under this study. Chapter 3 presents the housing case studies representing the various typologies identified from the survey/analysis with key characteristics of each, including the building materials, costs, method of construction, and key problems faced by the resident households from the “vulnerability” standpoint. Based on the house case studies, Chapter 4 presents a detailed analysis of the process of construction, the materials used and the associated costs, and identifies the problems in each.

In general, the team’s conclusions address the following broad issues –
• The selection of a site for a home and preparation of the site;
• The quality and safety of structural elements;
• The life-cycle of cladding materials;
• Delays related to gaining approvals from local regulatory bodies;
• The impact of length of a household’s tenure on decisions regarding choice of construction system.

While the issues and challenges are many, there are also distinct opportunities as revealed by the surveys. In particular, residents of informal housing are prolific users of recycled building products procured from secondary markets or from large construction sites. The team has also identified good construction practices that are currently being implemented by local contractors or residents that if adopted by a larger number of slum dwellers will greatly enhance the life-cycle of materials and the micro-environment of each home.
INFORMAL HOUSING
SETTLEMENTS IN MUMBAI
1. INFORMAL HOUSING SETTLEMENTS IN MUMBAI

Overview

This study involves a random sampling of eight informal housing settlements in different parts of the city of Mumbai to ascertain patterns of use, spatial layouts and methods of construction. The sampling reveals differences in location, length and type of tenure, and occupational characteristics.

Despite these differences there is an overlap of construction practices and methods that may be synthesized into distinct typologies. These typologies could form the basis for recommendations for safer homes that are adaptable by a variety of settlements in Mumbai.

Case Studies

1. Kumbharwada, Dharavi
2. Kunchi Kurve Nagar, Kalina
3. Qureshi Nagar, Kurla
4. Shiv Krupa Society, Govandi
5. Behrampada, Bandra East
6. Darukhana, Reay Road
7. Bharat Nagar, Bandra Kurla Complex
8. Shivaji Nagar, Govandi
Location Plan of informal settlements
1.1 KUMBHARWADA, DHARAVI

Overview

1. **Location:** A hundred year old potters’ settlement in the centre of Mumbai.

2. **Materials:** The ground floor of the houses are generally built with brick and sometimes with wooden frames and tin sheet cladding. Upper stories are built with either wooden or steel frames and clad with tin or cement sheets. The roofs are made up of corrugated cement sheets.

3. **Typical house configuration:** Typically, each house is a long narrow space (normally single storied but occasionally double storied), with parts of the house used to store raw materials, intermediate products, finished products, and tools and implements. The houses facing the street have shop fronts where the products are sold. Many such long narrow houses are stacked next to each other to form the settlement.

4. **Space utilization:** Spaces between the two stacks form the streets and the open spaces, which double up as work spaces and hold numerous kilns, storage spaces etc…. Small parts of these streets are covered with make-shift materials. This is done to usually protect and save the raw clay and unfired pots.

Aerial photo of settlement
Section through a typical home.

The home fronts an external street (left of image), where the shop front is located. To the rear of the home is an internal street with kilns where clay pots are fired. The work areas are located at the back of the house along the internal street.

The ground floor residential areas are located between the shop front and the work area. The upper floor consists of additional living areas.

Photo, typical internal street with kilns.
1.2 KUNCHI KURVE NAGAR, KALINA

Overview

1. **Location:** A tightly knit tribal community in the western suburbs.

2. **Occupation:** Broom makers

3. **Materials:** There are two types of houses – ground story homes built with bricks and two story homes built with steel frames and tin sheets. The roofs of all houses are constructed of tin sheets.

4. **Typical house configuration:** The upper floors are generally rented and are accessed by a ladder from outside the house. Two storied houses generally have a smaller ground cover with a single room on each floor; while ground storied houses have two to three rooms with an occasional verandah in the front.

5. **Space utilization:** Toilets, when inside are on the ground floor. When there are no toilets inside, water is stored inside a mori, where clothes and vessels are washed. These are also washed outside the house. Spaces within and outside the houses are used for manufacturing of brooms.
**Key plan**

A  Section through two typical homes. The ground floor consists of work spaces, living areas and toilets. The upper floors consist of bedrooms and storage areas.

B  Typical work areas along internal streets.
1.3 QURESHI NAGAR, KURLA

Overview

1. Location: slum in an eastern suburb of Mumbai, along the city’s eastern railway line.

2. Occupation: Many residents in the slum engage in the specialized activity of processing animal fat.

3. Infrastructure: There is a thin drain outside the houses to carry sewage from the nahani ghar as well as toilet. These drains are sometimes covered, and when open they are full of garbage. Washing of utensils and clothes are done on the street.


5. Typical home configuration: The settlement is made up of rows of houses (locally called chawls) back to back and touching each other along the sides. Spaces between these chawls become internal streets and open spaces. Houses are two or three stories tall. Houses are approximately 10’ x 10’ or 12’ x 12’, with only one small window. All the houses have nahani ghar (mori) inside the room. Some of them have made toilets inside the house. The roofing material is either GI or cement sheets. Higher floors are accessed by metal or timber ladders, which are usually outside the house.
Key plan

Illustrations – typical home

Type 1: The “Chawl”

A Sections through typical home.

Type 2: Homes along railway tracks

B Animal fat storage, main street
1.4 SHIVKRUPA NAGAR, GOVANDI

Overview

1. **Location:** A settlement in an eastern suburb of Mumbai.

2. **Occupation:** Miscellaneous

3. **Infrastructure:** Most houses have toilets provided through a municipal sanitation program.

4. **Materials:** All the houses are built with brick with steel and stone floors.

5. **Typical home configuration:** The houses are built with steel frames and brick walls. The ground cover of each house is about 150 square feet and the total built up area ranges from 150 to 500 square feet per dwelling unit. Houses are stacked next to each other, back to back with a small gutter between two houses on their rear. The upper floors are constructed with stone-koba-stone and the roofs are made of corrugated cement sheets.

6. **Space utilization:** Stories are added as space requirements grow and presently, each house is two or three stories.
**Key plan**

A  Internal street with ladders for access to upper floors.

B  Typical section through houses
1.5 BEHRAMPADA, BANDRA

Overview

1. **Location:** A dense settlement located in a western suburb of Mumbai.

2. **Occupation:** Garment enterprises including zari works, embroidery, tailoring and dyeing activities, bakeries in the settlement.

3. **Infrastructure:** The area has water supply by the municipality and most houses have water meters. There are no sewers, just a nullah along the station road. Eight Public toilets in the vicinity. Drainage channels covered with slabs for waste water and water supply pipes.

