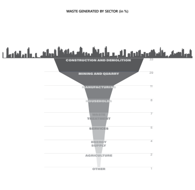

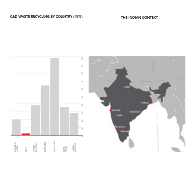

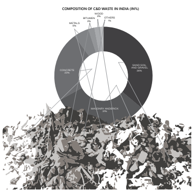

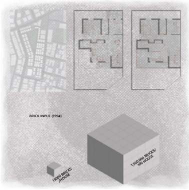

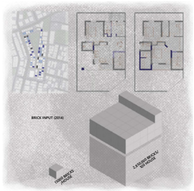

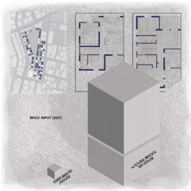

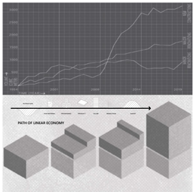

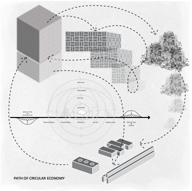

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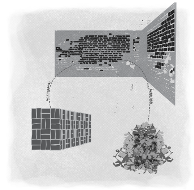
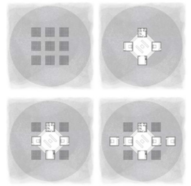
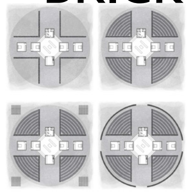
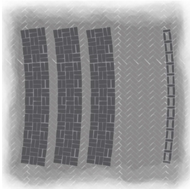
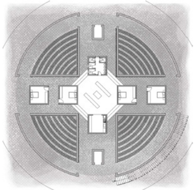


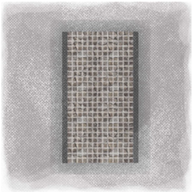


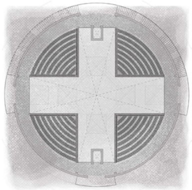


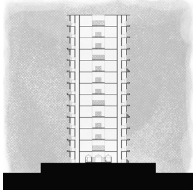


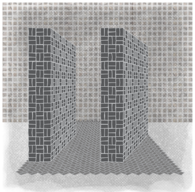
Sustaining within a closed loop system

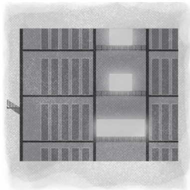


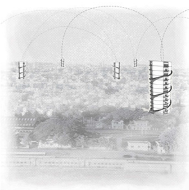












BRICK BY BRICK

Sustaining within a closed loop system

Rukmini Priyanka Arunmozhi
Bachelor of Architecture, Anna University, 2017

Submitted in partial fulfillment of the requirements for the degree of
Master of Architecture
in
The Faculty of Graduate Studies,
School of Architecture and Landscape Architecture, Architecture Program

GP I Mentor: Matthew Soules
GP II Chair : Blair Satterfield
Committee: Roy Cloutier, Allison Earl, Katy Young

The University of British Columbia
Vancouver, Canada

ABSTRACT

Rising demands, finite resources.

There it is, just left ignored or incinerated, the waste.

To close the loop, the world sees it fit to reclaim and reuse.

But where does the debris from brick demolitions lie within this loop?

Thus, in search of an afterlife for brick.

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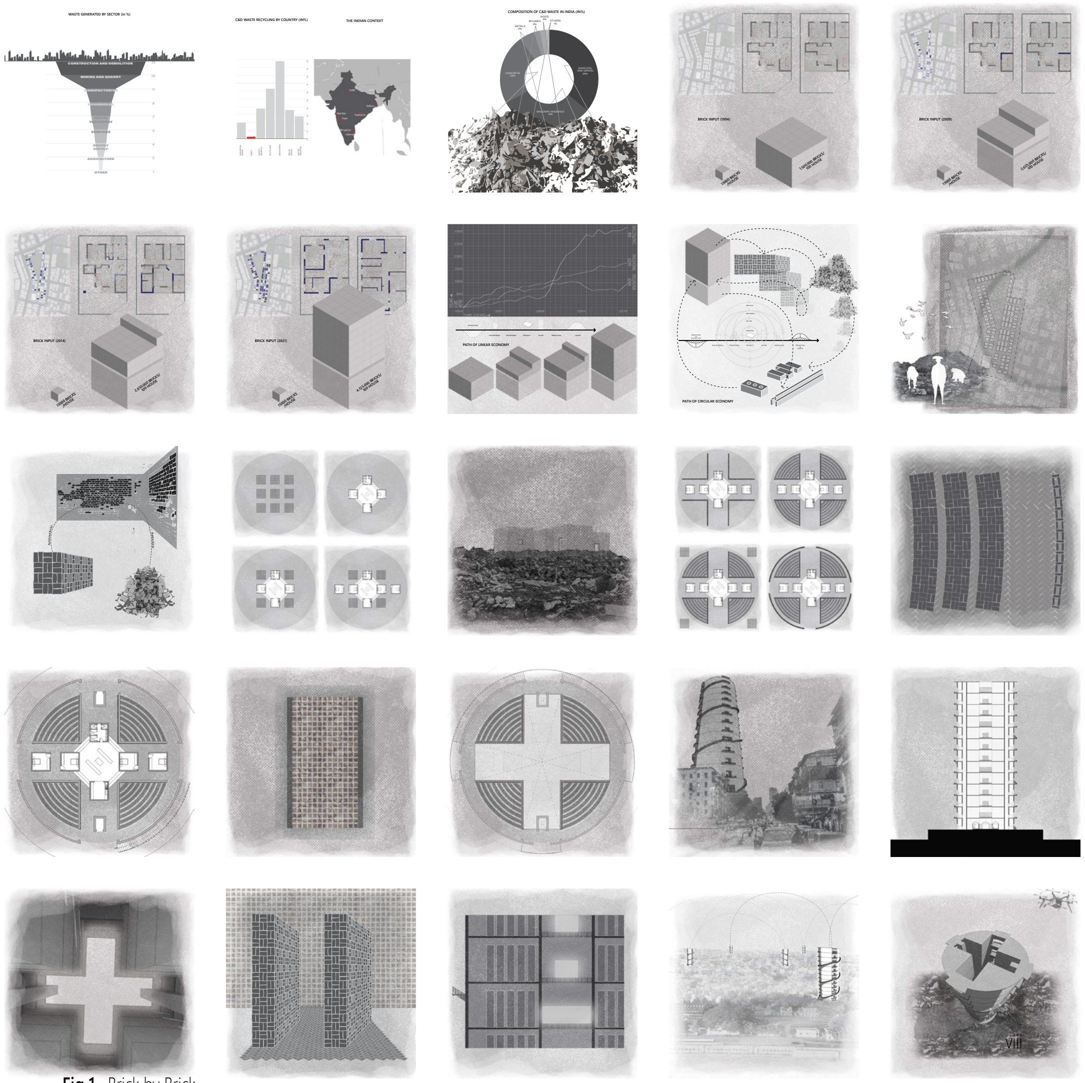


Fig 1. Brick by Brick
Source: Author, 2022

THESIS

Brick buildings have a life expectancy of over 100 years, but the dynamics of changing spatial relationships of the single family residences in India forces such buildings to be reconstructed within a decade leading to large-scale brick waste.

This thesis re-imagines the life-cycle of such buildings by altering the way brick structures are deconstructed and reconstituted to establish a new system that manages the existing brick material stock in a closed loop.

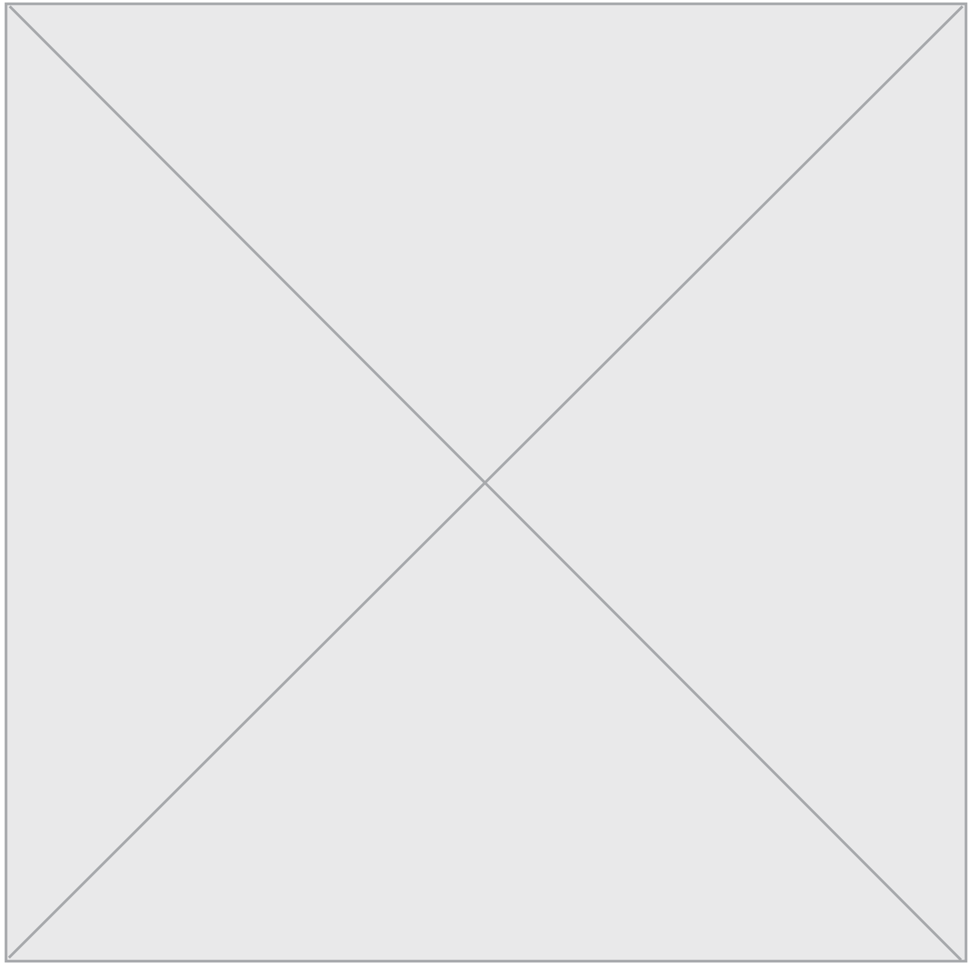


Fig 2. Waste Generation by Person
Source: https://www.mdpi.com/2071-1050/12/7/2892

CHAPTER ONE

A CRISIS

Ever since man started creating things, the environment has gone through changes. And ever since the industrial revolution, these changes have become so prominent that people are faced with unprecedented challenges. Humans tend to consume natural resources faster than nature's capability to replenish, and this creates an imbalance. Excessive mining of resources can never be replaced because there is only so much that the earth can provide us with. A study published in the Yale Journal of Industrial Ecology by Gaya Herrington, a sustainability and dynamic system analysis researcher, suggests that the world's natural resources are estimated to run out within the next 20 years. Even when paired with unprecedented technological development and adaptation, business as usual would inevitably lead to declines in industrial capital, agricultural output, and welfare levels within this century. [i]

But with the steady increase in population and unsustainable expansion of the urban boundaries, the demand for new constructions is least expected to decrease. Where would these demands for construction source the required materials from? Consider a future where there is no more mining, one where there are restrictions to the utilization of raw materials. This would eventually make manufacturers and product designers resort to other sources of material – the one that already exists in the economy.

