

## **Dharavi an Urban Ecology of Recycling, Living and Working**

*By Vitul Agarwal\* , Katharina Borsi<sup>±</sup> & Tim Collett<sup>°</sup>*

*This paper provides an in-depth typo-morphological analysis of Dharavi's 13th Compound to expose the spatial specificity through which this socio-spatial ecology of living, working, and recycling is supported. It maps the process of recycling and patterns of inhabitation graphically, and analyses how the permeability of the urban tissue and the flexible definable thresholds between the inside and the outside engender and support the coexistence of living and production. The research has identified several typological and morphological concepts, such as a porous ground level, facilitating exchange and interaction; active roofs, which create social and workspace; a sectional stratification that allows both inhabitation but also material and production flows and progressive construction using recycled and scrap materials. The paper argues that these spatial concepts perform as a productive multi-scalar ecology of living and working from which lessons can be learned. These lessons can be adapted in the design to propose reuse, recycling, and live work as sustainable way forward in construction and architecture.*

### **Key Literature Review**

“I strongly believe that the west has much to learn from societies and places which, while sometimes poorer in material terms, are infinitely richer in how they live and organize themselves as communities.”- King Charles III.

King Charles III, King of United Kingdom said this for Dharavi from his visit in 2003.<sup>1</sup> This paper builds upon this statement through in-depth research of the recycling, live - work industry of Dharavi and learns about the makeshift methods that make it successful. These lessons would be analysed and later adapted to the UK Industry.

The research methodology combines literature survey with a detailed typo - morphological graphic analysis.

Two reports, codeveloped by SPARC (Society for the Promotion of area resources centres), an NGO involved with urban poverty provided useful background information. The first, entitled “Reinterpreting, Reimagining and Redeveloping Dharavi”, was a collaboration with KRVA, an architecture college in India and

---

\*Master Student, University of Nottingham, UK.

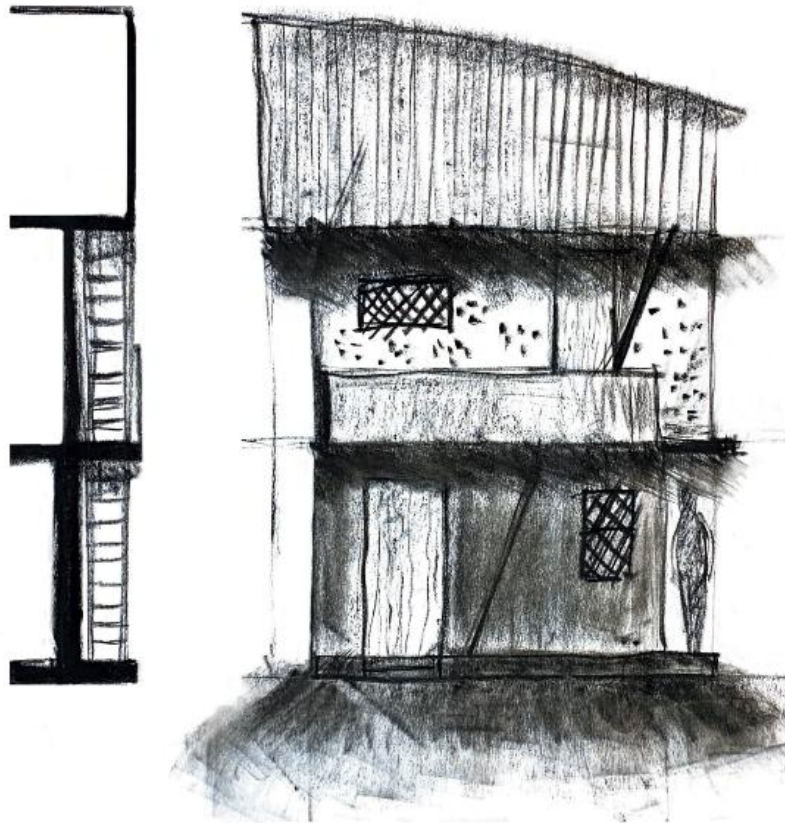
<sup>±</sup>Associate Professor, University of Nottingham, UK.

<sup>°</sup>Associate Professor, University of Nottingham, UK.

1. Robert Booth, ‘Charles Declares Mumbai Shanty Town Model for the World’, *The Guardian*, 6 February 2009, section Art and design <<https://www.theguardian.com/artanddesign/2009/feb/06/prince-charles-slum-comments>>.

analysed the Dharavi live world and its productive and economic contribution, as a basis for a proposal for the Dharavi Redevelopment project.<sup>2</sup>

SPARC partnered with the University of Melbourne Architecture department published a report in 2012, “Dharavi Informal Settlements and Slum Upgrading”. The report focussed its research on the inhabitation of Dharavi’s settlements to develop recommendations for upgrading and redevelopment.<sup>3</sup> Research on the circular economy of Dharavi provided a further data base of analysis.<sup>4</sup>



**Figure 1.** *Typical Dharavi Shanty*

Source: Author, 2023

---

2. SPARC and KRVA, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*, 2010 <<https://www.environmentandurbanization.org/re-interpreting-re-imagining-re-developing-dharavi>>.

3. Kim Dovey and Richard Tomlinson, ‘Dharavi: Informal Settlement and Slum Upgrading’, 2012 <<https://minerva-access.unimelb.edu.au/items/bc0cfa30-e705-5bb8-802e-06a44e7dea26>>.

4. Sourav Dey, ‘The Circular Economy of Dharavi: Making Building Materials From Waste’, *PennState University Libraries*, 14 May 2018 <<https://etda.libraries.psu.edu/catalog/15724szd62>>.

This paper extends and contributes to the existing research by providing an in-depth typo-morphological analysis of Dharavi's 13th Compound to expose the spatial specificity through which this socio-spatial ecology of living, working, and recycling is supported. It maps the process of recycling and patterns of inhabitation graphically, and analyses how the permeability of the urban tissue and the flexible definable thresholds between the inside and the outside engender and support the coexistence of living and production.

The research identified several typological and morphological concepts to show how this supports the multi-scalar ecology of living and working. It graphically analyses how living and working, and an ingenious recycling process intersect. It also examines progressive construction through reusing scarp and waste materials. These themes are then concluded to be used as a sustainable approach in architecture and construction.

## Dharavi Introduction

### Dharavi an Urban Creative Cluster in the Heart of Mumbai

Dharavi Slum is 525 acres of informal township in the heart of the metropolis of Mumbai in India. It is a city within a city - a maze of matchbox houses and shanties stacked together illegally to capitalize on whatever space is available for inhabitation. Negligence of the government has left Dharavi's hygiene and safety levels grossly inadequate. Its unending dirty lanes, open sewers, and cramped huts exacerbate the effects of inadequate healthcare provision.<sup>5</sup>

Featured in the Oscar winning film *Slumdog Millionaire*,<sup>6</sup> Dharavi is tagged as an infamous slum. "The film depicts a cliché of Indian squalor: dirt, overcrowding, and dangerous living conditions."<sup>7</sup> Bollywood film *Gully Boy*<sup>8</sup> exploits the sensitive area of living in the slums very easily such as cramped houses, petty crimes, illegal drugs, domestic violence.

However, Dharavi's informality and improvisation is a "response to the social ties and economic needs of the community."<sup>9</sup> It provides one million people with basic living and work and generates an informal annual economy of "one billion dollars".<sup>10</sup> The song 'Mere Gully Mein' from the movie *Gully Boy*,<sup>11</sup> vocalizes the

---

5. Carlin Carr, 'The Best Idea to Redevelop Dharavi Slum? Scrap the Plans and Start Again', *The Guardian*, 18 February 2015, section Cities <<https://www.theguardian.com/cities/2015/feb/18/best-ideas-redevelop-dharavi-slum-developers-india>>.

6. *Slumdog Millionaire*, dir. by Danny Boyle and Loveleen Tandan (Pathe Distribution, 2009).

7. Lucile Guéguen, 'India's One-Billion-Dollar Slum', *VOICES*, 25 May 2022 <<https://voices.kopje.org/2022/05/25/indias-one-billion-dollar-slum/>>.

8. *Gully Boy*, dir. by Zoya Akhtar (Zee Studio, Cinestaan, 2019).

9. Carr, 'The Best Idea to Redevelop Dharavi Slum?'

10. Jim Yardley, 'Dharavi: Self-Created Special Economic Zone for the Poor', *Deccan Herald*, 2 January 2012 <<https://www.deccanherald.com/content/216254/dharavi-self-created-special-economic.html>>.