4. **Typical home construction:** Three to four storied structures with framework of steel sections and walls of plywood, tin sheet and brick. Roofs are made up of tin sheets. A porch cantilevers out at each level bearing a steel ladder-like staircase.

5. **Space utilization:** The ground storey is mostly a shop if the structure is along the road or along the lanes. Otherwise, the owner of the shanty occupies the ground floor. The upper stories are rented out to laborers or other families. The topmost stories also house public spaces such as community halls.

Aerial Photo of Settlement
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Key plan

A Photograph of typical home in Behrampada; often plastic sheets are used to protect the interior from heavy rainfall. This practice inhibits ventilation.

B The first and second floors of homes fronting the main street are typically shops or workshops; upper stories (shown in grey in cross-section) are private zones with bedrooms/storage areas.
1.6 DARUKHANA, REAY ROAD

Overview

1. **Location**: It is located along the water’s edge of the Eastern Waterfront within the ports of Mumbai.

2. **Occupation**: Ship-breaking; a variety of objects from dismantled ships are recycled into building materials and furniture. The main street also has very small shops that sell convenience goods and services (e.g. groceries, telecommunications, hair stylists).

3. **Infrastructure**: The settlement has a four to six feet wide street edging the waterfront. Houses are built on both – landward side as well as the seaward side of the street.

4. **Typical Home construction**: The houses on the seaward side are built on wooden stilts that are firmly anchored to the sea floor or the retaining edge. These stilts are built during low tide and connected at the top with wooden planks to form the floor of the houses. Walls of either patched tin panels or plywood are constructed on these floors with small openings for windows. Roofs are made of tin and usually covered with tarpaulin. Small openings are left between groups of houses, which form access to the sea.
**Key plan**

A Typical cross section through house in Darukhana.

B Photograph of typical home raised on stilts for protection from changes in tides; photograph of material recycle yard, often the source of building materials.
1.7 BHARAT NAGAR, BANDRA

Overview

1. **Location**: an old resettlement colony close to the business district of Bandra Kurla Complex with very high property prices. It is presently undergoing redevelopment.

2. **Infrastructure**: Every house has a water connection provided by the Municipal Corporation. Most houses have also built toilets inside the houses. The sewage is drained into the Vakola Nallah through covered drains on the street. Garbage from individual homes is collected in a common garbage bin which is further collected regularly by the Municipal Corporation.

3. **Typical home construction**: 2-3 story homes built in brick, metal, stone. Roofs are built in GI corrugated sheets.

4. **Space utilization**: Houses along main roads have shops or industrial units in the part of the ground floor edging the main road. Upper floors consist of bedrooms.
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Key plan

Brief history of the settlement: The Maharashtra Housing and Area Development Authority (MHADA), owned the land and provided the resettlement. The entire settlement was divided into several plots. One large plot was used to build transit accommodations for people who were to be shifted to new houses (however they were never moved). The transit accommodations were in three storied buildings built in steel framework, stone-koba-stone floors and cement sheet walls and roofs. They had common toilets. About 1000 houses were built as transit accommodations. In four plots, MHADA built about 1000 small (120 square feet) ground storied houses with brick walls and cement sheet roofs.

In thirteen plots, MHADA gave 160 square feet pitches to people where they built their own houses. Each of these plots had about 160 pitches stacked next to each other in rows where people initially built their houses using wooden frames, brick walls and tile roofs. Later, as families grew, every house was extended by about 3 to 4 feet on the front and the rear and upgraded with steel frames, brick walls and cement sheet roofs. Floors were also added using steel frames and stone-koba-stone construction. There are more than 2000 such houses generally with two stories, sometimes with three stories. Upper floors are also sometimes rented.

A Typical cross section through houses in Bharat Nagar

B Photo of typical homes in Bharat Nagar.
1.8 SHIVAJI NAGAR, GOVANDI

Overview

Location: This is a settlement abutting a city garbage dump. The garbage dump is now being moved out of the city.

Shivaji nagar is a thirty year old settlement abutting a large city garbage dump. The land belongs to the city municipal corporation. Due to the adjacency of the garbage dump, the place has low real estate value. Due to this the development pressure on this land is low.

The garbage dump is now in the process of being shifted away from this location. This settlement shows variety of different construction types varying from consolidated wet construction to recently built dry construction. Several new houses have been built by existing residents to rent out to new migrants to the locality. The rent obtained from this supplements the family income.
Key plan

Illustrations – typical home

Upper floor, typically consists of bedroom

Ground floor, typically consists of main living areas or shop

A Typical cross section through house in Shivaji Nagar

B Photo of typical homes in Shivaji Nagar.
PART 2
CONSTRUCTION TYPOLOGIES
2. CONSTRUCTION TYPOLOGIES

Overview

From the case studies, several construction systems were identified, which can be grouped under three broad categories – dry, wet and hybrid.

A. Dry building system -
• Materials used require little to no water for assembly;
• May be built within accelerated time frames;
• Associated costs are low;
• Materials are easy to salvage/replace, in case of damage to the house;
• Typical choice of construction for households that are new to the slum community.

B. Wet building system -
• Materials used require the use of water for assembly;
• Time frame for construction is typically longer than time frame for dry building systems;
• Associated costs are higher than for dry building construction system;
• Materials are not easy to salvage/replace in case of damage to the house;
• Typical choice of construction for households with established presence in a slum community.

C. Hybrid building system.
• Materials used require some water for assembly;
• Time frame for construction is a compromise between dry and wet building systems;
• Associated costs are a compromise between dry and wet building systems;
• Dry components are easy to salvage/replace;
• This is a typical choice of construction for households with established presence in a slum community, but who’s means are still limited.