Fig 3. A World Consumed by Waste
Source: Author, 2022

WASTE ACCUMULATION

Our economic system is based on the principle of the exhaustion of natural resources for the purpose of production, entailing the fabrication of waste. [ii] Many of our production methods are inherently wasteful, that is, every process for the creation of a product has a counter-part, a by-product that we consider as waste which is never given importance and eventually cast away. It is the same in our habit of throwing things away that we consider is old or useless and buying anew. Over the past century, consumer culture, the consumption of goods driven by social norms, has had enormous impact on the environment.

According to the United States Environmental Protection Agency humans produce 2.2 billion tons of waste every year. By 2050, it is expected to increase by 70% to 3.4 billion tons. However, only 20 % of this trash is being currently recycled. The things that we consider as useless is tagged as waste and is dumped in landfill sites taking up space in unsightly waste 'mountains' or 'islands' of debris at sea that are harmful to the environment.

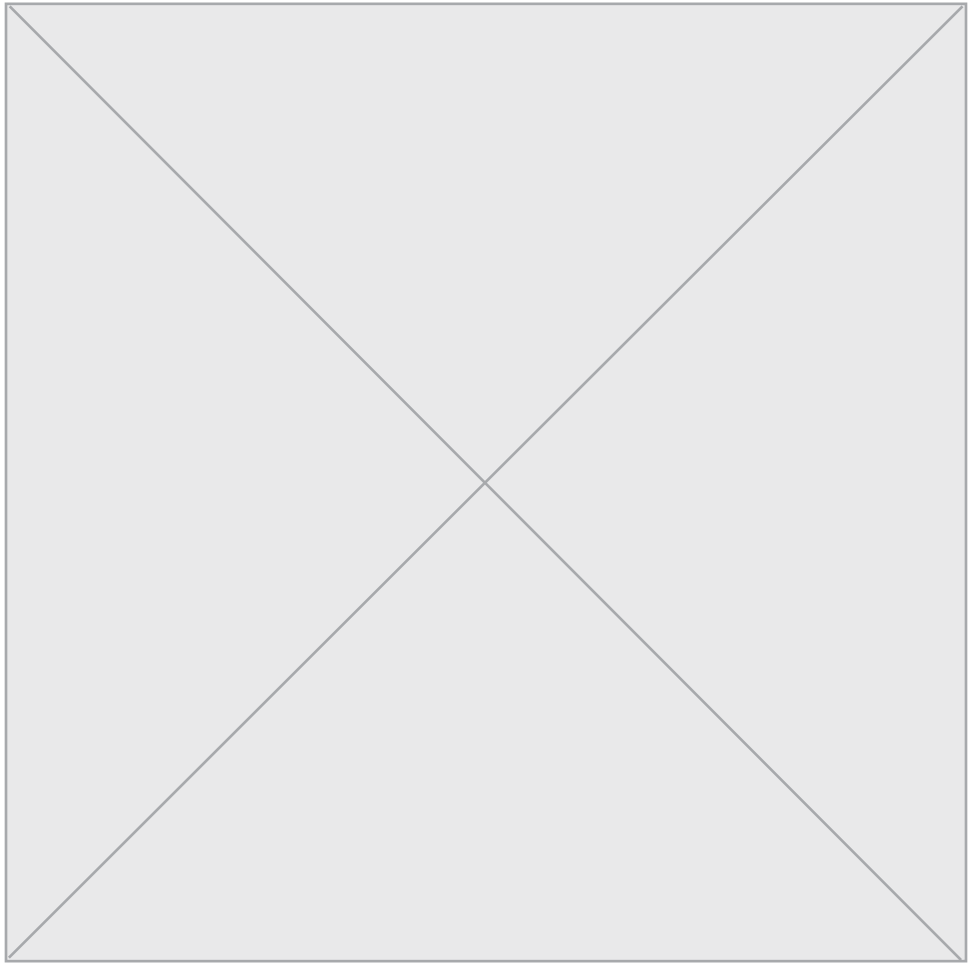


Fig 4. Attitude towards Waste
Source: https://www.canadiangeographic.ca/article/canadas-dirty-secret

ATTITUDE TOWARDS WASTE

Humans have been ignorant of the quantity and impact of the waste that we produce that the average person's mentality has grown numb to look at waste as an end matter, something to be left behind, to be taken care of by the Earth. The same can be found explained in the book 'Building from Waste' where the author explains the mentality of humans towards waste. Instead of being included in a metabolic cycle and flow model of goods and resources, waste is considered within a dead-end scenario of a linear process; to be literally buried from view – out of sight, out of mind – as a formless substance that has no value and is therefore covered by thick layers of earth or burned to ashes. [iii]

In the book 'Cradle to Cradle', William McDonough and Michael Braungart explain how human's process of production is different from other beings. The process of production by humans gives us the end product that we desire along with the waste that we discard as useless. But if you look closely at a colony of ants, the way they build their homes out of the ground and the way they live in a symbiotic relationship with another organism for food shows how production does not always lead to the generation of waste. McDonough and Braungart explain further that factories should start to imitate nature, that is, to generate by-products that nourish the environment rather than deplete it.

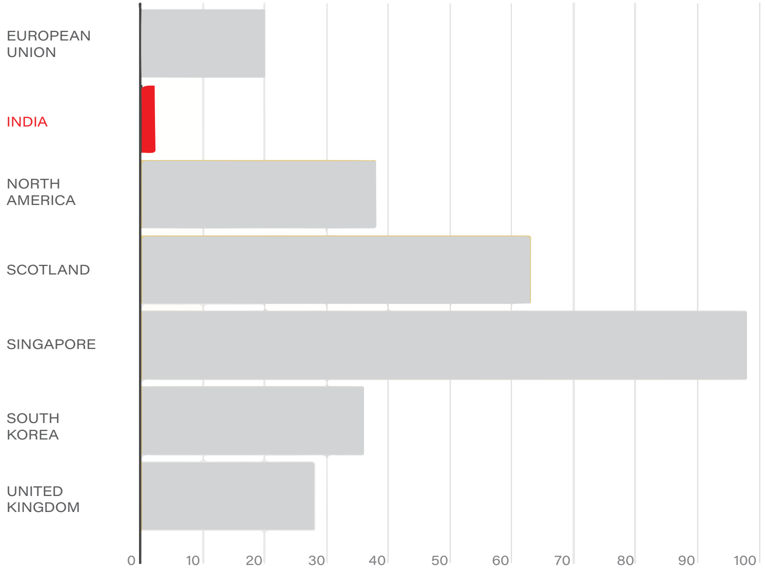


Fig 5. C and D Waste Recycling by Country (in %)
Source: Author, 2022

CHAPTER TWO

THE INDIAN CONTEXT

The waste generation and disposal scene in India is glaring to say the least. According to the Central Pollution Control Board report of 2015-2016 which have the last collated figures on the implementation of Solid Wastes Management Rules, 2016, over 1.3 lakh (1,35,198.27) tonnes of solid waste is generated per day in India. Of the total waste generated, while over one lakh tonnes per day (1,11,027.55 TPD) is collected, only a fraction (25,572.25 TPD) is treated while 47,415.62 TPD is landfilled. [iv] When compared to other Nations such as USA (38%), UK (28%), Singapore (98%) and Scotland (62%), India (2%) falls behind in its rates of recycling and this has put India in an existential crisis where its people literally walk on trash on a daily basis. Currently, some 340 million people live in Indian cities; by 2030 the number is estimated to double, presenting a frightening demand for housing and construction and along with it there would be a spectacle of imploding garbage.

Fig 6. Cities Drowning in Waste
Source: Author, 2022

DROWNING IN WASTE

Partly because of the government's negligence and partly because of people's ignorance the metropolitan cities of India are literally drowning in waste. The trash that is not being collected by the municipal organization finds its way to the environment in other ways. Since waste from construction and demolition sites is unregulated in India, building construction and demolition contractors find it easy to cast away the debris in the simplest way possible without being noticed. This waste is dumped illegally on vacant sites, on the sides of highways, below flyovers, beside lakes and rivers, in other low-lying areas and open storm-water drains. The lack of stringent measures to punish those who pursue these methods has lead to these areas being wasted and unusable. Metropolitan cities in India, namely, Chennai, Mumbai, Kolkata, Delhi and Bengaluru provide glaring examples of this practice, commonly known as "fly-tipping. [v]

The capital city of Karnataka, Bengaluru, saw a boom in urbanization in the past decade due to increased employment rates but was unprepared to handle the unsustainable growth and the waste that the increased population generated. Once hailed as the 'Garden City of India' it has now been nicked name as the 'Garbage City of India'. Such unexpected growth and the eventual failure of waste disposal methods is nothing new to Indian cities. Chennai, Delhi, Mumbai and Kolkata, to name a few, face similar fates.

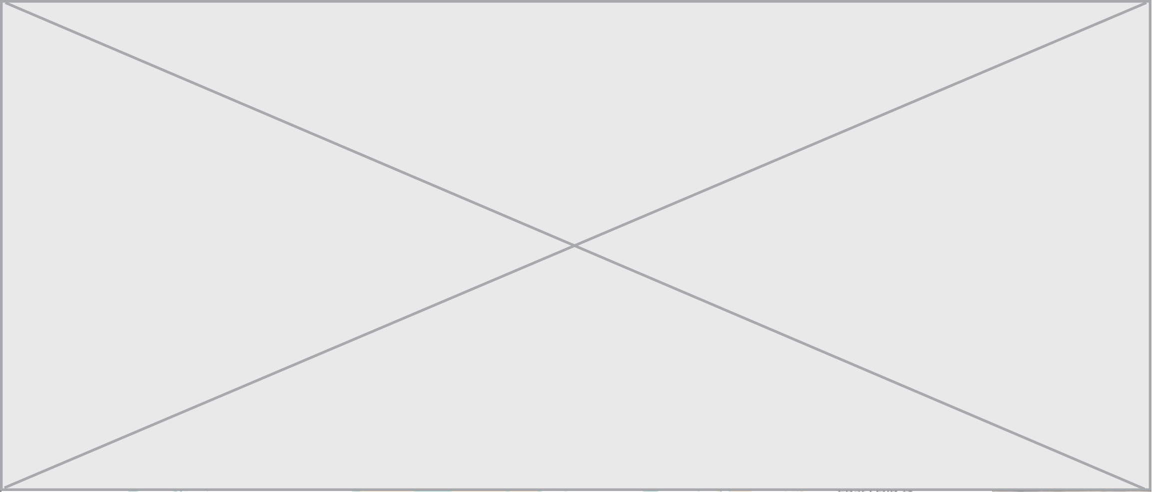
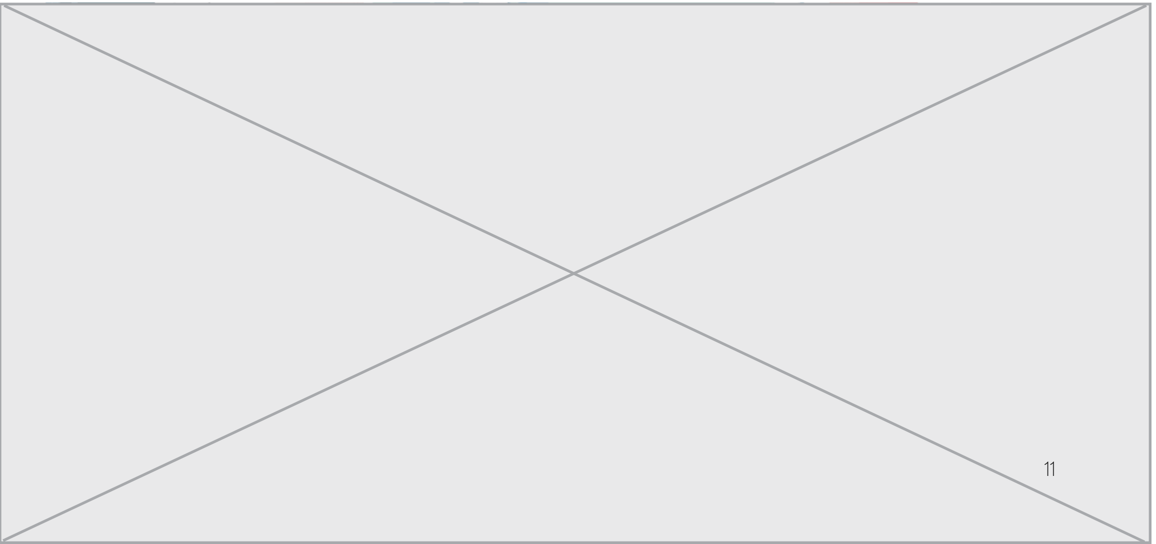