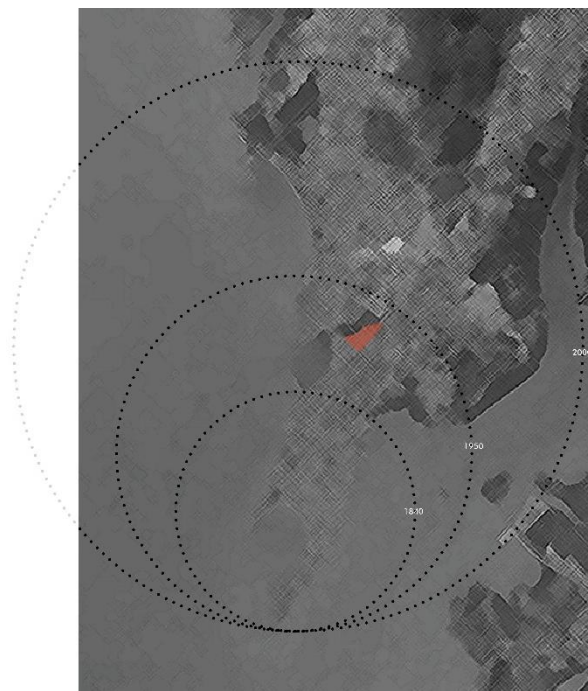
11. *Gully Boy*.

purity, unity, hard work, and innocence in the life of Dharavi Slums even with the challenges it possesses.

## History

Till the 19th Century Dharavi used to be a marshy wet land on the north most tip of Mumbai Island city and the home to the Koli Fishing community of Mumbai. Mahim Creek, north of Dharavi was their source of fish and livelihood. The first people who migrated into Dharavi were artisans forced to relocate to set up micro scale industrial colonies in which they specialise. The growth of Dharavi was proportional to the migration of people in Mumbai (formerly known as Bombay). “People settled there “because the land, mainly used as an informal rubbish dump, was free and unregulated”.<sup>12</sup> Free space with the liberty to build illegally and without any regulations supported the cause of cheap accommodation for the migrants.

The activities of the squatters in the past did not affect the main city, but as this marshy land started to dry up and Mumbai started to expand northwards due to increase in population and industries, Dharavi was drawn into the heart of Mumbai. Figure 2; explains the growth of Mumbai Municipal limit and how Dharavi has become a centrally located prime location in the 21st Century.



**Figure 2.** Mumbai Historical Urban Edge of Dharavi's Shift into the City

Source: The New Landscape by Correa, 1985, p.26 (Recreated by Author)

..... Mumbai Urban Edge      ■ Dharavi

---

12. Mumbai SRA, 'Growth History : Slum Rehabilitation Authority (SRA)' <<https://sra.gov.in/page/innerpage/growth-history.php>> [accessed 14 December 2022].

## Location and Context

The illegal occupation of Dharavi by the squatters on this government owned land created a collection of slums built in a “haphazard manner”.<sup>13</sup> Thus, in 1971 an act called the Maharashtra Slum Areas (Improvement, Clearance, and Redevelopment) Act was introduced. This was to improve the living conditions and hygiene levels of the slum.

The Isolated triangular piece of land was connected to the main city, through the Sion-Mahim Link Road, the 60 feet and 90 feet roads. A census of hutments was carried out in 1976 and photo passes were issued to the slum families. People were provided with taps, toilets, and electrical connections. Open sewers and pipelines were created for waste disposal. These developments displaced people whose houses came in between; therefore, transit camps were created to relocate them.

Mumbai is famous for “some of the world’s most expensive real estate transactions in the world”.<sup>14</sup> With constant growth of the city today Dharavi has become a “goldmine” location.<sup>15</sup> Mashian then states that the prices of the properties in Dharavi have sky-rocketed, where shacks as small as 40 square feet command prices up to INR 10 lakh (GBP 10,000) on the market and the same sized shack can be rented for approximately INR 5,000 (GBP 50) per month.

Today Dharavi is just a few kilometres south of the new business district of Mumbai - the Bandra - Kurla Complex. Famous landmarks like Gateway of India and Colaba are just south, and the Chhatrapati Shivaji Airport is less than eight kilometres away. Located on the intersection of two main train lines of Mumbai, Dharavi is very well connected to the city. If Dharavi was to be cleared and revamped, it would be one of the most valuable real estates in the world.

## Atmosphere

Dharavi is busy every day, Carr<sup>16</sup> mentions how it is noisy by 8am with tea stalls clinking, vegetable vendors ready to wrap up and plastic crushing machines cranking through the long day. It is like “being on a treadmill” and “everyone is busy”.<sup>17</sup> It’s a city of enterprise that sells, produces, and manufactures everything.

Dharavi always has traffic; it is always noisy and busy. Hawkers are selling everything they can and an array of shops and restaurants behind them. The diverse communities that work and function together in Dharavi showcase the guidelines of the constitution of India - a secular and democratic country.

---

13. SRA, ‘Growth History: Slum Rehabilitation Authority (SRA)’.

14. Sean Mashian, ‘Dharavi: When a Slum Becomes a Goldmine (6 Mins)’, *Cornell Real Estate Review*, 20 March 2018 <<https://blog.realestate.cornell.edu/2018/03/20/dharavi/>>.

15. Mashian, ‘Dharavi’.

16. Carr, ‘The Best Idea to Redevelop Dharavi Slum?’

17. SPARC and KRVIA, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

## Present Day

Today Dharavi seeks of hope for the low-income group people who migrate into the city. Patel<sup>18</sup> mentions Dharavi to have “literally risen from the marshes” and how the poor have developed and reclaimed the land bit by bit. It is “a testament to the survival instincts of the poor – and the success of incremental development”.<sup>19</sup> This migration led to the creation of families and neighbourhoods, which created a township for generations to live and work. Today these clusters are supposed to house “20,000 small-scale manufacturing units”<sup>20</sup> providing for the basic livelihood for millions.

These clusters house micro scale industries specialising in recycling, pottery, leather tannery, embroidery, savouries, sweets, surgical thread, kites, gold and jewellery and printing.<sup>21</sup> Dharavi, therefore, is a prime example of hosting creative clusters which successfully orchestrate the live/work culture. My research focuses on these topics through - The 13th Compound, Dharavi’s unique recycling industry.

## The 13<sup>th</sup> Compound

### The Informal Recycling Industry in Dharavi

The 13th Compound is Dharavi’s unique recycling industry. It is located on the Northwest Rim of Dharavi, on the junction of the two main roads - 60 Feet Road and Mahim - Sion Link Road. Even after living and working in hazardous and cramped conditions the 13th Compound is successful in processing “approximately 80% of Mumbai’s hard domestic waste”.<sup>22</sup>

The 13th Compound Industry provides for the livelihood of “up to 250,000 rag-pickers”<sup>23</sup> who gather rubbish all around Mumbai. “40,000 people are employed”<sup>24</sup> inside the recycling micro-enterprises of 13th Compound. Heavy metal work and plastic recycling make up most of the industries within this 8.34 acres of informal settlement.

Figure 3. represents the aerial view of the 13th Compound. Immediately the drawing shows an impenetrable settlement with a few wide lanes and main roads which reflect the routes which can be used to travel through the 13th Compound.

---

18. SPARC and KRVI, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

19. SPARC and KRVI, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

20. Raina Assainar, ‘At the Heart of Dharavi Are 20,000 Mini-Factories’, *The Guardian*, 25 November 2014, section Cities <<https://www.theguardian.com/cities/2014/nov/25/dharavi-mumbai-mini-factories-slum>>.