Each of these categories include several typologies, as follows:

1. Temporary shacks (pavement dwellings)
2. A1 Dry building system, single storey
3. A2 Dry building system, multi storey
4. B1 Wet building system, single storey
5. B2 Wet building system, multi storey (Load bearing)
6. B3 Wet building system, multi storey (Frame construction)
7. C1 Hybrid building system, multi storey (2-3 stories)
8. C2 Hybrid building system, multi-storey (3-5 stories)

Of these 8, this study has focused on 6, as shown here. The other two, namely, temporary shacks (for pavement dwellers), and multi-storied structures (3-5 stories), are deemed beyond the scope of this work, primarily because there is little by way of guidelines for better construction that can be developed for those housing types. This report, therefore, focuses on the six housing types discussed here.
Different construction systems

A1 DRY BUILDING SYSTEM
SINGLE STOREY

A2 DRY BUILDING SYSTEM
MULTI STOREY

B1 WET BUILDING SYSTEM
SINGLE STOREY

B2 WET BUILDING SYSTEM
MULTI STOREY (LOAD BEARING)

B3 WET BUILDING SYSTEM
MULTI STOREY (FRAME CONSTRUCTION)

C1 HYBRID BUILDING SYSTEM
MULTI STOREY
This section includes an in-depth case studies of individual houses in three settlements: Behrampada, Bharat Nagar, and Shivaji Nagar. These particular houses were selected from among the 10 case studies due to the inherent advantages they offered in terms of existing networks of the survey team within these communities, the willingness of the leadership and/or owners to assist with the surveys/interviews.

The houses within these communities were selected to represent each typology identified above. The house study includes: measured drawings of each house to determine space usage, an analysis of the construction method/details to identify the typical structural, construction and climate-related problems associated with each.

Houses from three communities – Behrampada, Bharat Nagar and Shivaji Nagar – have been selected for further analysis and documentation, to substantiate the team’s preliminary assumptions regarding typologies.

**BEHRAMPADA**
- Hamida’s workplace
- Hasan’s house
- Nasir’s house

**BHARAT NAGAR**
- Ibrahim bhai’s house

**SHIVAJI NAGAR**
- Chandrabai’s house
- Hazrat Ali’s house
- Imran’s house
- Abdul Sheik’s house
Part 2: Construction Typologies

BEHRAMPADA

BHARAT NAGAR

SHIVAJI NAGAR
2.2 HAMIDA’S WORKPLACE, BEHRAMPADA

Overview

Hamida works at the clinic and has lived in Behrampada for 40-45 years. She works for the doctor in the morning shift, and has been doing so for the past 14 years. The ground floor is tenanted to two general physicians, one who comes in the morning shift, and another who comes in the evening shift. Both come from outside Behrampada. The first floor is rented out to another family.

The house faces a major internal street within Behrampada consisting of various stores and a market. The structure is 25 years old. It has been built incrementally. The ground floor is wet construction. Steel beams and stanchions form structural members and the walls are made of brick. The wet construction goes up to 600mm above the flooring level of the first floor, after which the walls are made of AC sheets and wooden planks. The first floor projects out 600 mm beyond the ground floor. The first floor has a washing area and mori in the front. It also has a small mezzanine for storage.

A  Ground floor (wet construction) used as clinic by two doctors.

B  Upper floor (dry construction) is rented out to a family.

C  The house faces a major internal street within Behrampada consisting of various stores and a market.
2.2 HAMIDA’S WORKPLACE, BEHRAMPADA

- **No. of households:** 1 clinic, 1 family
- **No. of people:** 3 + 4
- **Uses:** Clinic and Residential
- **Locational characteristics:** Abutted by houses on two sides. There is an alley of 0.6m on one side. The front faces one of the internal market streets.
- **Age of structure:** 25 years
- **Floors:** G + 1
- **Ground Area:** 12.7 m²
- **Const. type:** Dry and Wet construction
- **Materials used:** Brick, steel, AC sheets, wooden boarding, plywood
- **Rooms:** 2 (1 on ground and 1 on first floor)
- **Toilet / mori:** Mori on the first floor
- **Kitchen sink:** None
- **Plinth:** None
- **Walls:** Ground floor has a steel frame structure. First floor takes support from the neighbor’s wall. Wall panels of AC sheets and wooden sheets supported by wooden posts.
- **Floors:** Wooden boards, resting on I-sections
- **Roof:** Wooden joists with AC sheet above. Plastic sheet above AC sheet
- **Windows:** Small window of plywood on first floor
- **Doors:** Main door is a rolling shutter, first floor has a second-hand panel door
- **Mezzanine:** None
- **Loft:** There is a small loft at the back of the first floor
- **Staircase:** Wooden ladder accessed directly from outside

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**Flooring Detail**

- PCC Flooring
- Stone Flooring
- T-Section
- I-Section
- Steel Beam
- Gusset Plate
- Steel Stanchion

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**Part 2: Construction Typologies**
• **Problems**

1. The House is enclosed by surrounding houses. Hence, there is limited natural light. Artificial lighting is used throughout the day.
2. No cross-ventilation because of the lack of openings.
3. Lack of airflow, combined with the materials used causes the house to become unbearably hot.
4. Roof assembly is not waterproof. Tarpaulin is used to cover the roof, which also ends up accumulating water, which then slowly seeps down dampness.
5. Wooden members used are untreated and of poor quality and are prone to rot.
6. There is a problem of water seepage from the ground due to the absence of a plinth.

• **Good Practices**

1. Painting of the steel members prevents them from deteriorating quickly.
2. Light color tiles on the walls of the ground floor increase interior light levels, despite the lack of openings.
3. Vertical orientation of corrugated sheets makes water flow out easier, preventing rusting.
2.3 HASAN’ S HOUSE, BEHRAMPADA

Overview

Hasanbhai has lived in Behrampada for 20 years. He has been in Mumbai since 1984.

He first built the house on this plot using tin sheets. He then re-built it using timber. After this, the house was reconstructed by a contractor. The house was built incrementally, first the ground floor, then one floor and then another floor was added. It is a self-owned house and he lives there with his family.

The ground floor is his tailoring shop. It has a mezzanine, used mainly for storage. There is a small betel nut leaf shop which fits into his store. There is an alley on the side from where there is a staircase to access the upper floors. The first floor has no partition walls, and is used for sleeping by the entire family. The second floor has a kitchen, washing space and a bathroom. There is also some space left over on the second floor for sleeping. The roofing is a GI corrugated sheet. The construction uses brick for the walls, and wooden planks placed on steel I-sections as the flooring. The entrance consists of rolling shutters. The walls are clad with glossy white ceramic tiles.

Since Behrampada is located on a relatively higher ground in Mumbai, there are no water logging issues except during periods of excessive rainfall as was the case on 26th July, 2005.

A Ground floor (wet construction) used as tailoring workshop.