Fig 7. A Residential Building next to the huge Ghazipur Landfill Site in New Delhi on November 15, 2018
Source:https://www.newsweek.com/trash-mountain-india-could-taller-taj-mahal-next-year-1442227

Fig 8. Ghazipur Landfill - India's Mount Everest' of Trash
Source: https://www.newsweek.com/trash-mountain-india-could-taller-taj-mahal-next-year-1442227



'MOUNT EVEREST' OF TRASH

Even the small fraction of the collected waste that is being dumped in landfills is flawed. The carelessness of the governing body has created mountains of trash from which chemicals and stench seep into the city. Landfill sites that were supposed to have been closed once they reached 20 meters in height are still being operated to dump waste. Cities like Delhi and Mumbai have tall dump yards at Ghazipur, Bhalswa, Okhla, Deonar, Mulund and Kanjurmarg that are 30 to 60 meters in height. As tall as the towers of London Bridge, New Delhi's Ghazipur landfill continues to grow at a startling pace. Even after a landslide from this dump yard had already claimed two lives in 2017 the government has not found another way to divert the trash that comes to this site. Within a year, it is set to rise higher than the Taj Mahal, one of the country's most iconic monuments. [vi]

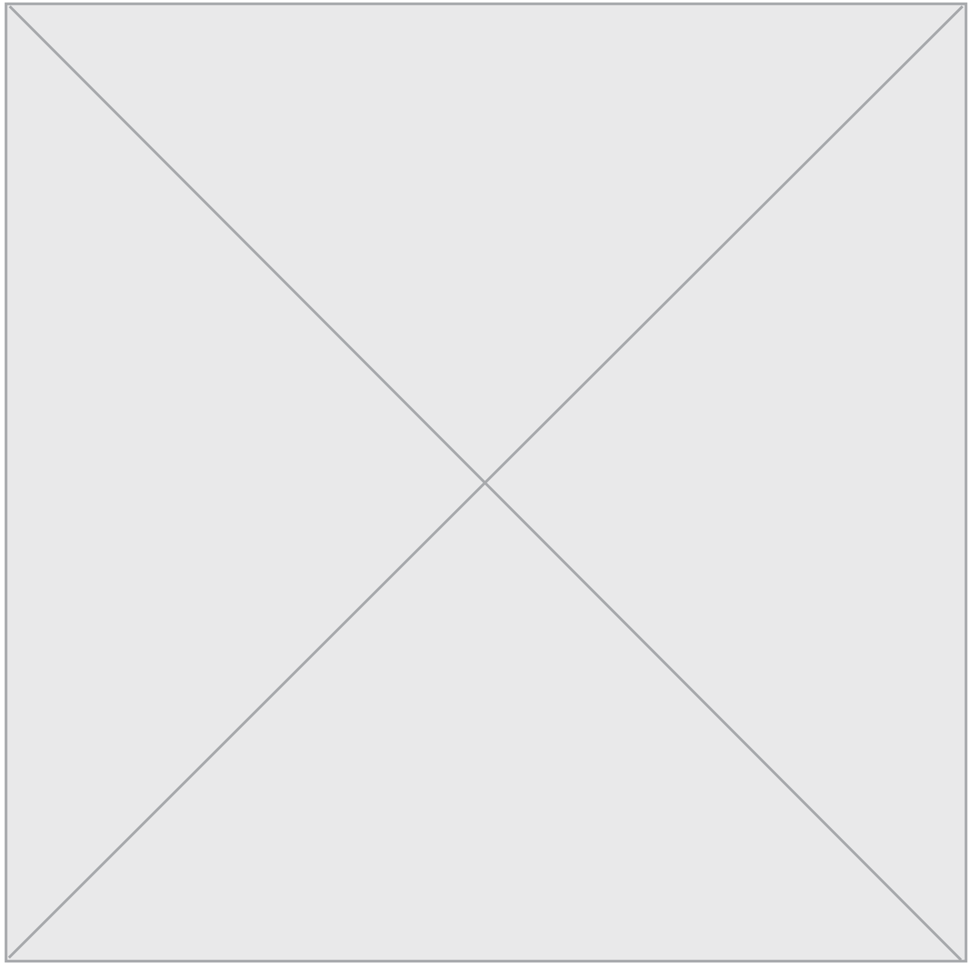


Fig 9. Height of Biggest Landfills in Delhi
Source: https://swachhindia.ndtv.com/year-ender-2018-waste-management-landfill-how-indian-cities-dealt-with-landfill-crisis-29247/

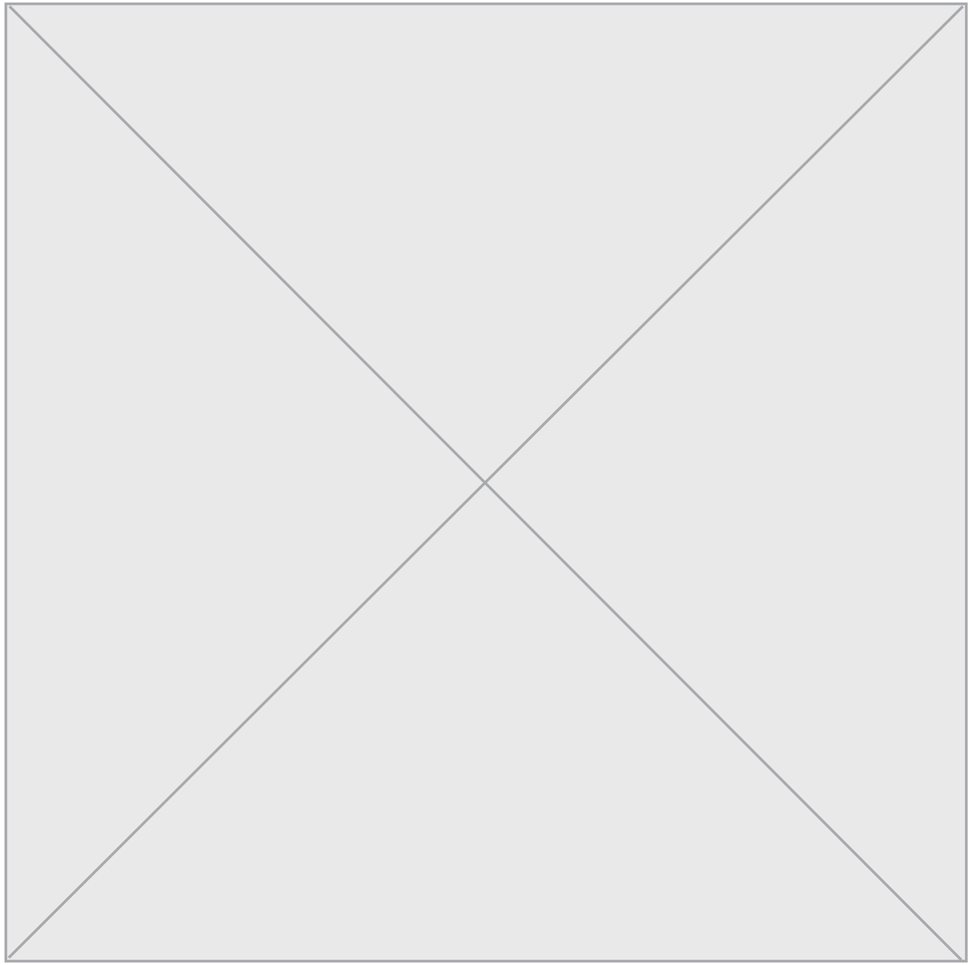


Fig 10. Height of Biggest Landfills in Mumbai
Source: https://swachhindia.ndtv.com/year-ender-2018-waste-management-landfill-how-indian-cities-dealt-with-landfill-crisis-29247/

Fig 11. Potential for Material Salvagibility from Buildings

CHAPTER THREE

ARCHITECTURE'S CONTRIBUTION

The building industry is the single largest consumer of resources and the single largest contributor to the waste stream. Waste materials such as scrap metals, plastics, paper, cardboard, rubber, and other products are generated in substantial quantities every day but even then, according to statistics, constructions and demolitions contribute more than 33% of overall waste generated based on industrial sectors. Furthermore, this situation is not helped by a culture where people tend to remodel and renovate their buildings on a regular basis in accordance to their preferences and current trends which leads to further generation of waste. Thus the average lifespan of a building has drastically reduced from 100-120 previously to just 25-30 years currently.

It is tempting to accept defeat and conclude that the only way to be truly sustainable is to stop designing altogether and make do with what we already have. But this will never be a viable solution in our society, so rather than give up we must find ways to make use of the existing materials from the building stock. Design strategies to stop the flow of waste created from construction and demolition can make a huge difference and reduce the burden on dump yards.