21. SPARC and KRVI, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

22. Bath Spa University, ‘GtR’, 1 December 2020 <<https://gtr.ukri.org/projects?ref=AH%2F5005897%2F1>>.

23. Bath Spa University, ‘GtR’.

24. Bath Spa University, ‘GtR’.

This density of the 13th Compound can be compared to Mumbai which is referred to as densest city in the world.<sup>25</sup>

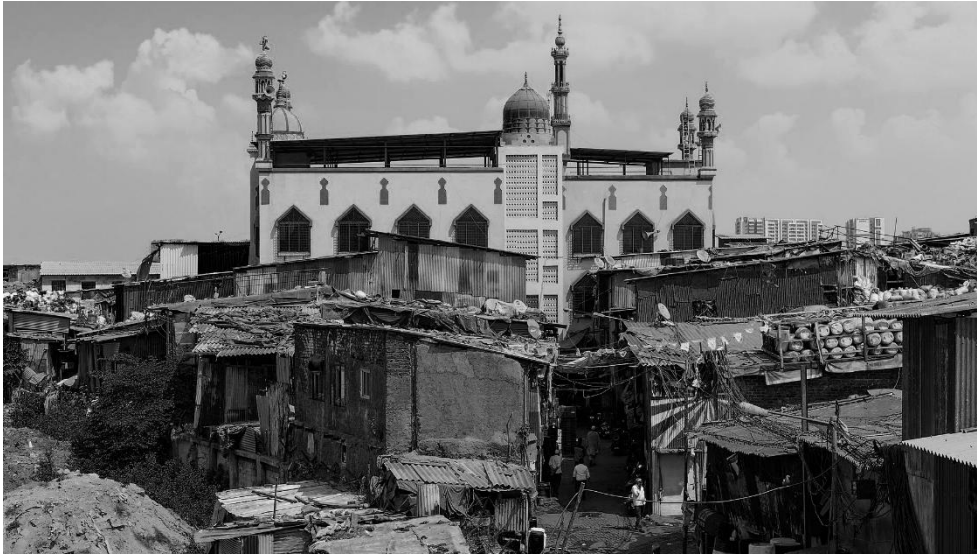
Dharavi is much more concentrated in comparison to Mumbai. However, 13th Compound is able to host the recycling industry as it is well connected with the Mahim Station on its West and three main roads on the other sides which has made it possible for the regular exchange of materials from and to Mumbai.

The small, narrow lanes which disappear inside are what makes this exchange of materials and horizontal movement around possible. These lanes are so dense that they do not allow any light inside however create openings and access for the shanties inside.



**Figure 3.** *The 13<sup>th</sup> Compound Roof Plan*  
Source: Author, 2022

25. Elzy Kolb, '75,000 People per Square Mile? These Are the Most Densely Populated Cities in the World', *WLST*, July 2019 <<https://www.usatoday.com/story/news/world/2019/07/11/the-50-most-densely-populated-cities-in-the-world/39664259/>>.



**Figure 4.** Dharavi V/s Mumbai City

Source: Savin, 2025

The Sanaullah Recreational Ground is a cleared area of land by the government, which is now used as an informal space for keeping larger materials and storage for the industry. It is also used as an illegal camping site for the migrants.

The 13th Compound (Figure 5) is a cluster of recycling industries set in five sectors - Paper Recycling, Tin Recycling, Goods Manufacturing, Plastic Recycling and Dye Manufacturing. These sectors create a system of initial sorting and structure which enhances the efficiency of the recycling process.

### Key Spatial Principles

The wider lanes inside the 13th Compound are used for vehicular movement to allow for the material to be exchanged smoothly. It allows small trucks to enter the vicinity to drop off scrap to the recycling distributors and larger facilities.

These materials are then transported further into the industry through people by accessing through the narrow lanes which connect the whole 13th compound together. They also work as breathing space for the houses on them. A key design aspect is that every house opens to a lane and all houses tend to have two narrow lanes to them. The use of these narrow lanes is key to the successful horizontal movement through the area.

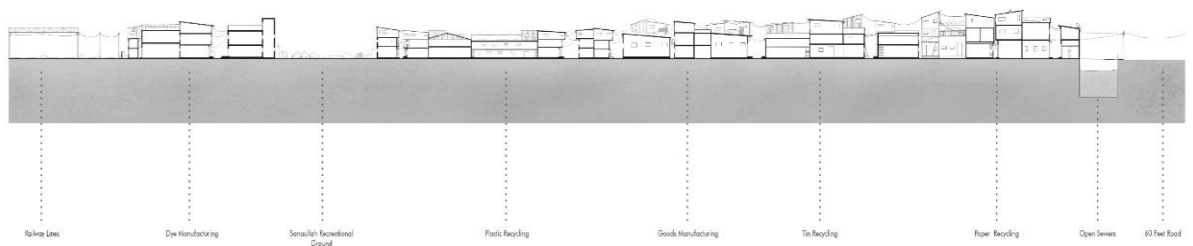
To make the most use of space, the shanties cantilever three to four feet on free sides. This tends to create overhangs and increase space on the higher floors. Vertical access is generally through steel ladders outside the house to free up space and attain privacy. Proper steps to gain vertical access are created only when they purpose three to four settlements to gain most from.

Raised Plinths are almost a must for every house front in Dharavi. Mumbai has a tropical and wet climate; therefore, these plinths act as a flood barrier to stop water entering the house. These have also been adapted in the design to host the first-floor staircase, add informal storage space to the house. It also creates a semiprivate space

forcing people to walk further from the house. This design feature has acted as a key to facilitate interaction among the residents of Dharavi.

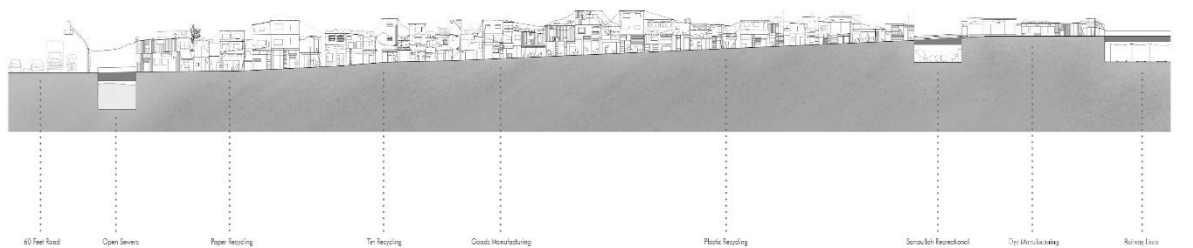


**Figure 5.** *Figure Ground Plan of the 13<sup>th</sup> Compound*  
*Source: Author, 2023*



**Figure 6. Section AA**

Source: Author, 2023 (Both)



**Figure 7. North Elevation**

Source: Author, 2023 (Both)

## Section AA

Figure 6, shows the variation in sizes of the settlements. Working industries tend to be much larger than the housing facilities. However, it is a mix of live / work in every house. The figure depicts the density and creates a vision of how narrow the paths are for movement. Slanted corrugated asbestos sheet is a constant for all roof constructions to run off rainwater.

## North Elevation

Figure 7, is the north elevation of the 13th compound. The informality in construction is really depicted here, however what is noticeable is construction through reuse. Scrap materials sourced through time are the main source of construction here. A high density of shops looks to have taken over the facade on the main road explaining that the industries are behind them. Even on the main roads the shanties have a height of less than 10m, which imply that they rarely build above three storeys. The slum seems to go down to one storey on the eastern region; however, it is the bridge which hides the other two storeys of those houses beneath it.

## Key Social Principles

Dharavi is known to be a home to multiple occupations, religions, ethnicities, cultures that are integrated within the space of living and working.<sup>26</sup> The 13th Compound possess the same vibrant and diverse society hidden among the live work culture. The sense of its community is very strong, since all activities take place in the cramped and dense setting of Dharavi. As mentioned before the Dharavi residents are migrants from all over India, hence the diversity of the community is very high. The main communities are - Hindu (60%), Muslim (33%), and Christian (6%) - each living in its own district, with temples, mosques, and churches.<sup>27</sup> The 13th Compound is a Muslim dominated district which can be identified with the dominance of three mosques in the area.

Even after being completely covered with the live work ethic, religious places can differ on how they are seen. Figure 8, shows a formal place of worship, which stands out because of its architecture, construction, design, and dominance over the shanties. However, Figure 9, shows an informal place of worship which blends with the settlements around it and can only be identified through its signage. Being a Muslim District, people from all cultures are still intertwined within this place of living, working, worshipping, leisure, and socializing. Instincts of churches and Hindu temples being present in the 13th compound are clearly visible, and different communities stay together as this informality of space has created an overlap among the day-to-day cycle of existence.

## Recycling Industries

In a study conducted by Pandey and Sharma<sup>28</sup>, it was estimated that the 13th compound hosts 1200 waste recycling units, and out of these 780 units are part of the plastic recycling industry. 13th Compound is the largest recycling industry in India and is famous for recycling and reusing everything, “Oil cans, plastic drums, chemical drums, cotton scrap, iron scrap, empty tins, empty bottles and plastic drums, anything”.<sup>29</sup>

The recycling industry in Dharavi is a way of reducing the carbon footprint of Dharavi’s polluting environment. It can be analysed that people sit in deep piles of waste sorting materials and grading them accordingly. Every minor item is recycled here. Lanes and paths are fully covered with recycling material - paper, cardboard, metal wires, aluminium tins, plastic bottles, plastic drums, plastic bags, glass, car batteries, computer parts, everything. Workshops have aluminium smelters that recycle drinking cans. Large Oil cans are reused by cleaning and hammered back into shape to be sold off to oil companies. The Scrap industry is also concentrated

---

26. UCL, ‘UCL – University College London’, *The Bartlett Development Planning Unit*, 2013 <<https://www.ucl.ac.uk/bartlett/development/files/contested-urbanism-dharavi>>.