B Mezzanine floor (dry construction floor) used for storage of material and finished goods.
2.3 HASAN’S HOUSE, BEHRAMPADA

- No. of HH: 2
- No. of people: 7
- Uses: Self-owned tailor’s shop on ground floor. Small space rented out to a pan-wallah. First floor is residential occupied by family and second floor is residential given on rent.
- Locational characteristics: Abutted by houses on three sides and a main internal road in front.
- Age of structure: 20 years
- Floors: G + 2
- Ground Area: 19.5 m²
- Const. type: Wet construction
- Materials used: Brick, steel, wood, AC sheets
- Rooms: 3 (1G + 1F + 1S)
- Toilet / mori: Mori on the first floor
- Kitchen sink: None
- Plinth: None. The house goes below the road level by 150mm
- Walls: Brick
- Floors: PCC slab supported by I-sections
- Roof: AC sheets supported by I-sections
- Windows: windows on the first and second floor which have aluminium shutters with a grill on the outside
- Doors: 2 rolling shutters on the front and a wooden paneled door at the side
- Mezzanine: on the ground floor used for storage
- Loft: Open loft used for storage
- Staircase: Wooden staircase inside the house
Hasan’s house

- **Problems**

1. With the ground floor of the house being lower than the external road level, as well the absence of a proper plinth there is a problem of water seepage from the ground below. Ceramic tiles are used to control this seepage problem.
2. On the first floor, the slab is projected to act as coping. But the lack of a cove causes the water to accumulate and seep into the walls.
3. There are no gutters provided to direct the water from the roof.
4. Rusting of steel members take place in this house.
5. Bricks used are of poor quality.
6. External surfaces are not plastered and painted due to lack of funds and lack of access due to narrow adjoining alleys.
7. Lack of provision of adequate slopes on the roof lead to water logging. This water further seeps down through the walls.

- **Good Practices**

1. Painting of the steel members prevents rusting.
2. Large openings are protected by grills for security.
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I Book 1: Situation Analysis

Part Three: Construction Typologies
2.4 NASIR’S HOUSE

Overview

The house is owned by 35-year old Nasir who works at Reliance Industries and lives with his wife and son. The house is located deep within an internal lane near Madni Masjid in Behrampada. The house was built by his father in 1960. The ground floor itself was developed in phases by filling up the land over time. The front portion was built first. The construction materials were procured from Kurla.

The wider back portion was built later, and is at a higher level than the front. The back of the house extends till the next house. The back of the house goes up two floors more. The ground floor consists of the kitchen and a mori, and a small bed. The first floor consists of a bed and storage space. There are no windows on the front because the first floor of the neighboring house extends up to their house.

The second floor consists of a family area with a television set. The first and second floor takes support from the brick wall of the adjoining house. The lower level of the house relative to the surrounding houses causes flooding during monsoons.

Ground floor (wet construction) extension is used as a kitchen; the house suffers from periodic flooding during the monsoons.

Above clockwise starting at top left: ladder to upper floor, mori for washing, rust on wall panels. The house suffers from poor ventilation, and water damage.
2.4 NASIR’ S HOUSE, BEHRAMPADA

- No. of HH: 1 HH
- No. of people: 3
- Uses: Residential
- Location: It is abutted by houses on three sides and an alley of 0.6m on the front face
- Age of structure: 50 years
- Floors: G + 2
- Ground Area: 27.63 m²
- Const. type: Dry construction
- Materials used: Brick, bamboo posts, wooden panels, AC sheets
- Rooms: 4 (2G + 1F + 1S)
- Toilet / mori: Mori on the ground floor
- Kitchen sink: No kitchen sink
- Plinth: No plinth in front portion. The back portion has a plinth of 700 mm.
- Walls: Ground floor takes support from the neighbour’s walls. Paneling of AC sheets/ wooden sheets supported by bamboo/ wooden posts.
- Floors: Wooden boardings supported by wooden joists and beams
- Roof: Wooden joists with AC sheet on top covered by a plastic sheet.
- Windows: Small plywood window on first floor
- Doors: Main door is a second hand wood paneled door
- Mezzanine: None
- Loft: None
- Staircase: Wooden ladder
Problems

1. Since the house is almost completely enclosed by the surrounding houses, there is practically no natural light in the house. Artificial lighting has to be used throughout the day.

2. Lack of openings results in poor ventilation. With a lack of airflow, the house becomes unbearably hot.

Good Practices

1. Vertical orientation of the corrugated sheets prevents water from stagnating.
2.5 IBRAHIM BHAI’S HOUSE, BHARAT NAGAR

Overview

Bharat Nagar was formed in the year 1976. People residing in an area near Bandra Masjid were asked to select a plot of land within a 3 km. radius. They chose land in Bandra East adjacent to the Vakola nallah. Forty four acres of land was allotted to them in 2 parcels, one consisting of rooms of 3m by 4m (this was done for 1000 tenements) and the other parcel consisted of 2147 plots of 16 sq.m.

At the beginning the site was infested with pests (scorpions, snakes, wild animals) and the marshy land behind - now Bandra Kurla complex, an important business district today - was a breeding ground for mosquitoes. The community covered under this study is the Bharat Nagar Paradise co-operative housing society, comprising of 11 plots housing 160 tenants occupying 58,74 sq.m.

The streets outside the houses are maintained by the BMC. There is a drainage line that runs along the streets. The allotment of houses took place in 1976. No sale transactions are allowed. Some places are given out on rent, commanding high prices.

Nearly all the houses are wet construction G+1 or G+2; the terraces have often been covered using AC sheets, GI sheets or tarpaulin. The houses were made incrementally as families grew.

A Homes are organized with narrow alleyways between them; shared parti walls are common. Ibrahim Bhai’s house is built of wet materials, with a corrugated galvanized iron sheet roof. The top floor is a partially open terrace, protected from the elements by plastic sheets.

B The home has an internal toilet and kitchen. The roof is a metal structure with corrugated galvanized iron sheeting.
2.5 IBRAHIM Bhai’s House, Bharat Nagar

- **No. of HH:** 1 HH + 3 shops
- **No. of people:** 8 (+3 people in the shop)
- **Uses:** Residential, 3 shops on ground floor and tuition classes on first floor
- **Location:** The house is located at a corner. It has a street on two sides. Behind is a small service alley where the drains are laid.
- **Age of structure:** 34 years
- **Floors:** G + 1 and a covered terrace
- **Ground Area:** 98.5 m²
- **Const. type:** Wet construction, load bearing
- **Materials used:** Brick, steel, AC sheets
- **Rooms:** 3 (1G + 1F + 1S)
- **Toilet / mori:** Bath area on first two floors, toilet on first floor and a mori on the terrace
- **Kitchen sink:** Kitchen with sink on the first floor
- **Plinth:** None (because of road construction)
- **Walls:** Load bearing brick walls
- **Floors:** The floor consists of 5” x 3” I-sections, above them are 3” wide T-sections between which there is 17”x 23” kota stone
- **Roof:** Pitched roof with AC sheets sitting on MS truss
- **Windows:** Wooden shutters and frames with MS grills
- **Doors:** Second hand panel doors
- **Mezzanine:** None
- **Loft:** The space above the bathrooms is used as loft
- **Staircase:** MS staircases

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**Diagram descriptions:**

- **A** Ground Floor
- **B** First Floor
- **C** Terrace Floor
• Good Practices

1. The painting of the steel members prevents them from rusting.
2. The terrace has been converted into a living space by additions which allow flexibility in usage.