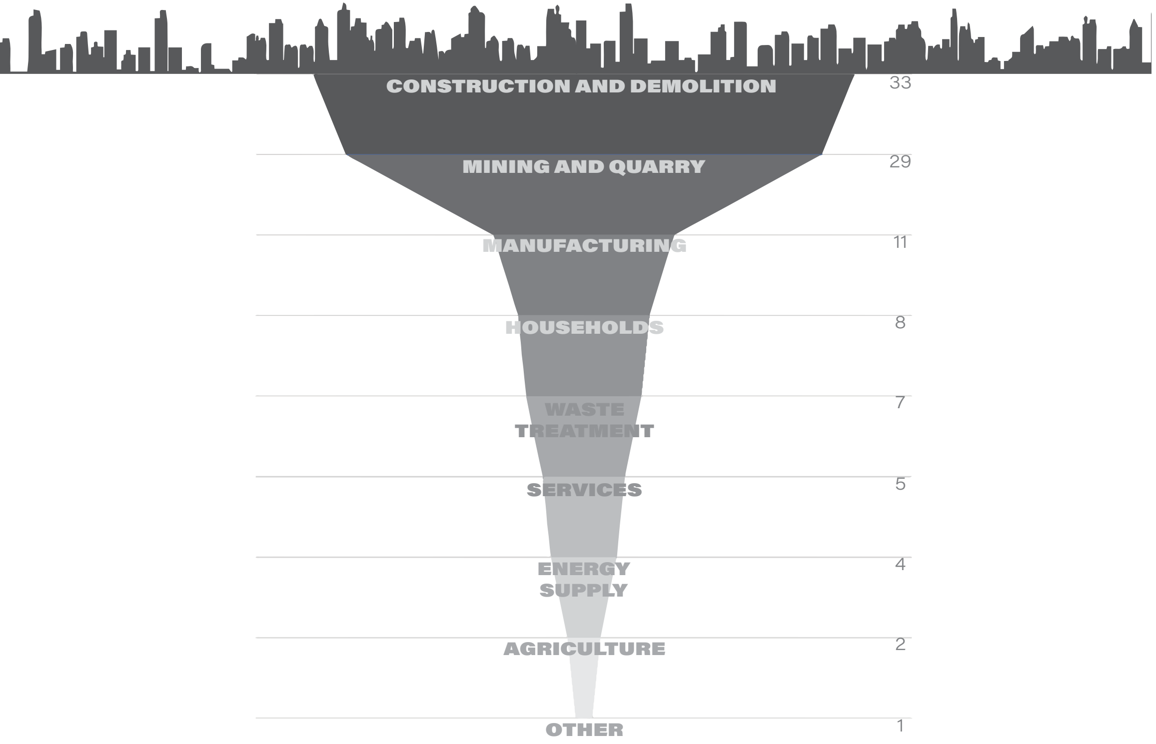


Fig 12. Waste Generated Globally by Sector (in %)
Source: Author, 2022

C AND D WASTE

While construction and demolition (C and D) waste was earlier typically sent to dump sites in many countries, in the past 20 years or so there has been a greater appreciation of the reuse and recycling possibilities of the waste into construction material (recycled aggregate concrete, manufactured sand, etc.) and its implication for the conservation of natural resources. [vii] But this does not completely remove C and D waste from the waste stream, it only delays it. Furthermore, the flow of C and D waste in India is still unsupervised. There is no agreement on the volume of C and D waste that is generated in India.

The Ministry of Environment, Forests and Climate Change in 2010, put the annual estimate of C and D waste at 10-12 million tonnes. The Central Pollution Control Board settled for 12 million tonnes in 2011, but its Guidelines Document of 2017 has upped the estimate to 25-30 million tonnes, based on information from the Ministry of Urban Development. The Centre for Science and Environment, swung to the other extreme and estimated C and D waste at a humongous 530 million tonnes for 2013, as they include the waste from renovations/repairs, assuming that one-third of the existing stock of buildings carried out renovations/repairs in 2013. The most recent annual estimate of C and D waste in Indian cities is 165-175 million tonnes, jointly prepared for the period 2005 to 2013, by two government agencies, the Building Materials and Technology Promotion Council, and the Centre for Fly Ash Research and Management. [viii]

The uncertainty regarding the quantity of waste generated makes it evident that the C and D waste from India is the single largest contributor to the overflow of waste situation in the Country.

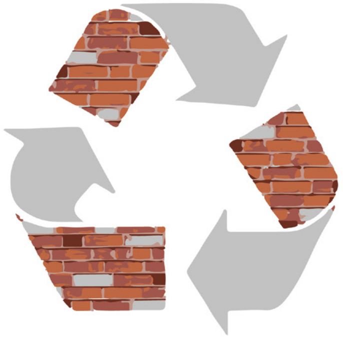


Fig 13. Reclamation and Reuse of Brick
Source: Author, 2022

RECLAMATION

William Addis, in his book 'Building with Reclaimed Components and Materials', explains that reducing extraction of new materials – reusing components and materials more than once brings environmental benefits in several ways. On the supply side, the demand for primary materials is reduced, as well as the resources needed to process primary materials. Reducing materials sent to landfill – reusing components and materials also takes material out of the waste stream before it goes to landfill. [ix]

In the North and South America, people are well aware of this practice of reclamation and is being implemented at a steady pace. In these regions where buildings are predominantly constructed with timber, careful deconstruction and salvage of wood can be reused in new construction. The Unbuilders based in Vancouver, Canada is a good example of a team that has developed and managed such a system of reuse. Their team of salvage experts consisting of former carpenters, roofers, framers and tradespeople have made a switch from construction to deconstruction to make this possible. [x] Many such initiatives can be seen across the world for the reuse of timber, metal and other building materials.

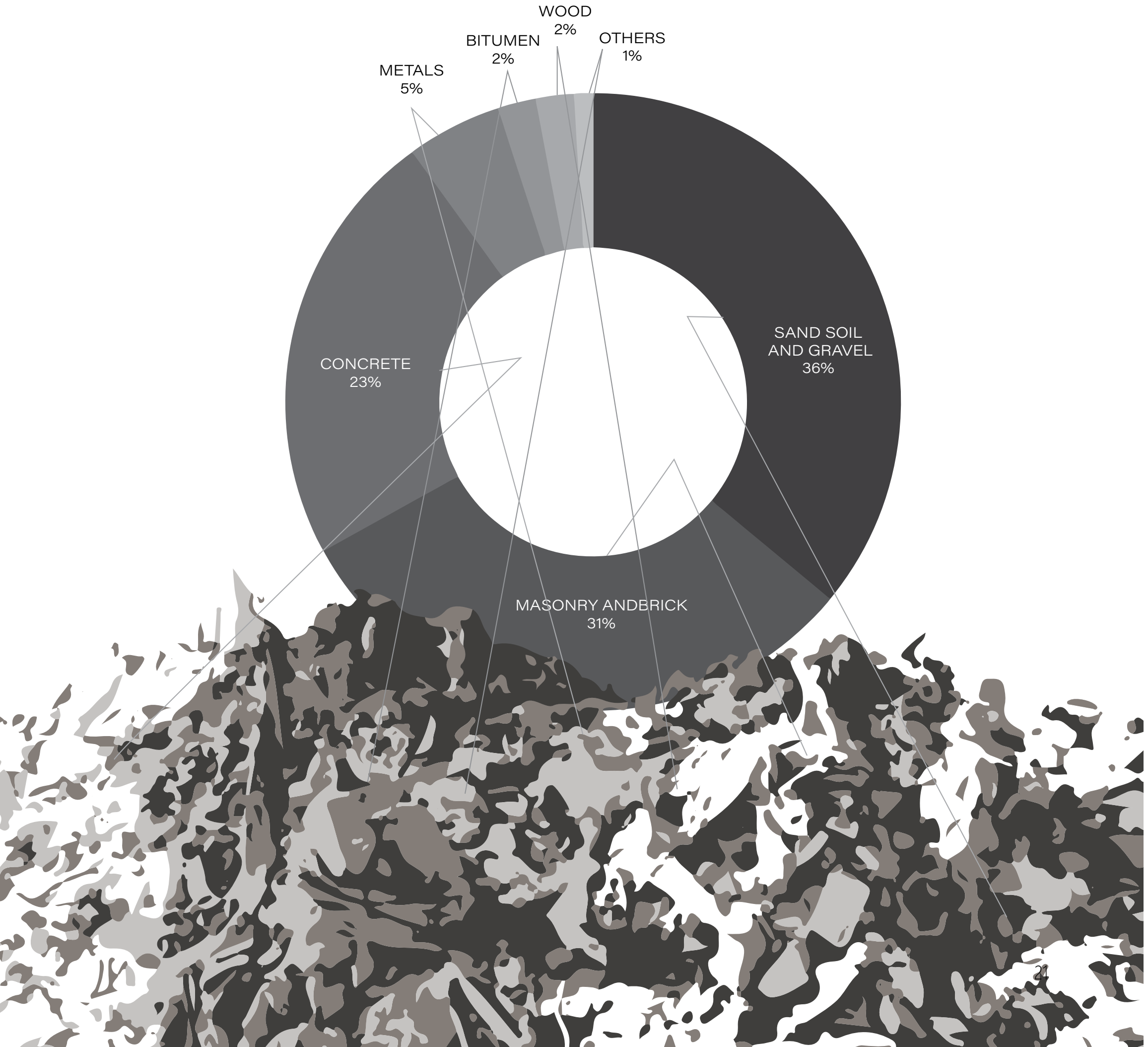


Fig 14. Composition of C and D Waste in India (in %)
Source: Author, 2022

BRICK

Reclamation of timber, metal and other building materials shows signs of positive impact on the environment by reducing its burden on the production of new materials thereby reducing much waste. One possible reason for this is that they are composed of monolithic materials that do not depend on any additives to elevate its properties to be used in construction. However, C and D waste in India is comprised predominantly of masonry bricks and concrete estimated at 31% ad 23% respectively while sand and gravel is estimated at 36% and other recyclable building materials makeup 10%.

Bricks components are composed of many aggregates to increase its value as a building material, thereby making it difficult to be taken apart from the building. This extensive use of brick matter in the Indian context poses a great challenge when considering its deconstruction for reuse. Addis explains that the ease with which stones, bricks and blocks can be separated for reuse depends on the type of mortar used. Modern cement mortars are highly tenacious and make separating the units both mechanically difficult and likely to cause damage to the units.[xi]

THE CONFLICT

McDonough and Braungart suggest that the production of materials should be separated into technical and biological nutrients. Technical nutrients are products that can be broken down and circulated infinitely in industrial cycles. Biological nutrients are biodegradable and decompose back into nutrients for the soil. [xii] Even if there is a shift in the production methods of new materials, as stated by McDonough and Braungart, the materials in the current building stock is still evidently within the linear production. The volume of materials that make up these buildings is unconceivable and covers every land that man has ever set foot on in India. Since large number of buildings were constructed with its linear life in mind, once these buildings near the end of its lifespan it tends to be demolished and eventually sent to dump yards.

As explained previously, the challenge of reusing bricks brings to light a serious problem in the waste generation in India. Without the proper metabolism of existing material in the building stock the generation of debris from old buildings will have great burden on the dump yards in India. Thus it is important to bring back the bricks currently in the buildings into the production cycle to create reusable components that can stay within the technical loop and out of the dump yards.

CHAPTER FOUR

SPECULATION

This thesis is based on a future where there would be no influx of raw materials but one in which there is abundant salvageable brick material from the existing buildings. As discussed previously, studies have shown that there would be an influx of population in the major cities of India giving rise to housing needs. With the need for new construction and in the event of a mining strike, maybe there could be an alternate design strategy where we can make use of the abundant masonry brick in the existing building stock before they get demolished by providing them with an afterlife. An afterlife in the form of a new component that can be reused multiple times as the requirement changes so that it stays within the technical loop of the economy and never goes back to the environment in the form of waste mater.

In his book, ' Building with Reclaimed components and Materials', Addis explains how this practice will allow existing and new building stock to one day serve as the primary source of materials for replacement construction, in effect mining and harvesting existing building stock rather than the natural environment. This resource flow will be encouraged by aging and obsolescent buildings, dwindling natural resources, and declining population in developed countries. [xiii] But the preexisting notion that there are limitations to reusing salvaged masonry bricks as a load bearing building material poses great threat to this theory.