27. ACI, ‘DHARAVI, INDIA’S MOST FAMOUS SLUM’.

28. Nisha Pandey and Deepti Sharma, ‘Creating Synergy between Environment and Employment: A Case Study of Plastic Recycling Industry in Dharavi, Mumbai’, 1.4 (2015).

29. SPARC and KRVIA, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

in the 13th Compound and cotton scrap, iron scrap, etc. are also recycled here. This industry, therefore, is part of the circular economy theme by reusing and recycling whatever waste is available to them.



**Figure 8.** *Moniya Jama Mosque (Formal) v/s Zakaria Mosque (Informal)*

Source: Author, 2023

## Plastic Recycling

### Largest Recycling Industry in the 13<sup>th</sup> Compound

The Plastic Recycling Industry (also known as Navrang Compound) is the largest industry in the 13th compound. This unregulated industry recycles 60% of Mumbai's plastic waste compared to that of Singapore's 19% and alone provides

employment and livelihood to 10,000 to 12,000 people.<sup>30</sup> Every day a minimum of 3,000 sacks of recycled plastic leaves the 13th compound, and whatever is not recycled is cleaned and repaired to be sold off second hand.<sup>31</sup>

### **Recycling Process**

The initial step of the recycling process involves the rag pickers around the city of Mumbai whose job is to collect waste materials and deliver them to waste buyers around the city. (Step 1; Figure 9)

These are then delivered to the plastic industry through trucks and people using local transport. Once delivered to the main distributors in the plastic recycling industry, it is delivered to the micro scale plastic sorting industries inside the narrow lanes by people. (Step 2; Figure 9)

Piles of plastic waste are sorted by people in the tiny warehouses according to colour, density, and grade (resin identification code). They have gained years of experience in the industry to perform this manual sorting, however a three-step process is involved: identification of the resin identification code; if not present match with a similar product, then immerse in a drum of salt water to help segregate. (Step 3; Figure 9)

After the separation of materials, they are shredded in the plastic crushing units. Metal machinery made of scrap waste metal is used to crush bigger pieces of plastic into micro plastics. (Step 4; Figure 9)

The tiny plastic pieces they are thoroughly cleaned and washed in the large blue plastic drums to get rid of any waste or toxins. Plastic fragments are then filtered using plastic colanders and filled in bags. (Step 5; Figure 9)

---

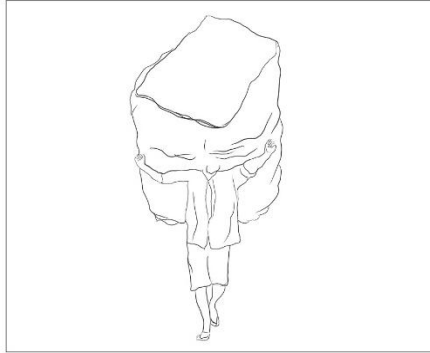
30. Trisha Mascarenhas A. geography nerd from NUS and others, 'Best Sustainable Gifts in Asia - Green Is The New Black', 8 March 2018 <<https://www.greenisthenewblack.com/dharavi-asias-large-st-slum-indias-recycling-circular-economy-goldmine/>>.

31. SPARC and KRVI, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

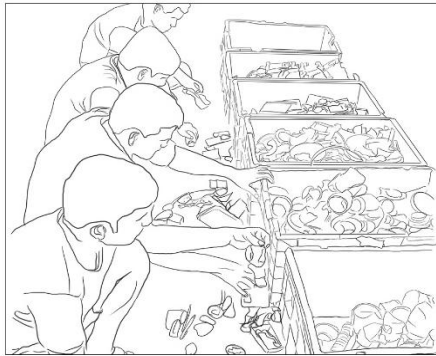
These wet plastic shreds are then spread out in open space, generally roofs and open ground to dry (Step 6; Figure 9) after which they are sold off to melting facilities over India to be reused. Due to health regulations Dharavi does not have any melting facilities.



Step 1. Rag picking



Step 2. Delivering



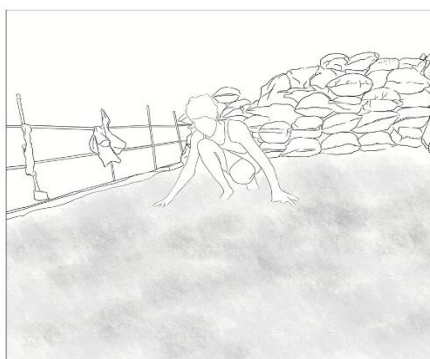
Step 3. Plastic Sorting



Step 4. Pulverizing



Step 5. Washing



Step 6. Drying

### Figure 9. The Recycling Process Storyboard

Source: Author, 2023

Recycling process video courtesy:

Materials of Hope - <https://vimeo.com/277435980>



**Figure 10.** *Plastic Recycling Industry Plan*

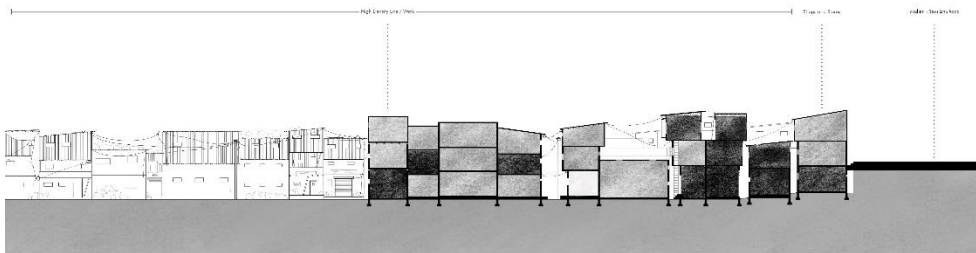
Source: Author, 2023

■ Living    ■ Working    ■ Institutional



**Figure 11.** North Elevation of Plastic Recycling Industry

Source: Author, 2023



**Figure 12.** Section Through Plastic Recycling Industry

Source: Author, 2023

## Design Principles

Foster and Partners<sup>32</sup>, a UK based architecture firm's design team conducted a study of Dharavi in 2008 for the redevelopment of Dharavi. The scheme illustrated the idea of mixed-use buildings hosting small commercial premises, industrial units, and housing. Another key observation, from the drawing was commercial and light industries (Figure 10) are present on the main roads and outer rims of the industry whereas high density live work industries thrive behind them. Figure 11, illustrates the idea of a commercial main road, and Figure 10, supports the case by showing the dominance of commercial units on the Northern edge of the side. Commercial units are present on the ground because of the dominance of work in the cluster and as a design principle to allow easy exchange of goods and interaction among the working community. Living sectors are much smaller and inside narrower lanes. Figure 12, expands on the mixed-use observations and cut through the dwellings to denote the recycling industries and living industries in comparison to one another.

32. Foster + Partners, 'Dharavi Masterplan | Foster + Partners', 2008 <<https://www.fosterandpartners.com/projects/dharavi-masterplan/>>.

## Inhabitation

### Live/Work Recycling Industry

The 13th Compound integrates the concept of live / work architecture in the recycling industry. It teaches us “how the informal settlements generate solutions for the demands of small businesses and housing”.<sup>33</sup> Flexibility in the work schedule, reduced travel time, home based occupations, work in various scales for everyone, connection with the community, and use of local products – these are the ways of “how the poor not only survive but thrive without handouts or charity”.<sup>34</sup>

### Inhabitation

Inhabitation in Dharavi means to utilise every square foot of ground they own. Live / Work scheme is adapted to the houses (Figure 14), meaning living and working under the same roof or same vicinity. Figure 13, shows an accurate example of dense living, where five people inhabit a room of 85 square foot.<sup>35</sup> Mezzanines and lofts are created in the vertical spaces to generate sleeping and storage area. Workplaces are more informal and open plan and adapt as to the need of the industries. These tend to be bigger compared to the living accommodations as the dweller’s livelihood is dependent on working and priority is given to that. Some migrants do not have living areas therefore, they live and work in the same place.