• Problems

1. Due to road construction the plinth is now below the road level outside the house. This is common for many houses in the area. Hence people have to put more money into the house to increase the plinth, which every household cannot afford.
2.6 CHANDRABAI’S HOUSE, SHIVAJI NAGAR

Overview

Chandrabai’s house sits right beside the nallah in Shivaji Nagar, on a 0.9m high plinth. The house is 19 years old and was rebuilt 3 years ago as the wooden members of the roof gave way because of rotting.

Chandrabai and her daughter are the sole occupants of the house. The house is a single large space which opens up to two streets. There is a washing area (mori) at one corner next to the kitchen.

The structural system consists of wooden posts and lintels. The house shares AC cladding of one wall with another house. The houses have their individual unshared support structures. The wooden tie members between posts are used to fix electrical fixtures and also act as shelves.

There is a mezzanine built with wooden posts, lintels and plywood and is suspended from the roof rafter. It is accessed by a steel ladder and used as a storage space.

A The house is adjacent to a main drain – and is subject to some periodic flooding. The building materials are dry.

B The house has a small mori (washing area), a kitchen and a mezzanine for storage.
2.6 CHANDRABAI’S HOUSE, SHIVAJI NAGAR

- No. of HH: 1 HH
- No. of people: 2
- Uses: Residential
- Location: The house abuts a nallah. While one side is flanked by a structure the other three sides are open.
- Age of structure: 19 years
- Floors: 1 (G)
- Ground Area: 23.1 m²
- Const. type: Dry construction
- Materials used: Steel, plywood, bamboo, AC sheets, plastic sheets.
- Rooms: 1
- Toilet / mori: Mori, no toilet
- Kitchen sink: None
- Plinth: 0.9 m
- Walls: GI cladding on wooden and bamboo posts
- Roof: Wooden rafters covered with AC sheets with plastic sheet on top
- Windows: None
- Doors: There are 2 entrances, each covered with a chhajja made of steel sections and AC cladding
- Mezzanine: Wooden joists supported on wooden lintels. End beam suspended from roof rafter
- Loft: Small loft.
- Staircase: Aluminum Ladder

A Ground floor plan.
Problems:

1. Structural members of the house are entirely made of untreated re-used wood. The roof has come down due to the rotting of members leading to dangerous living conditions.

2. Lintels are often used as shelves. The strength of the wooden lintels is compromised to get more width for the shelf against more depth as structural member. This makes the lintels sag, making the structure weak.

3. Problem of water seepage from the plinth.

4. Only internal surfaces of the house are painted. The external surfaces are not painted to save cost which causes rusting of metal.

5. The materials used are of poor quality, showing signs of wear within a year of construction.

Good Practices: None
2.7 HAZRAT ALI’S HOUSE, SHIVAJI NAGAR

Overview

Hazrat Ali lives at Gaza Chowk in Shivaji Nagar with his son’s family. There are five persons in this 25 year old house. It is a ground storey house flanked by a shop on one side. This single room structure shares three of its four walls with its surrounding structures. It has a very low plinth of 0.15m. The house has a mori.

The walls are load bearing brick finished with plaster. The roof is supported by a steel I-section and steel circular section as rafters, cladded by AC sheets. The house has two doors, both opening into Gaza Chowk. The same wall also has a small opening with an exhaust fan. All openings have kadappa stone lintels. The house has a kadappa stone loft for storage, again supported by steel I-sections and T-sections and a stone shelf with similar support.

A The house is built of wet materials; the external face of the walls are unplastered.

B The house has a loft and an mori (washing area)
2.7 HAZRAT ALI’ S HOUSE, SHIVAJI NAGAR

- No. of HH: 1 HH
- No. of people: 5
- Uses: Residential
- Location: It is abutted by houses on two sides, the third side faces a general store and the fourth side opens into the Gaza Chowk
- Age of structure: 25 years
- Floors: Ground structure
- Area: 23.1 m²
- Const. type: Wet construction
- Materials used: Brick, steel, AC sheets, plastic sheets, plywood
- Rooms: 1
- Toilet / mori: Mori, no toilet
- Kitchen sink: None
- Plinth: 0.15m
- Walls: Walls are 0.35m thick brick finished with 50mm thick plaster, with brick piers
- Floors: Indian patent stone (IPS)
- Roof: I-section beam supporting circular section steel rafters. Plastic sheet on top of AC sheet
- Windows: One window with exhaust fan
- Doors: 2 entrances, one into the living space, and a smaller one leading into the mori.
- Mezzanine: None
- Loft: Kadappa loft supported by steel I-section
- Staircase: None

A Ground floor plan

B Cross Section
Hazrat Ali’s house

- Problems:
  1. The house shares three of its four walls, due to which there are no openings in those three walls. As a result, the house has poor natural lighting and no cross ventilation.
  2. There is seepage of water through the floor, causing severe dampness in the house.
  3. Damp conditions result in the rusting of steel members.
  4. Bricks used are of a poor quality.
  5. External surfaces are not plastered and painted due to lack of funds and lack of access due to narrow adjoining alleys.
  6. Inadequate roof slopes lead to water logging on the roof. This results in seepage down through the walls.

- Good Practices:
  1. Small openings for security.
The house was built two years ago. The lower floor has two rooms—one is living space and the other a multipurpose space. A bathroom is tucked under a staircase leading to the upper floor. The staircase is made of RCC. The front of the house has a general store run by Imraan. The upper floor is divided into two spaces. It has a toilet, bathroom and a small storage. This space is rented out as shared accommodation to four people.

**Overview**

A The house is built of wet materials; the external face of the walls are plastered and the house has a high plinth to protect it from flooding during the monsoons. The front of lower floor is used as a shop, the rear is residential.