The main barriers to reclamation and reuse are unfamiliarity and inertia – being unaware of what can be done and how it can be done. [xiv]

Fig 15. Brick Debris
Source: Author, 2022

CURRENT STRATEGIES

To analyze the feasibility of salvaging and reusing masonry bricks as a the primary load bearing component for construction, I studied precedent strategies that seemed closely connected.

In principle, many precast concrete elements could be removed from a building, refurbished if necessary, and reused. This could apply particularly to, columns, beams and portal frames; floor planks made of ordinary or pre-stressed reinforced concrete; staircases (usually in units of a single straight flight); panels forming internal partitions or external walls blocks forming part of a proprietary flooring system. The success of such an operation will depend crucially on two factors, the condition of the reinforced concrete itself; the ease with which the components can be separated. [xv]

The Big Dig house (refer fig. 16 and 17) in Massachusetts is a good example of such a monolithic structure to be reused. The slabs of reinforced concrete that was salvaged from a highway ramp was used as the roof slabs for a single family residence. The design of the house was highly dependent on the size and shape of the slab and in essence this can not be replicated in all instances. Also the fate of these slabs is still in question when the residence would have to face its end of life in the future. As stated previously, this only delays the material from reaching the dump and does not stop it completely.

Fig 16. Reclaimed Precast Concrete Slabs from Big Dig Project
Fig 17. Residential House from Salvaged Precast Concrete
Source: Big Dig House / Single Speed Design | ArchDaily.

Fig 18. Stepped Roof containing Salvaged Concrete for Insulation
Fig 19. Gabion Wall of Salvaged Concrete for Insulation
Source: Hanil Visitors Center & Guest House / BCHO Architects.

Fig 20. Load Bearing Stone Wall before Refurbishment
Fig 21. Renovated Wall with Salvaged Stone Blocks
Source: Addis, Building with Reclaimed Components and Materials.

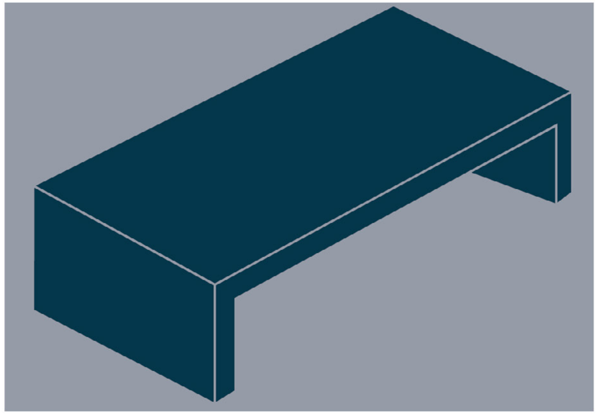
Fig 22. Reusable Brick Wall at Urban Mining and Recycling Unit, Switzerland
Fig 23. Mortar-free Brick assembly Post-tensioned with Steel Bars
Source: Heisel, O'Donnell, and Pranger, "New Deconstruction."

As mentioned earlier, in situ concrete is one of the difficult materials to be reused because it contains elements (reinforcement, aggregates, sand and mortar) that are inextricably linked. This makes it difficult to reuse it as a load bearing structure. The least that can be done is to crush it and use it as an aggregate for laying roads or cased in gabion walls or roofs for insulation as showcased in the Hanil Visitor's Centre and Guest House by BCHO Architects (refer fig. 18 and 19). This provokes a question, would it be possible to encase crushed brick or perhaps bind reclaimed brick with a load bearing form work so that it acts like a monolithic structure just like precast concrete? Perhaps this could be used as a building component for future constructions.

Additionally, it is highly unlikely to salvage bricks without damaging it in some form. Addis explains that old masonry constructions that used low binding lime mortar are easier to be salvaged but even then the reclaimed masonry will usually be sold 'as seen' without a warranty guaranteeing its performance.[xvi] This was implemented in a renovation of an old building for the University of Huddersfield which used lime mortar. (refer fig. 20 and 21)

This makes me wonder if there is any possibility, to remove brick walls totally intact in its entirety to be reused elsewhere. Perhaps there would be a way to hold the structure in a casing so that it is easier to be deconstructed as a monolithic form. Or there could be some way to dissolve the high binding mortar that is predominantly used these days so that the bricks could be removed without damage.

It seems that the way we bind building materials plays a crucial role in the way it can be salvaged. If these materials are salvaged and converted into a reusable component, it is imperative that these components are assembled in a fashion that can be dissembled with ease. A good example for this type of construction was showcased at the Urban Mining and Recycling Unit (refer fig. 22 and 23) built by Felix Heisel and Dirk E. Hebel, who were also the authors of the book 'The Architecture of Waste'. They installed a wall made up of bricks that were stacked without gluing, held by steel bars and then post-tensioned to have load bearing capacities. May be this type of assembly could be a starting point for the feasibility of reusing the salvaged bricks from India.



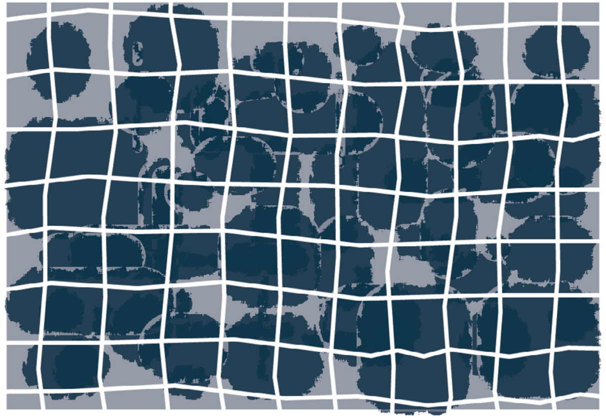


Fig 24. Reclaimed Precast Concrete Component
Source: Author, 2022

Fig 25. Gabion Wall of Salvaged Concrete
Source: Author, 2022

Fig 26. Salvaged Bricks with Infill to match new Brick Course
Source: Author, 2022

Fig 27. Recycled Blocks stacked on Pretensioned Steel Rods
Source: Author, 2022

AN AFTERLIFE

Bjorn Berge in the book 'The Ecology of Building Materials' explains how every material has a resource footprint and a pollution footprint, particularly during production. Much of this can be avoided by recycling and reusing products rather than manufacturing from new raw materials. A product that can be easily recycled will normally be preferable to a product that is initially quite 'green' but cannot be recycled. [xvii]

For the abundant masonry bricks in the existing building stock to be kept within the 'Technical loop' of the industrial sector, it is essential for it to be transformed into a component of sorts that can be reused. The overall goal is to increase resource and economic efficiency and reduce pollution impacts in the adaptation and eventual removal of buildings, and to recover components and materials for reuse, re-manufacturing and recycling. [xviii]

This thesis speculates the possibility of masonry workers being able to cease the opportunity and skillfully deconstruct a brick building to reclaim the bricks as building units or as rubble material for future constructions.

McDonough and Braungart suggested that designing products as products of service means designing them to be disassembled. [xix] Thus, the design of the building would follow the idea of Design for Disassembly which includes the development assemblies, construction techniques and management systems.

According to Brad Guy, the author of the book 'Design for Disassembly', this strategy would eventually facilitate the deconstruction and reuse of the material in a different site. When the customers finish with the material, or are simply ready to upgrade to a newer version of a building, the masonry worker replaces it, taking the old material back, using it as food for storage. The customers would receive the services they need from the workers for as long as they need them and could upgrade as often as desired; masonry worker's space would continue to grow and develop with the influx of the reclaimed material while retaining ownership of for the same. Ownership of material by the construction workers would help in creating responsibility towards waste management.

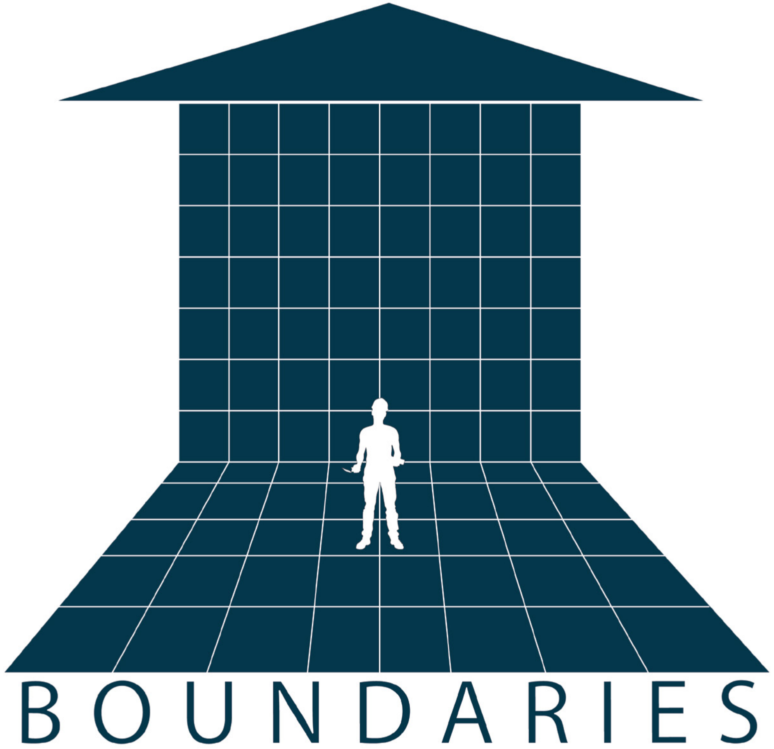


Fig 28. Setting Boundaries
Source: Author, 2022

CHAPTER FIVE

A RESOLUTION

This thesis has lent itself to become a project to develop a building that would act as a product of service as mentioned in the previous chapter. Since this thesis is aimed at finding a way to bring back the brick material existing in the Indian building stock into the technical cycle, the functional workings of the building as a product of service would be limited to the Indian context keeping in mind the variables that the place may present for the building's feasibility.

Brick buildings have a life expectancy of over 100 years, but the dynamics of changing spatial relationships of the single family residences in India forces such buildings to be reconstructed within a decade leading to large-scale brick waste. Thus the major focus of the project would be in recovering the bricks from these houses and keeping them within the industrial cycle for future house constructions.