### Active Roofs

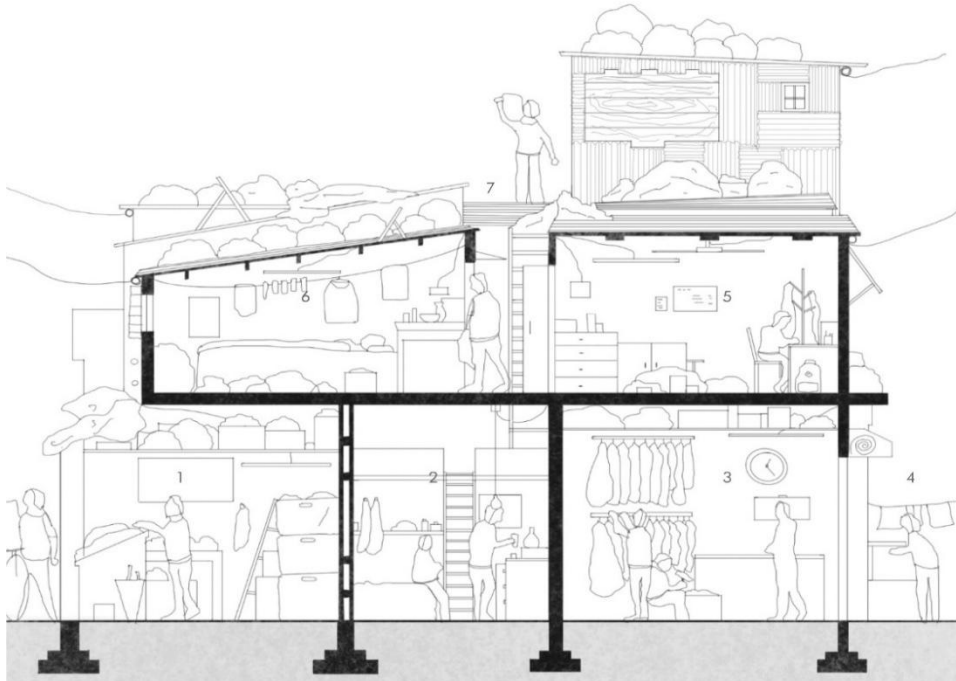
The roofs of the shanties provide the people of Dharavi with a sense of openness which is lost in the cramped and dense atmosphere of the ground level. The Recycling industry hosts a unique solution of utilising and inhabiting roof space. It is used as an informal storage dump and used as a drying area for the recycling industry. Some migrants use it as an extremely makeshift live workspace. Children and youngsters consider it there socialising and resting area.

---

33. SPARC and KRVA, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

34. SPARC and KRVA, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

35. Dovey and Tomlinson, ‘Dharavi: Informal Settlement and Slum Upgrading’.

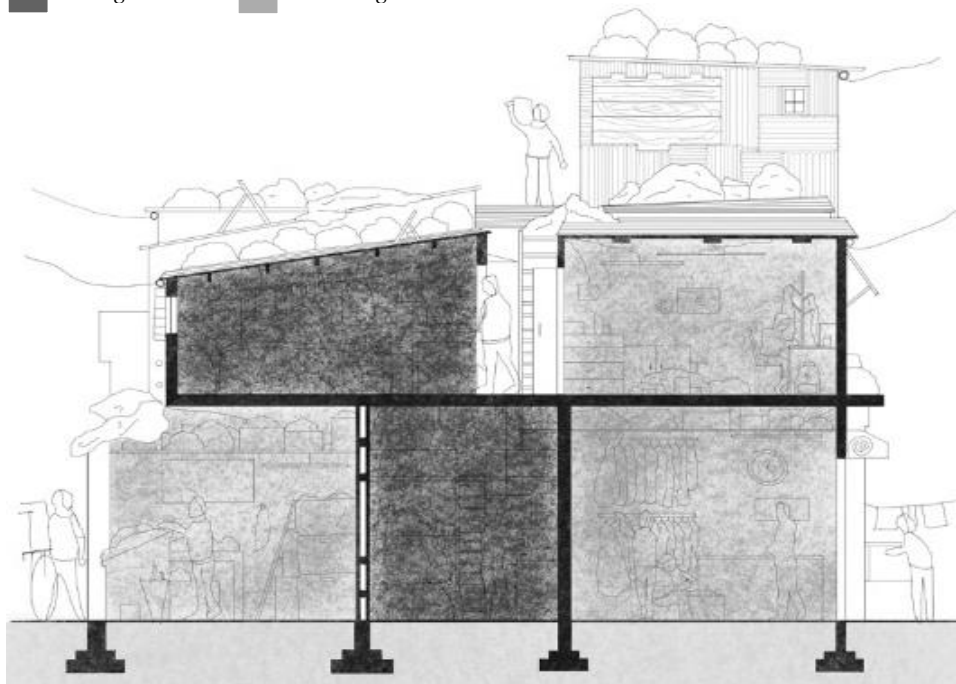


**Figure 13. Inhabitation Drawing**

1. Laundry; 2. Living – six people; 3. Dyeing Industry; 4. Outdoor Dyeing Area; 5. Embroidery + living; 6. Living; 7. Active Roofs

Source: Author, 2023

■ Living      ■ Working



**Figure 14. Inhabitation Drawing**

1. Laundry; 2. Living – six people; 3. Dyeing Industry; 4. Outdoor Dyeing Area; 5. Embroidery + living; 6. Living; 7. Active Roofs

Source: Author, 2023

■ Living      ■ Working



**Figure 15.** *Living Model with Loft (Dharavi Shanty 1:20 physical model)*  
 Source: Author, 2023

## Living

Figure 15 shows a typical model of accommodation with mezzanine in the 13th Compound. This living space is around 150 square feet and accommodates seven people. One thing which is very noteworthy is that even after being cramped into a small space, the house has everything the dwellers require through the day. It is well decorated and personalised with the residents emotional and materialistic values.<sup>36</sup>

During the day the men of the house leave for work early in the morning and are back for dinner. This allows the women to do household works, cook in the kitchen and look after their children. Sometimes women have small home businesses like tiffin services, sweets, and savouries production just to generate some extra income.

During the night is when everyone is at home, and to accommodate everyone, adults take the beds, and children and youngsters sleep on the floor and mezzanine over a carpet or rags. As shown in Figure 16, the house is very densely packed with storage under the bed and study table, over the cabinets and on the mezzanine floors.

36. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.



**Figure 16.** *Living with Loft Interior Vignette Model*  
Source: Author 2023



**Figure 17.** *Plastic Recycling Model (Dharavi Shanty 1:20 physical model)*  
 Source: Author, 2023

### Plastic Recycling Industry

Figure 17, shows the typical layout of a plastic sorting industry. Crates are used as a part of sorting mechanism. A corner is fixed for the rags of plastic waste to be dumped, and adequate amount is brought to be sorted and sent to the crushing units. Resting places inside are present for the employees to take rest because of the long eleven-hour shifts.<sup>37</sup> Sometimes the migrant workers live inside the rooms they work and generally use street vendors for food.<sup>38</sup>

Figure 18, shows the interior which looks to be very well illuminated with tube lights in the working areas and decrease around the room. Plastic sorting is the focus, and no other facility is present in here. Clothes hang around the walls as the workers change into different clothes so that the regular clothes stay clean. Fans are not seen, which suggests that they generally work in very humid and hot conditions.

37. SPARC and KRVIA, *Re-Interpreting, Re-Imagining, Re-Developing Dharavi | Environment & Urbanization*.

38. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.



**Figure 18.** Plastic recycling sorting Interior Vignette Model  
Source: Author. 2023



**Figure 19.** *Commercial Enterprise Model (Dharavi Shanty 1:20 physical model)*  
*Source:* Author, 2023

### **Commercial Working Space**

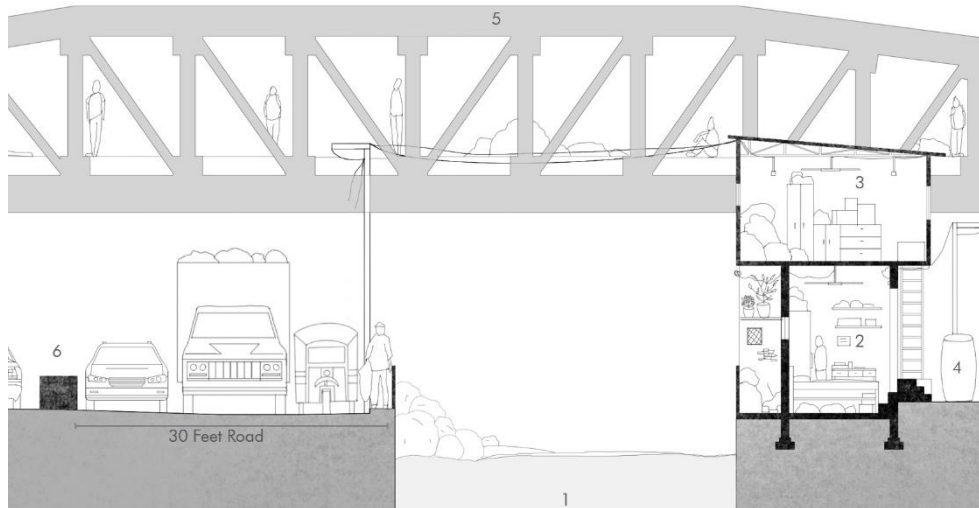
Apart from the recycling industry the 13th compound also hosts other commercial spaces such as offices, restaurants, hotels, and grocery stores. Figure 19, shows 100 square feet of space partitioned from the storage space, to be used as small office with 5-6 employees.