B The upper floor of the house has a toilet and is rented out to a family of four.
2.8 IMRAN’S HOUSE, SHIVAJI NAGAR

- No. of HH: 2 HH
- No. of people: 5 + 4 (on rent)
- Uses: Residential and commercial
- Location: The house abuts a nallah. On one side there is a house, the other three sides are open
- Age of structure: 2 years
- Floors: G + 1
- Ground Area: 63.1 m²
- Const. type: Wet construction, RCC
- Materials used: Steel, brick, RCC, aluminium, AC sheets
- Rooms: 4 (2G+2F)
- Toilet / mori: 2 toilets and one bathroom
- Kitchen sink: Has a kitchen sink
- Plinth: 1.4 m
- Walls: Brick walls with RCC beams
- Roof: I-sections covered with AC cladding
- Windows: Aluminium frame sliding windows with grill outside
- Doors: 2 entrances, each covered with a chhajja made of steel sections and AC cladding
- Mezzanine: None
- Loft: Small loft on top of bathrooms
- Staircase: RCC staircase
• **Problems:**

1. Due to proximity to the nallah, there is a problem of infestation of mosquitoes and flies.
2. The framed structure used for this house is very expensive and also requires skilled labor.

• **Good Practices:**

1. Tiles are laid till dado level (upto 1.5 m high on wall); this helps in waterproofing.
2. Adequate ventilation through windows.
3. High plinth prevents water logging.
Overview

The house is 20 years old. There are 6 people living in it. Initially it was a ground structure. In the following two years the first floor was added. It has been rebuilt 4 to 5 times, the last time was one year ago. The pitched roof has a storage space under the ridge. There is a bathroom on the lower floor. One end of the house is sinking. The plinth is 1m high.

Location

A The house is built of dry materials, and has been torn down and re-built over 4 times; the foundation is weak and the house settles quickly.

B The upper floor is a recent addition in dry materials, with a storage loft below the pitched roof.
2.9 ABDUL SHEIK’S HOUSE, SHIVAJI NAGAR

- No. of HH: 1
- No. of people: 6
- Uses: Residential
- Location: The house abuts a nallah. It faces an internal alley in the front, and is surrounded by houses on all other sides
- Age of structure: 20 years
- Floors: G + 1
- Ground Area: 63.1 m²
- Const. type: Dry construction
- Materials used: Plywood, bamboo, AC sheets, plastic sheets.
- Rooms: 2 (1G +1 F)
- Toilet / mori: 2 bath areas
- Kitchen sink: no kitchen sink
- Plinth: 1 m
- Walls: Wooden and GI panels on wooden posts
- Roof: Pitched roof constructed with wooden panels which is covered with a plastic sheet during the rains
- Windows: None
- Doors: Rolling shutter
- Mezzanine: Storage under pitched roof
- Loft: Small loft in the pitch of the roof
- Staircase: Wooden ladder
• **Problems**

1. All structural members of the house are entirely made of untreated reused wood which often rot during the monsoons.
2. The house was reconstructed only a year ago. Due to poor foundation and marshy soil conditions, the structure has already started sinking.

• **Good Practices**

1. High plinth protects from water logging.
PART 3
MATERIALS, METHODS AND COSTS OF CONSTRUCTION
3.1 MATERIAL PALETTE AND PROCUREMENT

- Recycled Bricks
- Recycled Corrugated Sheets
- Recycled Furniture
- New Tin Sheets
- Recycled Steel Sections
- Recycled Plywood
Shops selling recycled doors, Shivaji Nagar

Shop selling furniture, Shivaji Nagar

Shop selling old wood scrap, Shivaji Nagar

Scrap from demolition sites, Kurla

Wholesale market for recycled material, Kurla

Shop selling timber sections, Shivaji Nagar
3.2 DRY CONSTRUCTION, ONE STOREY

Based on Chandrabai’s House

Chandrabai’s house sits on soil that is unstable due to proximity to the nallah. Jute sacks stuffed with sand have been used for the foundation. The plinth is constructed over this. These jute sacks also provide waterproofing, but they are not fully effective. The material used for construction of plinth is brick with cement plaster.

The house was built a year ago with timber and bamboo posts. It is highly susceptible to moisture and insects. The posts are anchored at ground level. The structure does not rest on the plinth.

The structure of the roof consists of wooden rafters which rest on horizontal ties, which sit on the posts. The cladding for the roof is done using metal corrugated sheet covered with tarpaulin for waterproofing.
The kotmala (loft) consists of wooden joists. The joists sit on a beam which runs through the length of the house. At both ends, wooden blocks are used to attach the joists to the posts. Fixed vertically which helps in draining off water from the roof.

Panels of AC sheets form the walls of the house. One of the walls is shared with neighbors, but both have independent structural systems. The sheets are fixed vertically which helps in draining off water from the roof.

Area: 249 SFT
Total cost: Rs. 100,000
Bribes: Rs. 6000
Construction cost: Rs. 94,000
Construction time: 4 days
Materials are procured from: Stores on the highway edging Shivaji Nagar.
3.3 DRY CONSTRUCTION, MULTI-STOREY

Based on Nasir’s House

A The front part of the house does not have a plinth. Jute bags are rammed into the earth to provide stability. At the back, the plinth is 0.7m high. It is made using broken brick pieces along with cement plaster.

B The house consists of three dry construction walls which run between the wet construction walls of the neighbors on either side. The dry construction consists of second hand wooden boards and beams. The walls are made in an ad-hoc manner depending on the size of available materials.

C The roof consists of wooden rafters resting on the horizontal ties which sit on the neighbor’s walls.
Cladding is done using AC sheets which sit over wooden boards. The AC sheets are covered with tarpaulin for water proofing. Paver blocks are placed on the tarpaulin which prevent it from getting displaced.

The upper floors are constructed in a cavity between the neighbors’ houses. Similar dry construction methods are used to build upper floors as that of the ground floor.