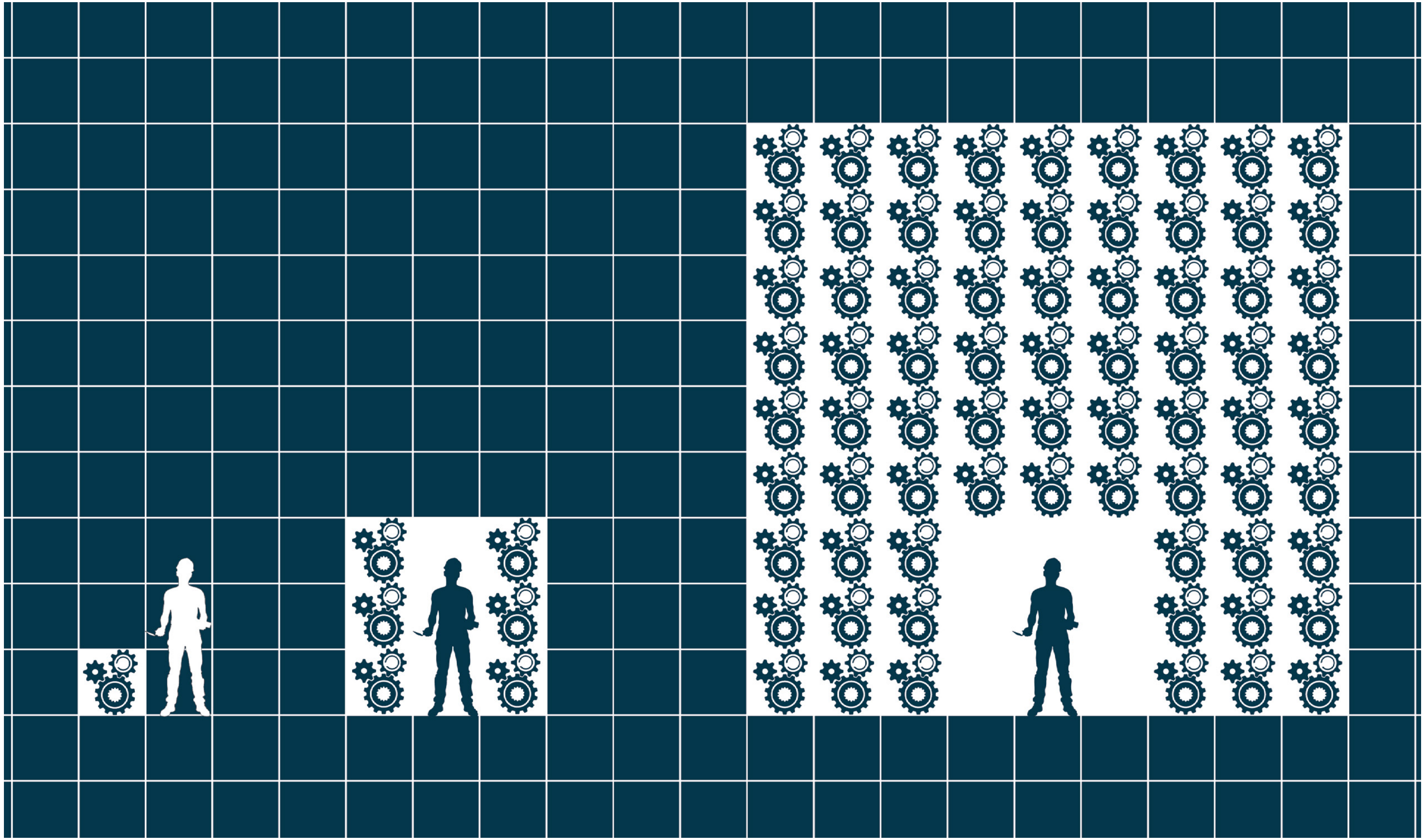


Fig 29. A Unit to an Enclosure
Source: Author, 2022

SITE

To test and speculate the feasibility of the developed building as a product of service, a neighborhood with typical single family houses in one of the Indian cities mentioned previous would be used as the site. These buildings would have been typically built of brick and would present various other factors depending on the city to consider during the building development.

It would be assumed that when a house nears the end of its life-cycle the material stock from the building would be salvaged using the masonry workers. It would then be deposited in their camp site primarily for their own use and then as the material becomes surplus it would be stored for future constructions in the neighborhood.

PROGRAM

The program for the thesis project would replicate a system to maintain the brick material in the technical loop of the economy. The suggested programs for the product of service is to act as a silo, a place of storage and an enclosure.

Fig 30. Methodology
Source: Author, 2022

METHODOLOGY

The methodology that would be followed for the next phase of this project would be to investigate and identify the a neighborhood with typical single family housing predominant in the Indian cities and extrapolate the rough dimensions and volume of material present in each typology.

Identifying fundamental and incidental interactions with other materials would be crucial to investigate methods of salvaging the brick, storing ad reusing the same.

This data would then be used to identify the elements and requirements needed for the building which would then be followed by drafting of the schema for the same.