These units adapt to the scheme of an open plan, which is inhabited as per need of the user. The office spaces are generally present on the topmost floor of a shanty as the priority is given to recycling and living in the 13th compound.

The offices have tube lights and have fans for ventilation. Electricity is pulled in from the streets. Piles of papers, files and folders lie open on the tables and racks. Stacks of paperwork lie around on the floor. Lightweight pavilion like construction is visible from the interiors because of the makeshift construction technique.



**Figure 20.** *Commercial Office Interior Vignette Model*  
Source: Author, 2023



**Figure 21.** *60 Feet Road Inhabitation*

1. Open Sewer; 2. Living; 3. Storage and working; 4. Outdoor Storage; 5. Foot Bridge; 6. 60 feet road

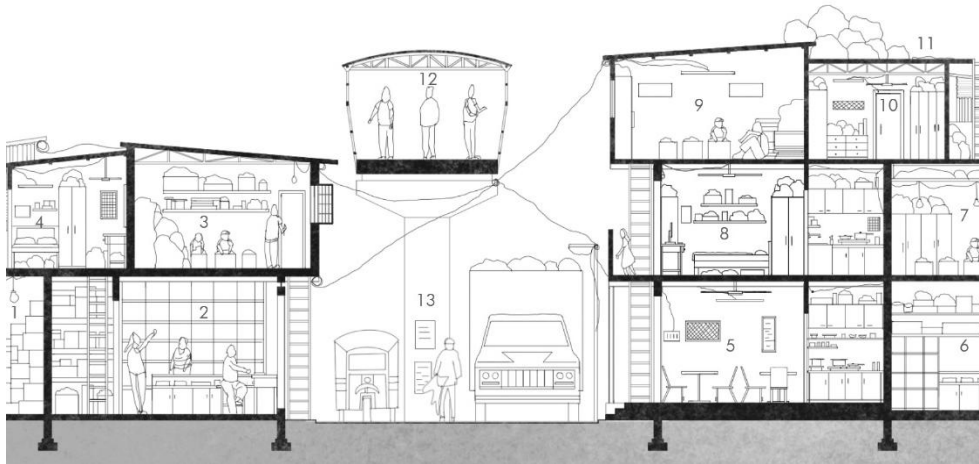
Source: Author, 2023

### **60 Feet Road**

The 60 Feet Road is a six-lane main road which allows trucks and lorries to travel through Dharavi (Figure 21). Part of the development in the Slum Rehabilitation act, the 60 feet road connects the community to the larger city. This enabled the vehicular material exchange of waste between the 13th compound and Mumbai's waste distributors and buyers, an integral source for the recycling industry.

The footbridge over the road connects the 13th Compound and Dharavi to Mahim Railway Station. This acts as an integral connection for the Rag pickers who sometimes deliver material directly to buyers in Dharavi. Using local trains are more economical and time saving and serves as a great link with the city.

Open Sewers are another infrastructural development part of the Slum Rehabilitation Act, this disconnects the 13th Compound from the main road and is currently used for the waste disposal of the Dharavi. Live work settlements are built at the edge of the open sewers even after being polluted with industrial waste and insoluble plastics.



**Figure 22.** Dharavi Main Road Inhabitation

1. Storage; 2. Living; 3. Recycling Industry; 4. Grocery Store; 5. Restaurant; 6. Grocery Store; 7. Recycling Industry; 8. Living; 9. Recycling Industry; 10. Living; 11. Active roof; 12. Foot bridge; 13. Main Road (7 metres)

Source: Author, 2023

### Dharavi Main Road

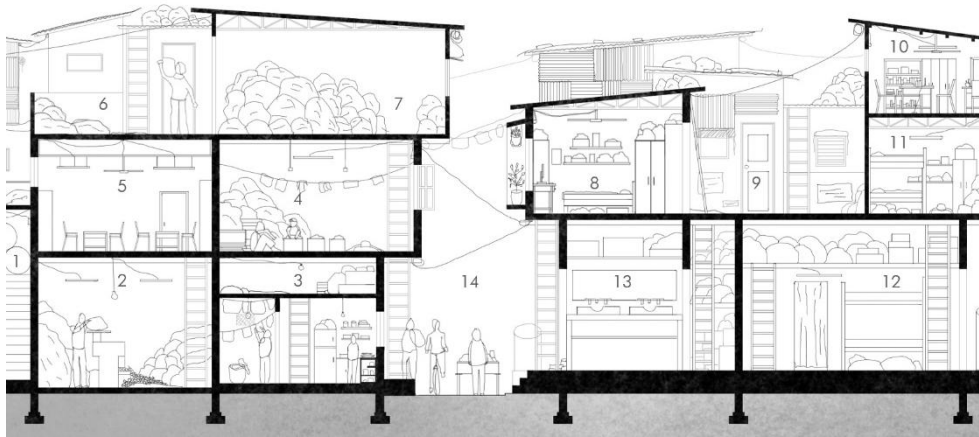
The Dharavi Main Road ranges from 6 metres to 8 metres wide because of the irregular shape of the road created due to the slum housing.<sup>39</sup> This provides vehicular access to the south of the 13th compound and allows trucks to reach drop off and pick up points inside the 13th compound.

What is interesting about the main roads are that they tend to hide the living and working industries behind them. They are lined up with two to three storey houses with shops, restaurants, hotels, commercial bodies, and institutional places on the ground floor, similar to high street in cities. It is noisy with vehicles stuck in the dense pedestrian traffic. Vendors, shops, and tea stalls open up onto the roads decreasing road space in an already tightly packed street. Social spaces and pedestrian retreat points on the edges of the Dharavi Main Road are particularly valuable.<sup>40</sup>

Figure 22 shows, how the working industries dominate the main streets as compared to living. The use of roofs for storage, work and socialising is very important here.

39. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.

40. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.



**Figure 23.** *Narrow Streets Inhabitation*

1. Drum Manufacturing; 2. Plastic Crushing; 3. Living; 4. Plastic Sorting; 5. Office; 6. Active roof; 7. Storage; 8. Living; 9. Active roof; 10. Office; 11. Living; 12. Live/work; 13. Hair salon; 14. Narrow Street (3 metres)

Source: Author, 2023

## Narrow Streets

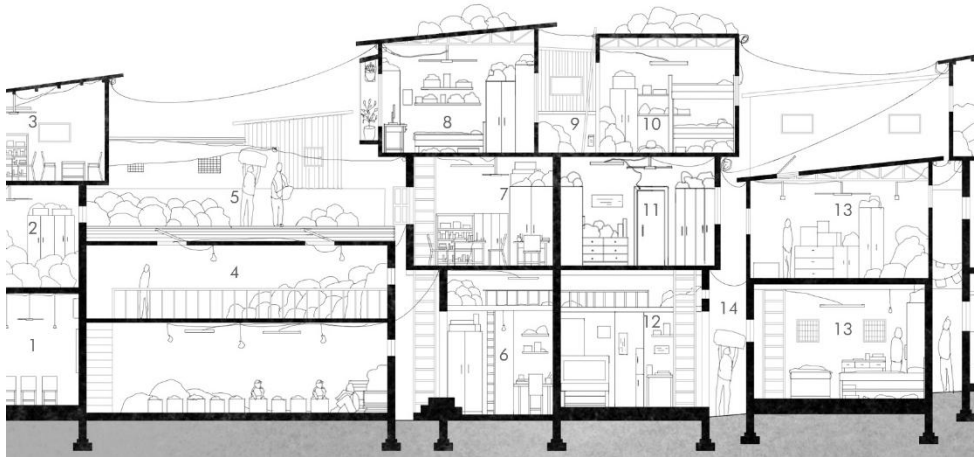
The narrow streets in the 13th Compound range from two metres to five metres and are lined up with building entrances on both sides. These entries are usually set behind the large plinths which act as flood barriers and interaction spaces.<sup>41</sup> The plinths also act as storage space in front and a base for the steep staircases to the floors above (Figure 23).