- Area: 297sf
- Cost: Rs.125,000
- Bribe: Rs.8,000
- Construction cost: Rs.117,000
- Construction time: the ground floor takes a week the other floors take about 3 days each.
- Material procurement: from Kurla, a large informal market for recycled items in Mumbai.
### 3.4 PROBLEMS WITH DRY CONSTRUCTION

#### Problems with Dry Construction

| A | Foundation | Lack of foundations or foundations of insufficient depth cause uneven settlement/ weakening of structure. |
| B | Plinth | Poor waterproofing: Seepage of water from the ground because of capillary action. |
| C | Vertical structural elements | 1. Rotting of structural members, which are not adequately protected.  
2. Problems of joinery of structural members. |
| D | Vertical cladding elements | 4. Use of too many materials causing problems in joinery details. Often water seepage happens through these. (see A)  
5. GI sheets are often not protected on the external surfaces due to lack of funds; this causes rusting. (see A)  
6. Corrugated sheets oriented horizontally to optimize material usage and costs. This prevents drainage of water, causing water logging on the surfaces, leading to rusting and water seepage.  
7. Size of windows restricted so as not to compromise strength of material (and also for security/ protect against theft). This causes ventilation problems in the house. (see B). To avoid seepage of rainwater, plastic sheets are used to cover external walls. This in turn blocks ventilation. (see C) |
| E | Horizontal floor structural elements | 1. Structural members not adequately protected, which results in rot.  
2. Orienting beams horizontally causes sagging and eventually weakening of structure. |
| F | Horizontal floor infill elements | Ply flooring is used to reduce costs. But wears away faster and needs frequent replacing. |
| G | Horizontal roof structural elements | Rotting of structural members, which are not adequately protected. |
| H | Horizontal roof cladding materials | Bad assembly of roof cladding materials causes water seepage from the roof. This is remedied by putting tarpaulin or plastic sheets secured loosely by weights or by nailing. Nailing further causes water seepage and rusting; creases in the plastic above causes water logging and even more seepage. |

Note: Foundations (A) and plinth (B) not shown. Often, these critical construction components are not built or are built in a substandard manner.
Multiple materials and irregular module sizes cause weak joineries that are prone to leakage.

Minimal windows result in poor ventilation.

Using plastic sheets to inhibit seepage of water results in poor ventilation.
3.5 WET CONSTRUCTION, SINGLE STOREY

Based on Hazrat Ali’s House

A The house has a plinth of 0.15m made by compressing sand in situ. The house does not have a foundation. The house is built over the soil consolidated by the foundation pit of the house situated in the same place earlier.

B The walls are constructed with brick masonry with wooden lintels for the openings.
The roof structure consists of wooden joists which sit on the walls and an I-section at the centre and at the edges. The cladding consists of AC sheets.

Area: 249sf
Cost: Rs.200,000
Bribes: Rs. 10,000
Construction cost: Rs. 190,000
Construction time: 15 days
Material procurement: stores on the highway edging Shivaji Nagar.
3.6 WET CONSTRUCTION, MULTI-STOREY (LOAD BEARING)

Based on Ibrahim Bhai’s House

A  The walls are made with brick masonry finished with plaster and paint. The wall abutting the neighbor’s house is a shared wall and the cost for that is also shared.

B  The foundation pit has been edged with vertically placed basalt and filled with reinforced concrete. Above that a four feet high plinth was constructed. The plinth consisted of brick walls on its sides with an infill of broken brick and sand.

C  The floor consists of 5” by 3” I-sections, above them are 3” wide T-sections between which there are 17” x 23” kota stone tiles.
The terrace level of the house has been covered with a pitched roof covered by GI sheets. There are wooden panels that go up to the pitched roof making the terrace a livable space.

The first floor of the house is built using the same construction system as that on the ground floor. There is a balcony in the front which has been converted partly into an additional living space.

Area – 1060sf
Cost: Rs.450,000
Bribes: Rs.15,000
Construction cost: Rs.435,000
Construction time : 2 months each for the ground and first floor. The terrace level took about a week.
Material procurement: first hand material, particularly steel, is bought from Khar. Second hand material is procured from Kurla.
3.7 WET CONSTRUCTION, MULTI-STOREY (FRAMED CONSTRUCTION)

**Based on Imran’s House**

A high plinth is constructed to keep the house safe from flooding and to plan for rising road levels. The high plinth also helps in providing a strong footing to for the house. This plinth is constructed by compressing sand along with broken bricks in a cement slurry. A brick wall is constructed around this infill. The house uses this plinth for support.

B There are RCC columns and beams. This framed structure has an infill of brick walls.

C As it is time-consuming to construct the slab in RCC, steel is used as a structural system for the floor. It consists of 5” by 3” I-sections, above them are 3” wide T-sections between which there are 17” x 23” kota stone tiles.
The staircase leading to the first floor is also constructed using RCC. The partition walls on the first floor do not go up to the roof. There is a bathroom and a toilet on the first floor.

The roof is sloping. A steel structure is used to support the roof. This is clad with AC sheets.

Area: 679sf  
Cost: Rs.500,000  
Bribes: Rs.15,000  
Construction cost: Rs. 535,000  
Construction time: 3 months  
Material procurement: stores on the highway edging Shivaji Nagar
## 3.8 PROBLEMS WITH WET CONSTRUCTION

### Problems with Wet Construction

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</tr>
<tr>
<td><strong>B</strong></td>
<td>Plinth</td>
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<tr>
<td><strong>C</strong></td>
<td>Vertical structural elements</td>
<td>Rusting of structural members in contact with wet construction. (see A)</td>
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</tbody>
</table>
| **D** | Vertical cladding elements | 1. Bricks used are often of a lower quality. A lack of availability of good quality bricks reported.  
2. External surfaces are often not plastered and painted due to lack of funds or lack of access due to narrow adjoining alleys. This causes seepage. (see B)  
3. Lack of water draining methods like coves etc. causes water logging on surfaces and dampening of walls. (see C). |
| **E** | Horizontal floor structural elements | Absence of ring beams at the top to tie the structural elements together makes the structure weaker. |
| **F** | Horizontal floor infill elements | NA |
| **G** | Horizontal roof structural elements | Absence of ring beams at the top to tie the structural elements together makes the structure weaker. |
| **H** | Horizontal roof cladding materials | 1. Lack of provision of adequate slopes lead to water logging on the roof. The water then seeps down through the walls.  
2. Lack of good water proofing practices more generally lead to water seepage from above. |
Structural members rust when in contact with wet construction elements such as brick walls.

Unplastered brick walls.

Lack of coves/gutters causes walls to become damp.
3.9 HYBRID BUILDING CONSTRUCTION, MULTI-STOREY

Based on Hamida’s Workplace

A The slab consists of wooden boards resting on non steel I-sections. These I-sections rest on two edge beams which sit on stanchions.

B The house does not have a plinth. It only has a threshold separating it from the road outside. The flooring consists of ceramic tiles which prevent water seepage from the ground. The tiles are laid on a cement slurry base. The structure of the ground floor consists of steel stanchions which are anchored directly to the ground.

C At first only the ground floor was constructed, where brick walls was used as infill between the I-sections.
The cladding consists of AC sheets and wooden boards. The roof has AC sheets sitting on a structure of wooden rafters sitting on the posts. There is a tarpaulin sheet above for waterproofing.