CHAPTER SIX

A SYSTEM

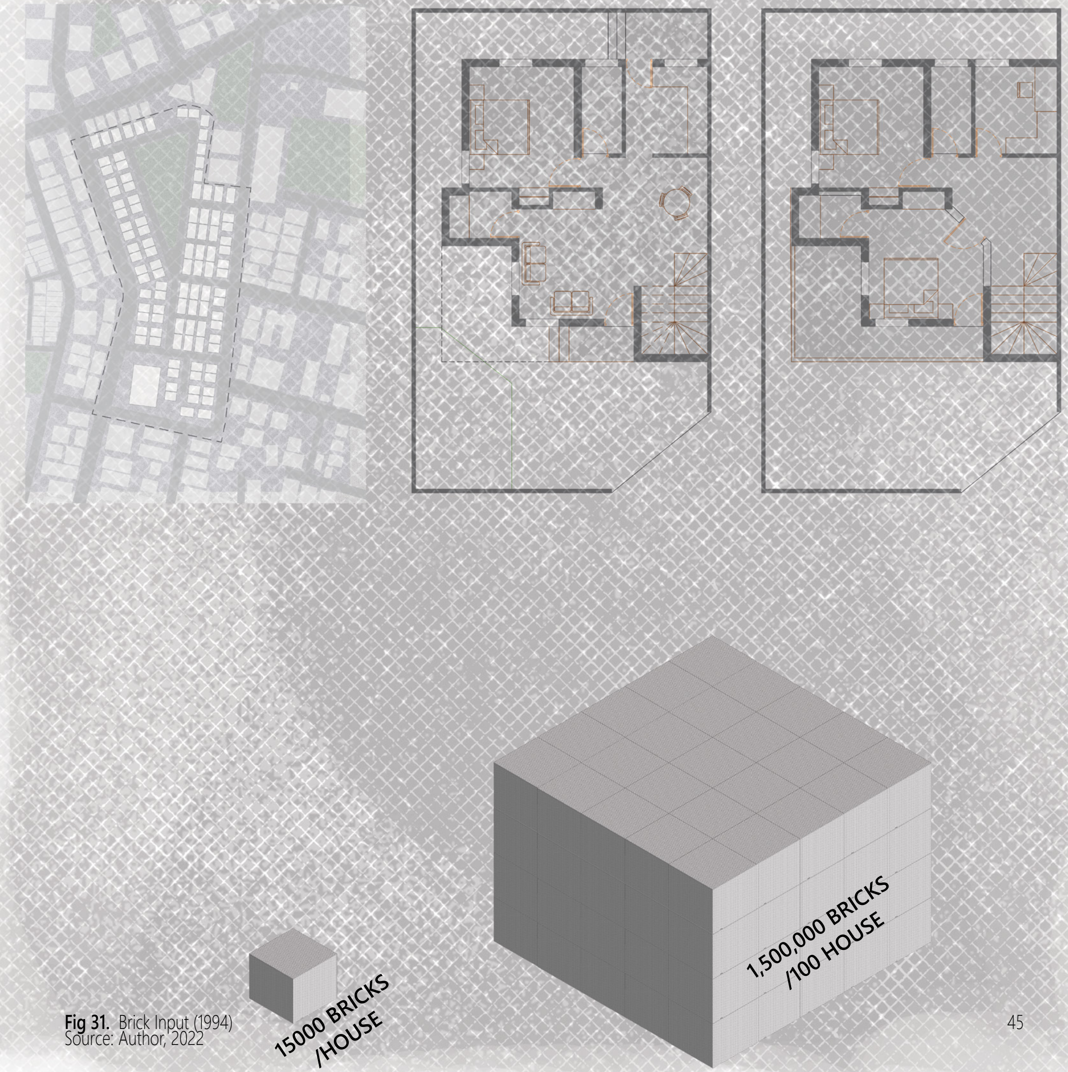


Fig 31. Brick Input (1994)
Source: Author, 2022

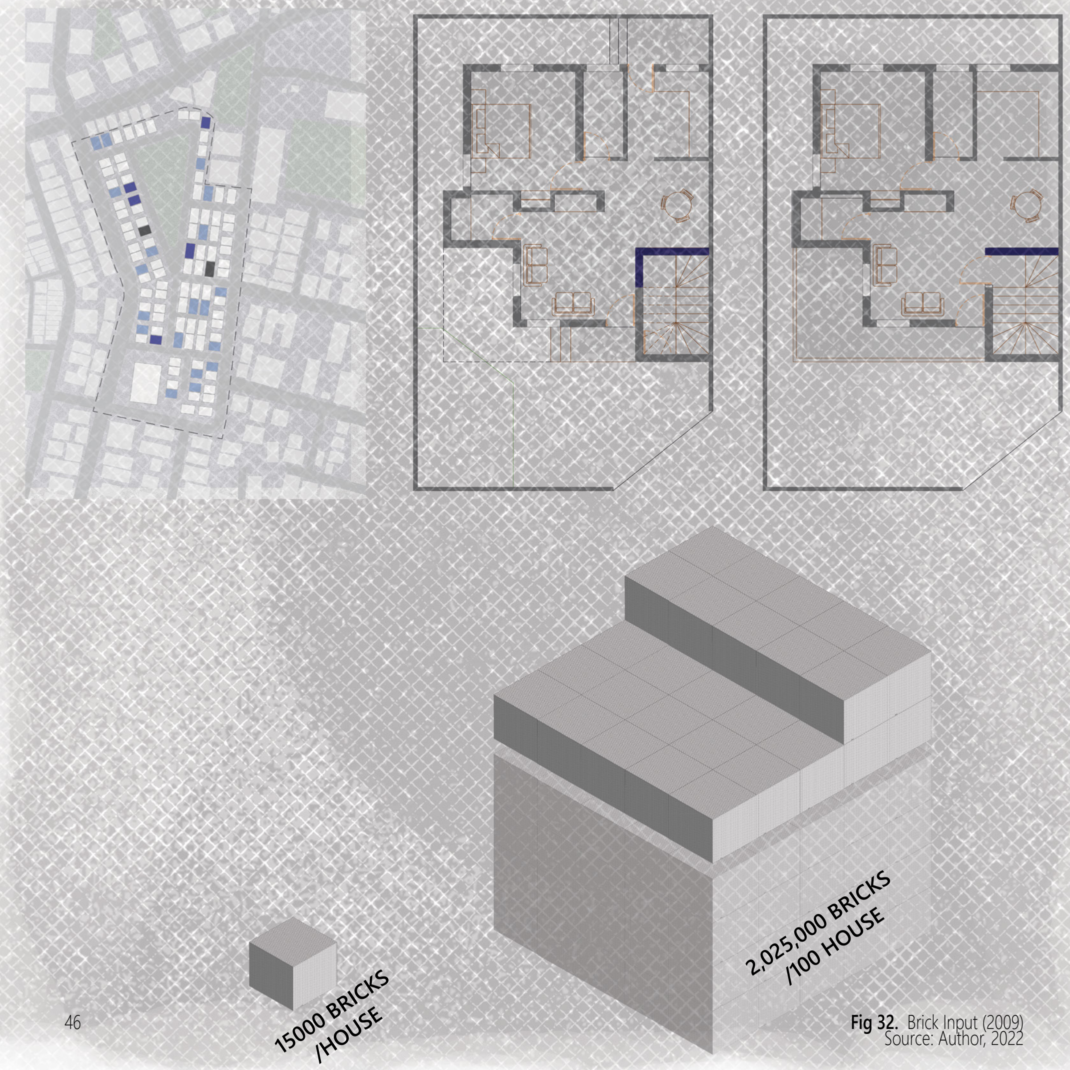


Fig 32. Brick Input (2009)
Source: Author, 2022

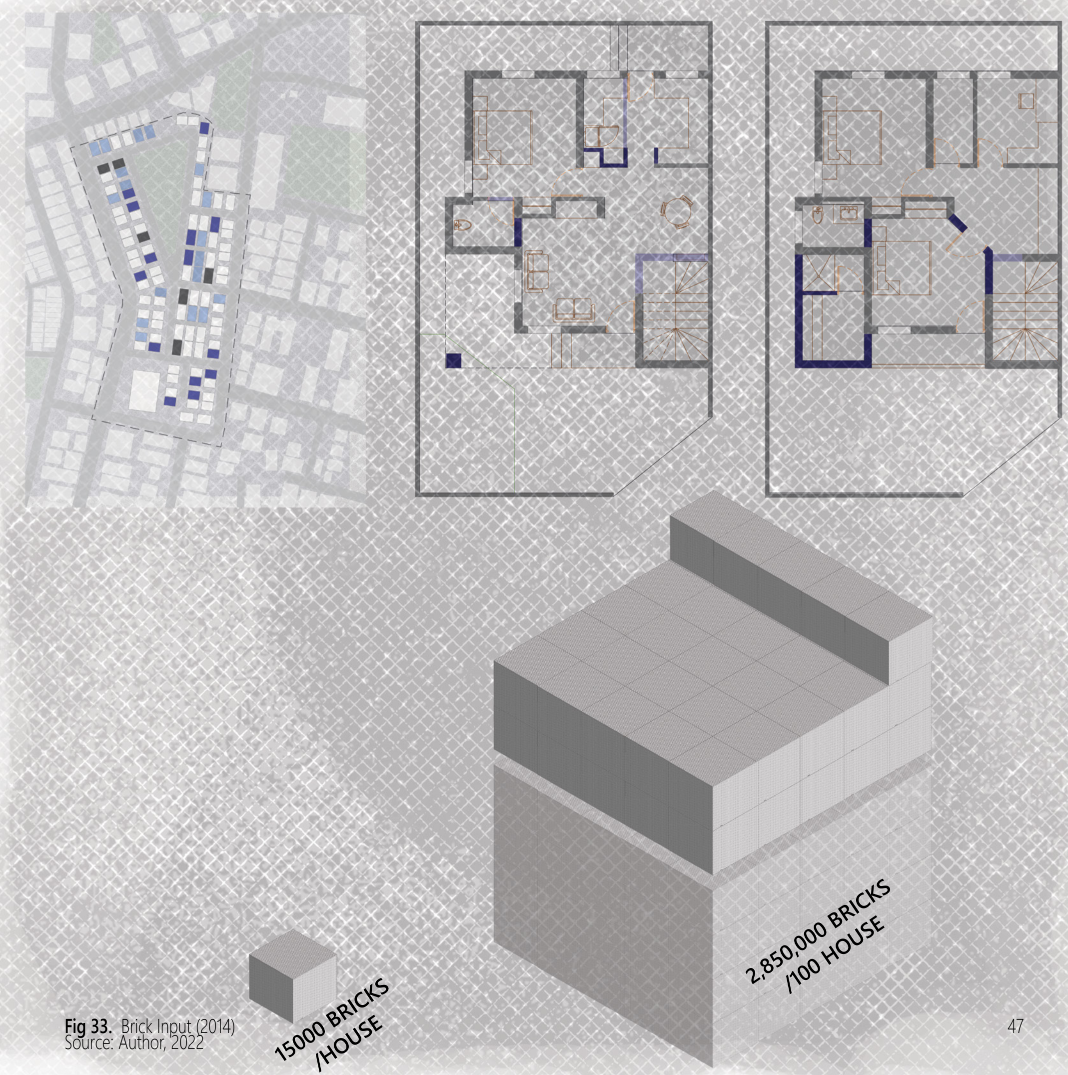


Fig 33. Brick Input (2014)
Source: Author, 2022

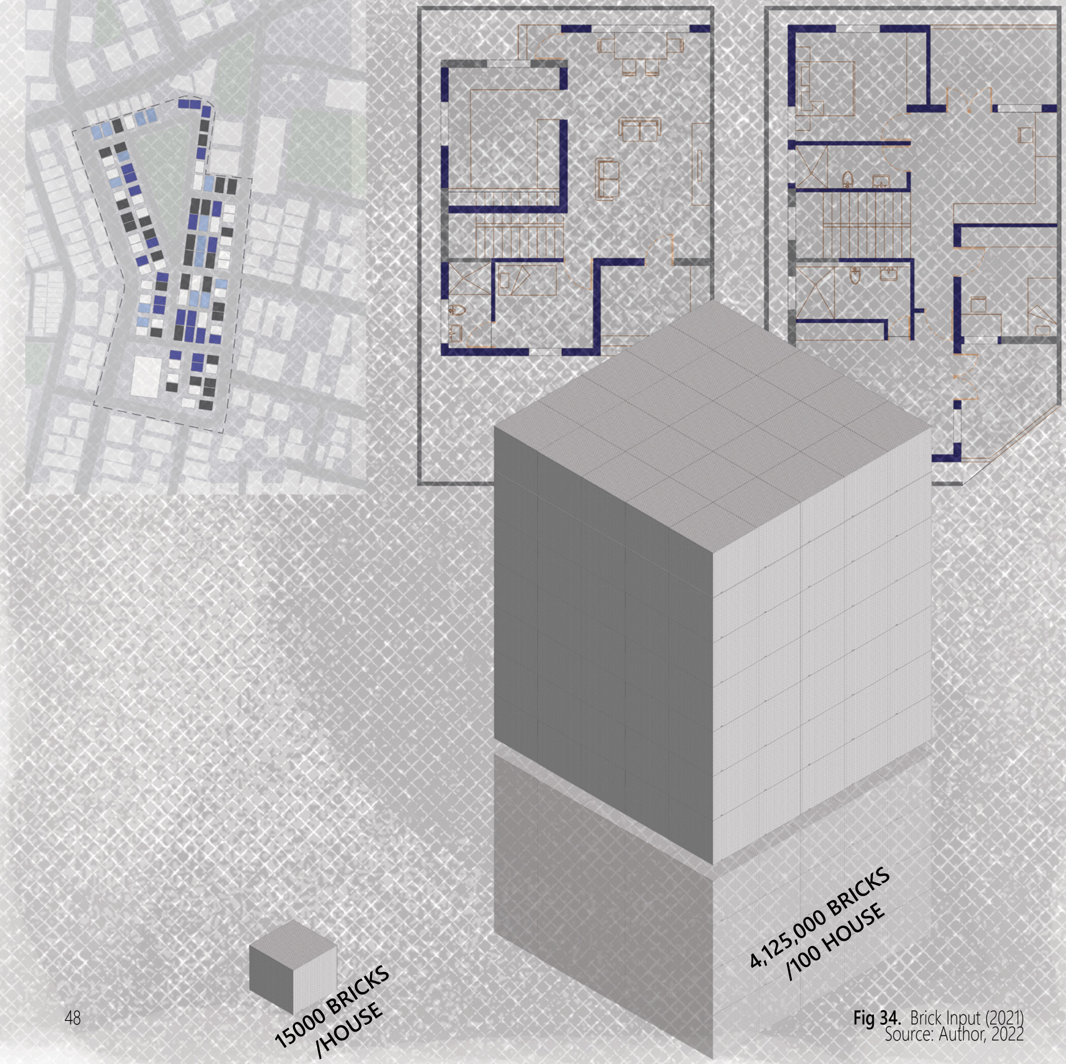


Fig 34. Brick Input (2021)
Source: Author, 2022

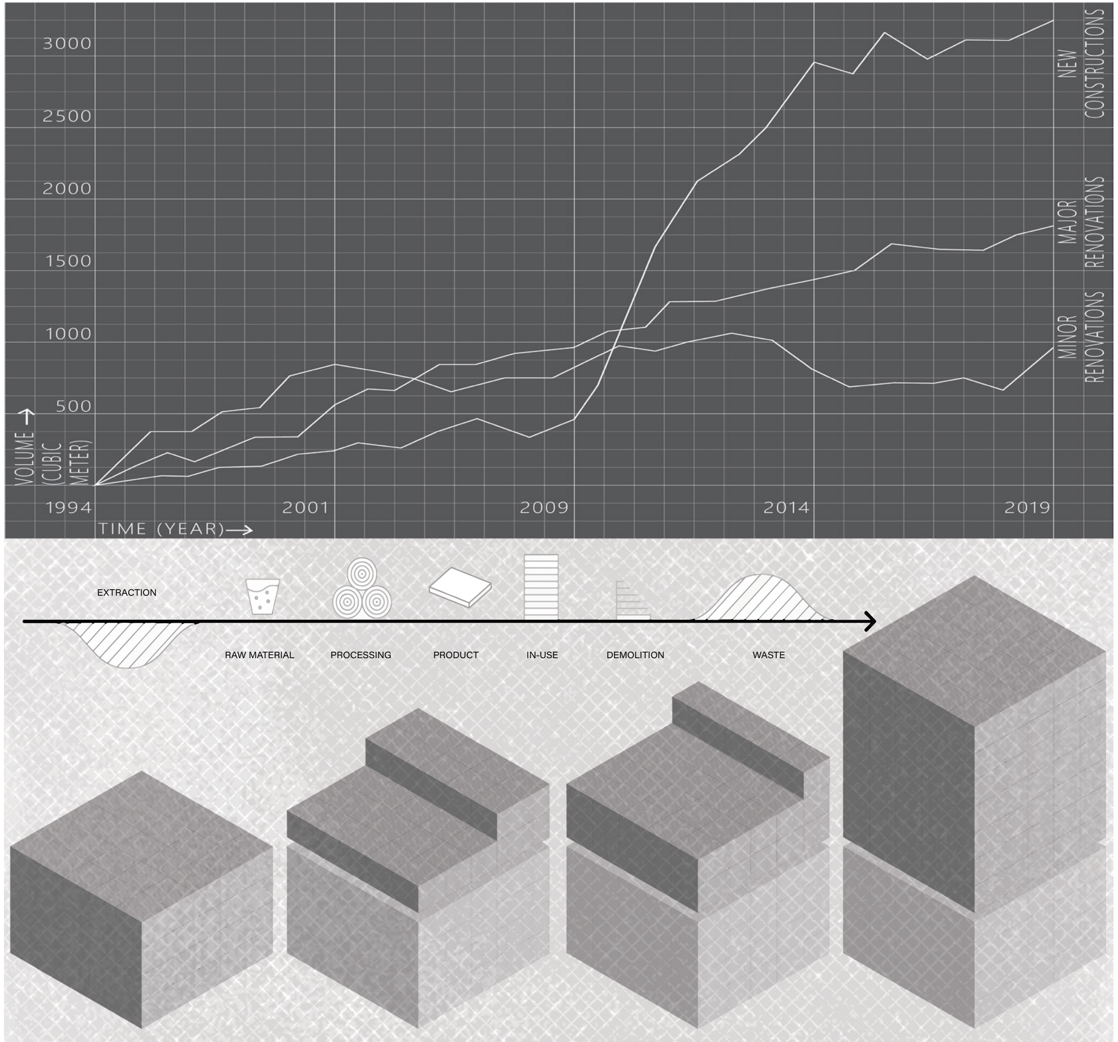
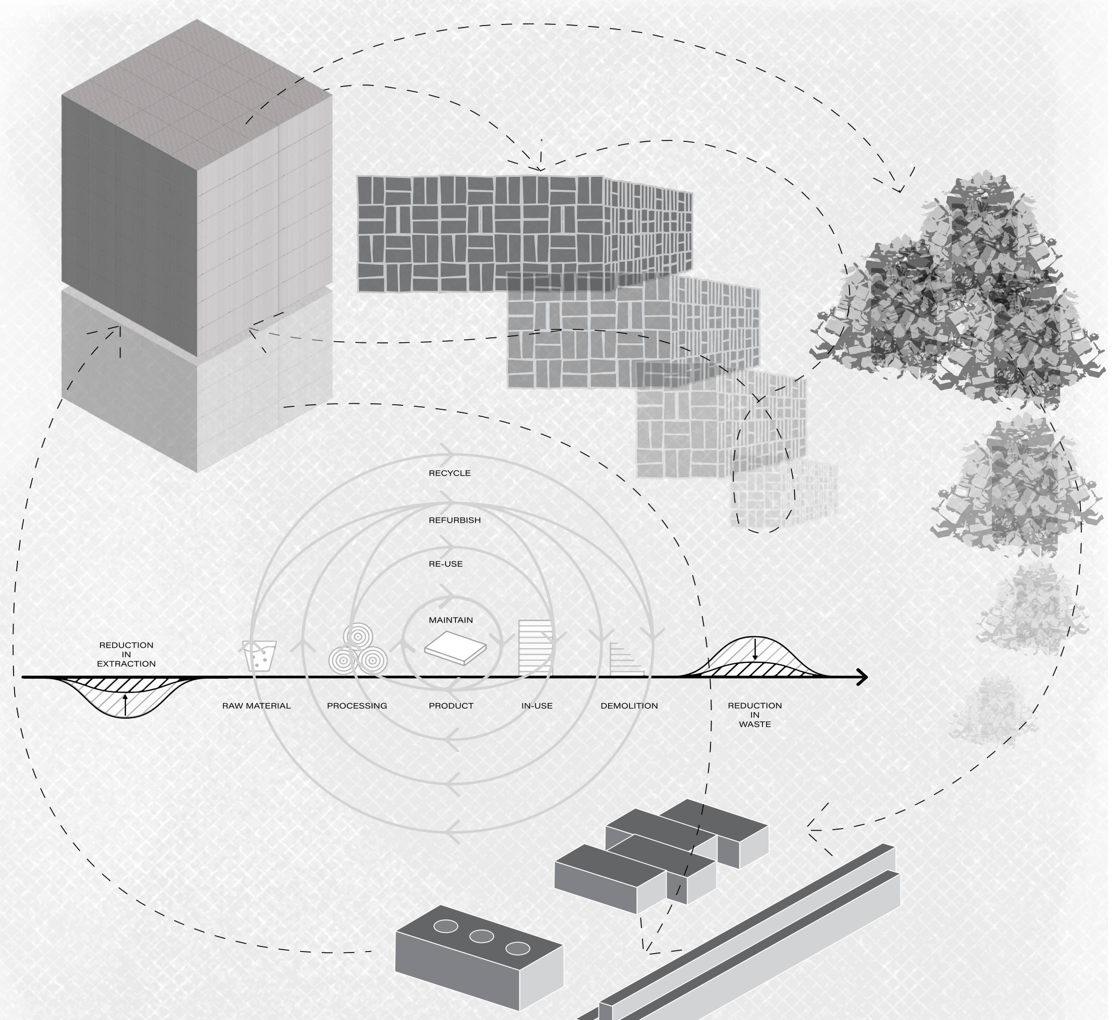