The narrow streets allow minimum to no vehicular transportation and are generally limited to two wheelers and bicycles. The waste and recycled materials are exchanged and transported further using hand cart and barrows. These streets host more personal shops on the ground floor like grocery stores, hair salon and offices which are related to the community in the 13th compound.

A series of electrical wiring can be seen hung around buildings, and over streets, showing illegal usage of electricity. Colourful Clothes are dried over the street and a very vibrant looking elevation of shanties are seen.<sup>42</sup> Waste and recycled material storage are seen everywhere on the roads.

41. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.

42. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.



**Figure 24.** *Narrowest Lanes Inhabitation*

1. Church; 2. Storage; 3. Office; 4. Plastic Sorting; 5. Active roof; 6. Living; 7. Office; 8. Living; 9. Active roof; 10. Live / work; 11. Living; 12. Living; 13. Living; 14. Narrowest Lane (1 metre)

Source: Author, 2023

## Narrowest Lanes

The smallest lanes of the 13th Compound range from 0.7 metres to 2 metres wide.<sup>43</sup> The main aim of these lanes is to provide easy passageways through the dense urban morphology of a slum. They are there to separate the shanties so that each house can at least have two open lanes and create some breathing space (Figure 24). However, due to overhangs some of the buildings join.<sup>44</sup>

Sometimes narrow routes are created through buildings on the ground floor to facilitate this strategy. The covered tops means that they do not allow any light to pass through, and ventilation is at its minimum. No vehicular movement takes place, and materials are delivered through them by people themselves.

These lanes can only host informal storage at junctions when the road widens. Very steep steel ladders are on the roads itself and small yet raised plinths are seen all around to act as flood barriers. In some scenarios the house starts from the first floor and people have to commute down through the interiors.

## Construction

### Incremental Building Process

Most dwellings in Dharavi are two to three storeys with highest being four storeys. Overhangs extend to about 500 - 800 mm using I Beams and are a key feature to enable external staircase access. All construction is done at a micro level of one room / space at a time. Ground floor constructions are generally finished with

43. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.

44. Dovey and Tomlinson, 'Dharavi: Informal Settlement and Slum Upgrading'.

concrete and decorated with tiles and stone finishes.<sup>45</sup> Upper floors are supported with I Beams, and a lightweight construction method are applied on the floors above.

### **Progressive Construction**

The houses in Dharavi are constructed progressively. Alterations and additions to the structure, materiality and interior are done incrementally as time goes by. As the dwellers gain economic stability and improvement; the house structures develop proportionally. Therefore, Dharavi houses range in quality - from a temporary shanty made up of bamboo sticks, wood beams and corrugated metal/asbestos sheet, to structure made of more permanent building materials such as bricks, concrete, I-Section Steel Beams, mortar, and plain cement.

Initially, a Dharavi House starts on the ground with the wooden/bamboo structure embedded into the soil. The wooden structure is the wall and roof skeleton which is covered by tin/asbestos corrugated sheets both on walls and roofs (Step 1; Figure 25). Tin sheets are generally used even after being high conductor of heat, which makes the indoor environment extremely hot and Improper overlapping and rust issues of tin are key problems leading to leakage and rainwater entering the house, this is tackled by using the blue tarpaulin sheets/similar plastic materials. Asbestos Sheets are used less frequently even after providing resistance from thermal heat as they are “known to be carcinogenic material”.<sup>46</sup>

Once the family can support the upgradation financially, the wooden structure tends to remain as a skeleton, but the tin sheets are replaced with brick-and-mortar walls and concrete foundations are laid to build over. This transformation of the walls is gradual depending on the resources and materials available to hand. It could take up to a year for a family to get one wall replaced,<sup>47</sup> hence a few years to complete the ground floor. (Step 2 - 4; Figure 25)

Families keep growing and migrating in, therefore demand of space increases, which requires the dwellers to build upwards. The floors above can support people from the same family and be used as a rent source from other families and recycling industries. At first, wooden frames are reused on the above floors to create instant space but later a similar procedure of a more permanent construction is executed by contractors. The upper floors are accessed using metal / wooden stairs to utilise maximum space inside. (Step 5; Figure 25)

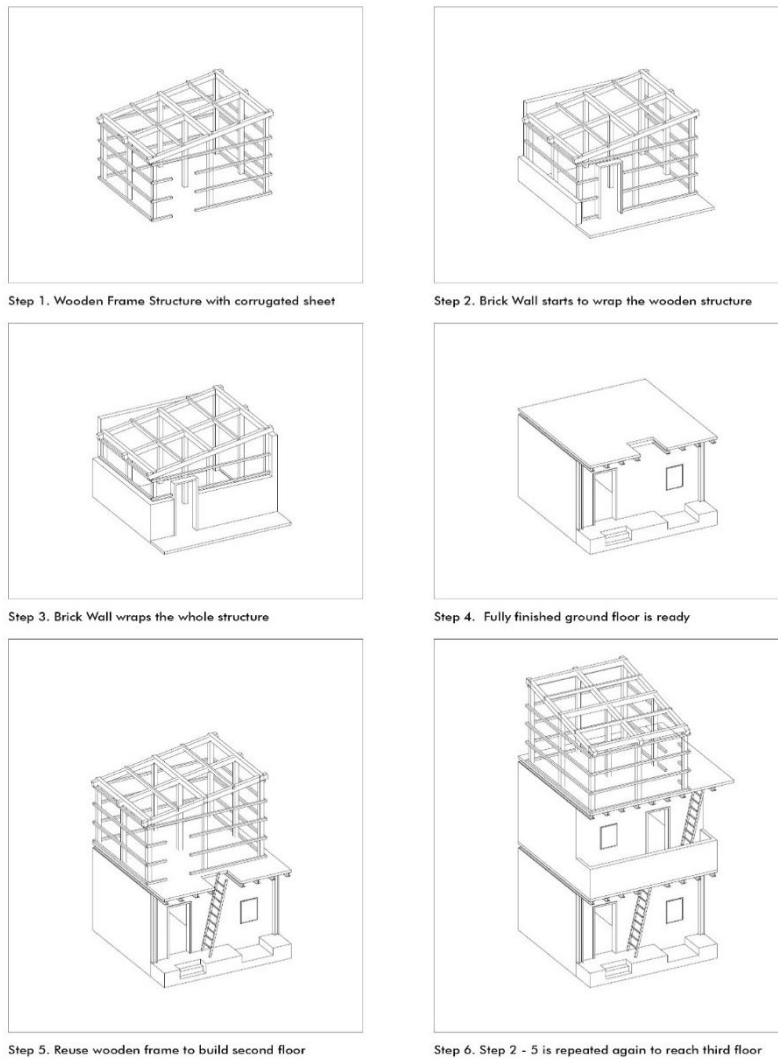
This procedure is repeated till the third storey, but it reaches its peak then as access and construction above that becomes very difficult. The cantilevered floors and outside staircase strategies can be followed just up to three storeys. As strong foundations are not laid out adding more weight and overhangs would make the shanty structure fragile. (Step 6; Figure 25)

---

45. Dovey and Tomlinson, ‘Dharavi: Informal Settlement and Slum Upgrading’.

46. Sourav Dey, ‘The Circular Economy of Dharavi: Making Building Materials From Waste’, *PennState University Libraries*, 2018 <<https://etda.libraries.psu.edu/catalog/15724szd62>> [accessed 12 January 2023].

47. Dey, ‘The Circular Economy of Dharavi: Making Building Materials From Waste’.



**Figure 25.** *Progressive Construction Drawing*

Source: Author, 2023



**Figure 26.** *Fully Constructed Shanty (1:20 Physical Model)*  
Source: Author, 2023

## Materiality

### Reuse, Recycle

The range of materials used for construction and housing are clay bricks, wood beams and studs, bamboo sticks, reinforced concrete, rusted iron sheets, I - Section Beams, corrugated asbestos, and tin sheets. Slate, ceramic, and clay tiles are used for the interiors. The iconic Blue Tarpaulin Sheets are used to cover the roofs and as window during rainy seasons to stop rainwater from entering the houses. The tarpaulin sheets are also used as shading device during the summer season.

Houses in the slums are made of mostly recycled materials with low embodied energy and follows pattern of incremental upgradation depending upon the monetary resources acquired overtime and the availability from waste materials that can be utilized for improving their homes.<sup>48</sup>

But how does Dharavi receive waste material, Dharavi has connections and relationships with most operations and restaurants around the city to send them their waste to be dealt with. It is a little like a recycling mafia chain.<sup>49</sup> This allows the informal recycling industry to thrive and create resources for construction and shanties.