The brick walls go above the slab to form a parapet wall. The floor above is made of Indian patent stone laid in situ. Dry construction method is used in the first floor. The structural members are put only on two sides as at back of the house it takes support from the wall of the house behind. The structure consists of horizontal wooden ties between wooden posts.

Area: 137sf
Cost: Rs.300,000
Bribes: Rs.12,000
Construction cost: Rs.288,000
Construction time: 1 month for the ground floor and about 2 weeks for the first floor.
Material Procurement: Kurla
### Problems with Hybrid Construction

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<tr>
<td><strong>B</strong> Plinth</td>
<td>1. Poor waterproofing: Seepage of water from the ground because of capillary action; level of plinth sometimes lower than outside ground level.</td>
</tr>
</tbody>
</table>
| **C** Vertical structural elements | 1. Rusting of structural members in contact with wet construction.  
2. Bricks used are often of a lower quality. There is also a lack of availability of bricks reported. External surfaces are often not plastered and painted due to lack of funds or lack of access due to narrow adjoining alleys. (see B)  
3. Lack of insulation against heat. Use of too many materials causing problems in joinery details. Often water seepage happens through these. |
| **D** Vertical cladding elements | 1. Often corrugated sheets are oriented horizontally to use less material. This causes water logging on the surfaces, leading to rusting and water seepage. (see C)  
2. Size of windows is restricted because of strength of material. This causes ventilation problems in the house.  
3. GI sheets are often not protected on the external surfaces due to lack of funds causing rusting. |
| **E** Horizontal floor structural elements | Absence of ring beams at the top to tie the structural elements together. |
| **G** Horizontal roof structural elements | Rotting of structural members, which are not adequately protected. |
| **H** Horizontal roof cladding materials | Bad assembly of roof cladding materials causes water seepage from the roof. This is remedied by putting tarpaulin or plastic sheets secured loosely by weights or by nailing. Nailing further causes water seepage. Further, creases in the plastic above, causes water logging and further seepage. |

*Note: Foundations (A) and plinth (B) not shown. Often, these critical construction components are not built or are built in a substandard manner.*
Problems with Hybrid Construction

A Settlement of structures due to lack of proper foundation.

B Unplastered brick walls due to inaccessible alley.

C Horizontal orientation of corrugations on metal sheets.
CONCLUSIONS

Changes in policies, regulations, market dynamics and large projects that bring about improvements in living conditions of slum communities are necessary and much work is being done by local governments, activist groups and aid/donor agencies to make these changes. However, structural changes of this kind are usually achieved over many years. In the interim, many people are forced to live in sub-standard housing, with scant attention paid to the associated day-to-day risks or compromised quality of life. This study is focused on decreasing the vulnerability of slum dwellers during the prolonged interim period before policies, regulations and large projects take effect. The study outlines a viable set of building guidelines for non-engineered, self-built housing that mitigates risks posed to slum dwellers on a day-to-day basis, enhances their resilience to climate and improves their quality of life.

Slum communities are income-constrained and cost-effectiveness is important if enhancements in building techniques are to be adopted. The objective of recommendations is to allow small, incremental changes without introducing completely new typologies, such as entirely pre-fabricated homes that are produced in a factory and brought to a site. The study is aimed towards slum house occupants and local contractors, to enable them to build a stable house, strengthen/maintain their existing houses, improve their living conditions, and reduce their vulnerability. And they can do all this by themselves with minimal support from governments, private players and donors.

This approach will –

1. **allow individual home owners to tailor enhancements to their own situation,**
2. **provide them with information with which they can make calculated trade-offs,**
3. **preserve local employment networks because it relies on existing skill levels,**
4. **allow for in-situ enhancements, thereby preserving delicate community networks, and**
5. **rely on existing supply chains and materials.**

In addition, the study will also offer new possibilities for sustainable building practices through the re-use of waste and the inclusion of materials that require less energy to manufacture and are easily replenished.

Main Findings:

The Situation Analysis identifies the following as primary issues relating to slum housing:

1. Vulnerability of houses to flooding
2. Poor structural stability due to incorrect building methods, suboptimal/incorrect use of materials and irregular/reactive maintenance practices.
3. Poor access to light and ventilation in the slum houses
4. Availability of alternative material in abundance like waste material (eg. PET bottles) and material that is comparatively cheaper than mainstream materials and which are easier to replenish (eg. Bamboo)
**Materials:** Materials for both systems are readily available in Mumbai. This study has provided extensive suggestions for choice and optimal use of all conventional materials along with specific focus on reused material.

**Construction:** The assembly details provided in this study are based on common building practices, known to the typical petty builder in Mumbai. Often, cost-considerations result in the exclusion of many of these simple and effective practices. However, it was found that with simple measures that are easy to implement and require little technical knowledge beyond what is available, major improvements can be made to the construction quality, and hence the durability of the structure. The cost of these measures is negligible when compared with recurring maintenance costs and vulnerability of life and property.

**Costs & Decision Making:** The true cost of not adopting these methods may not be fully apparent to the typical slum home builder who finances the construction through savings or borrowed money. As an aid to decision making, the team has prepared an illustrative ‘trade-off’ comparison (see page 27). Also included in the report are relative cost comparisons between the three systems of construction prevalent in Mumbai’s slums. These costs are for reference only – actual numbers may vary. However, for the purpose of comparison, the cost data included in this report is a reliable guide and will assist slum-dwellers in decision-making.

**New Possibilities:** In addition, there is a prolific amount of waste generated in the city, especially in the form of post-consumer plastic waste such as PET bottles. There are also other materials like bamboo which are easy to replenish, but are not used for building houses. This study has provided guidance for the use of such waste as a building material; this guidance leaves room for experimentation with these alternative materials. The intent is for homebuilders and contractors should view these as preliminary ideas that they can experiment with depending upon the availability in their own locality, and not as prescriptive recommendations.
Glossary

Abbreviations

AC - Asbestos Cement
GI - Galvanised Iron
MS - Mild Steel
PCC - Plain Cement Concrete
RCC - Reinforced Cement Concrete

Translations

chhajja - projecting or overhanging eaves or cover of a roof

kadappa - a blackish green stone

mori - washing area within the house with half walls.

nallah - storm water drain pan

panwallah - seller of tobacco, betel nut, etc. typically located in kiosks on street corners
INFORMAL HOUSING:
REDUCING DISASTER VULNERABILITY
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