Figure 27 shows a general concept of recycling and reuse in the construction of a house. I - Section Beams are sourced and used on the structures to create ceiling and support structure. Old wooden doors, window frames, grilles are salvaged and used on the house entrances. Tin and asbestos corrugated sheets are used for patchworks on the formal structures, and as main structures of the roof and top floor facade. Clay bricks are seen in general in the interior and outside plinths which stack up from waste materials. Plastic water drums are an important household product and come from the recycling industry if they are not good enough for the manufacturers.

---

48. Dey, 'The Circular Economy of Dharavi: Making Building Materials From Waste'.

49. NUS and others, 'Best Sustainable Gifts in Asia - Green Is The New Black'.



**Figure 27. Material Taxonomy**  
 Source: Author, 2023

## A Shanty

### 1:20 Model of a Typical Recycling, Live/Workhouse

The physical model brings in all the concepts of the research into a single piece of work. The model explains the themes of inhabitation inside the cramped living and working spaces. It shows the ideas of a recycled and reused facade and exhibits the materiality of the building through scrap. Vibrant colour scheme, generated because of availability is also very clear from the elevations and interiors.

Focus on details, such as big blue water drums outside the house, electrical wiring running around the exterior and interior of the building, overhangs, plinths, external ladders, informal storage spaces, raised platforms interaction spaces, solid and lightweight construction all have been brought together in the model.

Diverse community, with the idea of owner and tenants have also been explored in the model, which is a key aspect of the live work environment in the 13th Compound.

**Figure 28.** (Left) Front Elevation

**Figure 29.** (Right) Side Elevation



Source: Author, 2023



**Figure 30.** *Back Inhabited Section*  
*Source:* Author, 2023

## **Conclusion**

### **The Recycling, Live/Work Industry**

Dharavi attracts people for the poor, unhygienic, unsanitary, and inhumane conditions which lack any type of infrastructure. However, what Dharavi has created is an industry which creates, manufactures, and develops everything to prove to the world that if the poor work in unity they can thrive and survive and create something extraordinary.

The 13th Compound is an example of this theory; an informal model of a circular economy and sustainability with its key point being recycling and live work. It manages to recycle 80% of Mumbai's solid waste and keep it free from landfills and garbage. It has created an industry hosting 1200 micro units, which has informally created jobs for approximately 300,000 people. The 13th Compound is an urban creative cluster as they do the best of what they do even in inhumane conditions, with a bit of innovation and improvisation. The western industry has much to learn; it can benefit from adapting to the observations made in the research and apply them by adding a set of building and living regulations to the existing case study of the recycling industry.

### **Key Observations**

What makes 13th Compound easily accessible is the central location in the city and connection from main roads and railway networks allowing the easy exchange and interaction in the industry. Inside the industry the horizontal nature of the cluster makes it easy for the workers to send and bring in materials quicker. This makes the recycling process much efficient and faster and creates a continuity in the interaction of different processes. Mixed Used buildings have created an active interaction in the residents and workers, and the workers save crucial time and money which would have been lost in commuting.

What makes 13th Compound easily accessible is the central location in the city and connection from main roads and railway networks allowing the easy exchange and interaction in the industry. Inside the industry the horizontal nature of the cluster makes it easy for the workers to send and bring in materials quicker. This makes the recycling process much efficient and faster and creates a continuity in the interaction of different processes. Mixed Used buildings have created an active interaction in the residents and workers, and the workers save crucial time and money which would have been lost in commuting.

## Acknowledgement

I would like to extend my heartfelt thanks to my supervisor, Professor Dr. Katharina Borsi, for her invaluable guidance, insightful feedback, and unwavering support throughout the course of my research. Her depth of knowledge and academic expertise played a crucial role in shaping and completing this dissertation.

I am equally grateful to my co-supervisor, Mr. Tim Collett, whose thoughtful suggestions, and encouragement have been immensely helpful over the past year. His probing questions and constructive critiques challenged me to refine my ideas and enriched the overall quality of my work.

I gratefully acknowledge the financial support provided by the University of Nottingham, United Kingdom, which made this research possible.

Special thanks are also due to the 3D Model Staff at the Architecture and Built Environment Facility for their technical assistance and support in accessing essential resources. Their contributions were instrumental in facilitating the practical aspects of this project.

I would also like to express my deep appreciation to my friends, and most importantly my partner for her unwavering patience, understanding, and encouragement during this journey.

Finally, I dedicate this dissertation to my parents, whose early emphasis on the importance of education laid the foundation for my academic pursuits. Their constant support and belief in me have been a continuous source of motivation and strength.

## Bibliography

- ACI, 'DHARAVI, INDIA'S MOST FAMOUS SLUM'  
 Assainar, Raina. 'At the Heart of Dharavi Are 20,000 Mini-Factories', *The Guardian*, 25 November 2014, section Cities <<https://www.theguardian.com/cities/2014/nov/25/dharavi-mumbai-mini-factories-slum>>
- Bath Spa University. 'GtR', 1 December 2020 <<https://gtr.ukri.org/projects?ref=AH%2FS005897%2F1>>
- Booth, Robert. 'Charles Declares Mumbai Shanty Town Model for the World', *The Guardian*, 6 February 2009, section Art and design <<https://www.theguardian.com/artanddesign/2009/feb/06/prince-charles-slum-comments>>
- Carr, Carlin. 'The Best Idea to Redevelop Dharavi Slum? Scrap the Plans and Start Again', *The Guardian*, 18 February 2015, section Cities <<https://www.theguardian.com/cities/2015/feb/18/best-ideas-redevelop-dharavi-slum-developers-india>>
- Dey, Sourav. 'The Circular Economy of Dharavi: Making Building Materials From Waste', *PennState University Libraries*, 14 May 2018 <<https://etda.libraries.psu.edu/catalog/15724szd62>>
- Dovey, Kim, and Richard Tomlinson. 'Dharavi: Informal Settlement and Slum Upgrading', 2012 <<https://minerva-access.unimelb.edu.au/items/bc0cfa30-e705-5bb8-802e-06a44e7dea26>>
- Foster + Partners. 'Dharavi Masterplan | Foster + Partners', 2008 <<https://www.fosterandpartners.com/projects/dharavi-masterplan/>>
- Guéguen, Lucile. 'India's One-Billion-Dollar Slum', *VOICES*, 25 May 2022 <<https://voices.kopje.org/2022/05/25/indias-one-billion-dollar-slum/>>

- Gully Boy*, dir. by Zoya Akhtar (Zee Studio, Cinestaan, 2019)
- Kolb, Elzy. '75,000 People per Square Mile? These Are the Most Densely Populated Cities in the World', *WLSL*, July 2019 <<https://www.usatoday.com/story/news/world/2019/07/11/the-50-most-densely-populated-cities-in-the-world/39664259/>>
- Mashian, Sean. 'Dharavi: When a Slum Becomes a Goldmine (6 Mins)', *Cornell Real Estate Review*, 20 March 2018 <<https://blog.realestate.cornell.edu/2018/03/20/dharavi/>>
- NUS. Trisha Mascarenhas A. geography nerd from, and others, 'Best Sustainable Gifts in Asia - Green Is The New Black', 8 March 2018 <<https://www.greenisthenewblack.com/dharavi-asias-largest-slum-indias-recycling-circular-economy-goldmine/>>
- Pandey, Nisha, and Deepti Sharma. 'Creating Synergy between Environment and Employment: A Case Study of Plastic Recycling Industry in Dharavi, Mumbai', 1.4 (2015)
- Slumdog Millionaire*. dir. by Danny Boyle and Loveleen Tandan (Pathe Distribution, 2009)
- SPARC, and KRVIA. *Re-Interpreting, Re-Imagining, Re-Developing Dharavi / Environment & Urbanization*, 2010 <<https://www.environmentandurbanization.org/re-interpreting-re-imagining-re-developing-dharavi>>
- SRA. Mumbai, 'Growth History: Slum Rehabilitation Authority (SRA)' <<https://sra.gov.in/page/innerpage/growth-history.php>> [accessed 14 December 2022]
- UCL. 'UCL – University College London', *The Bartlett Development Planning Unit*, 2013 <<https://www.ucl.ac.uk/bartlett/development/files/contested-urbanism-dharavi>>
- Yardley, Jim. 'Dharavi: Self-Created Special Economic Zone for the Poor', *Deccan Herald*, 2 January 2012 <<https://www.deccanherald.com/content/216254/dharavi-self-created-special-economic.html>>