Fig 35. Path of Linear Economy
Source: Author, 2022



PATH OF CIRCULAR ECONOMY

Fig 36. Path of Circular Economy
Source: Author, 2022

Fig 37. Site Reclamation
Source: Author, 2022

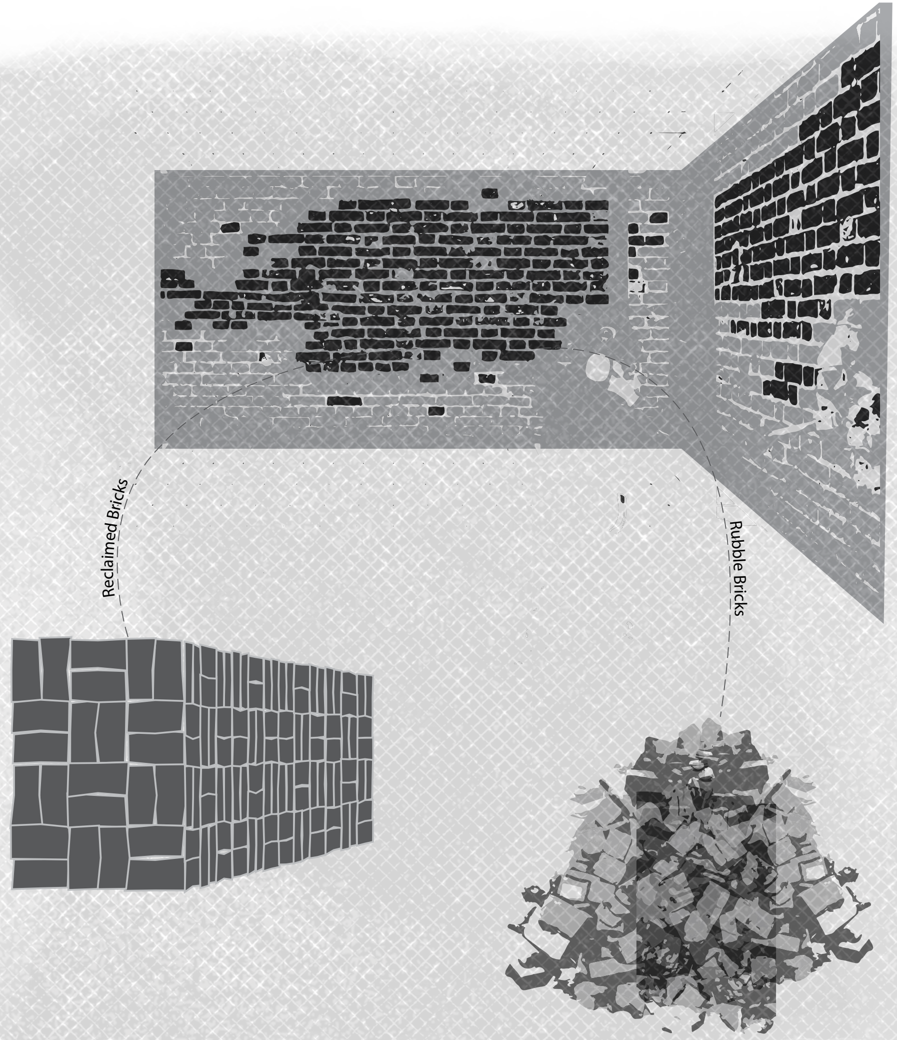


Fig 38. Chiseling and Sorting Bricks
Source: Author, 2022

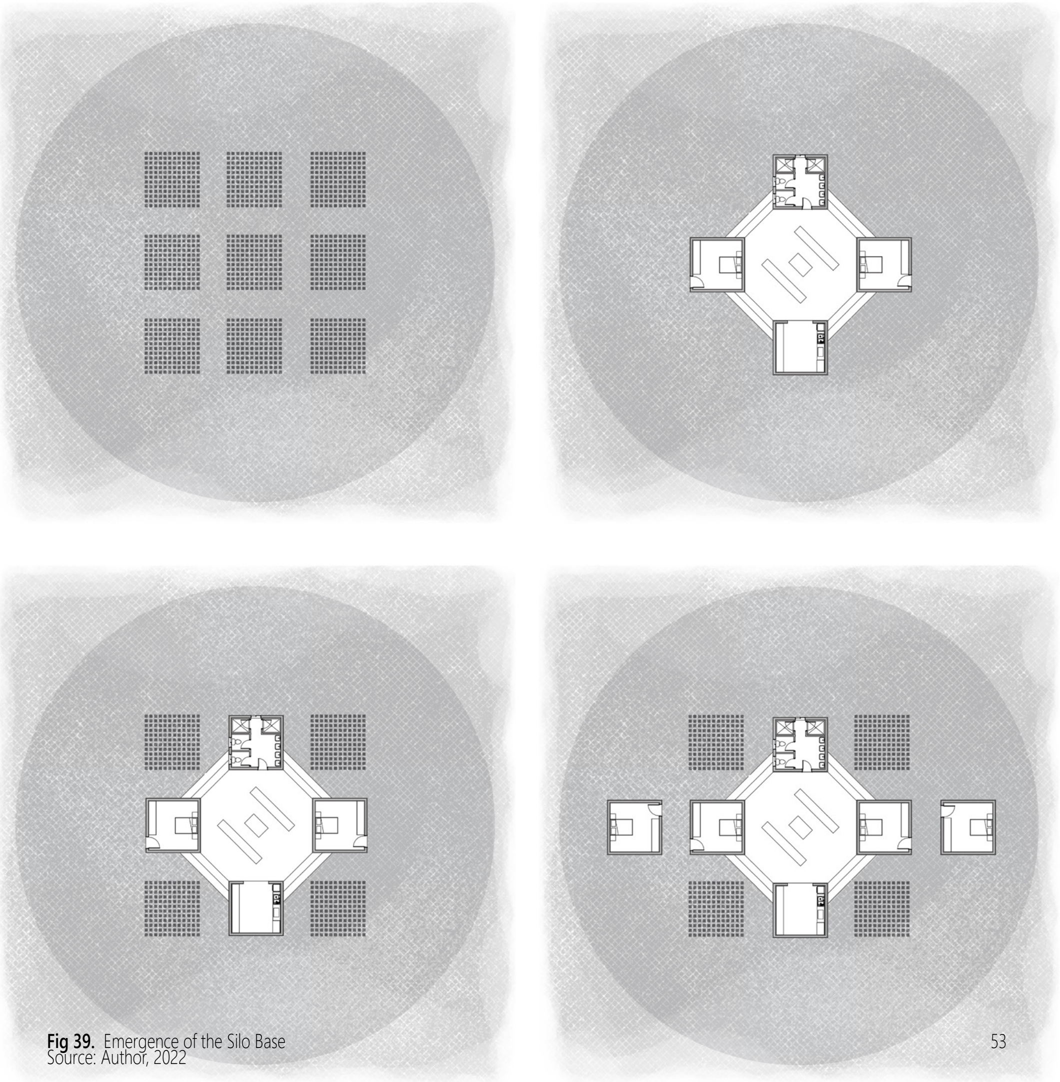


Fig 39. Emergence of the Silo Base
Source: Author, 2022

Fig 40. Silo Base and the Surplus Brick Rubble
Source: Author, 2022

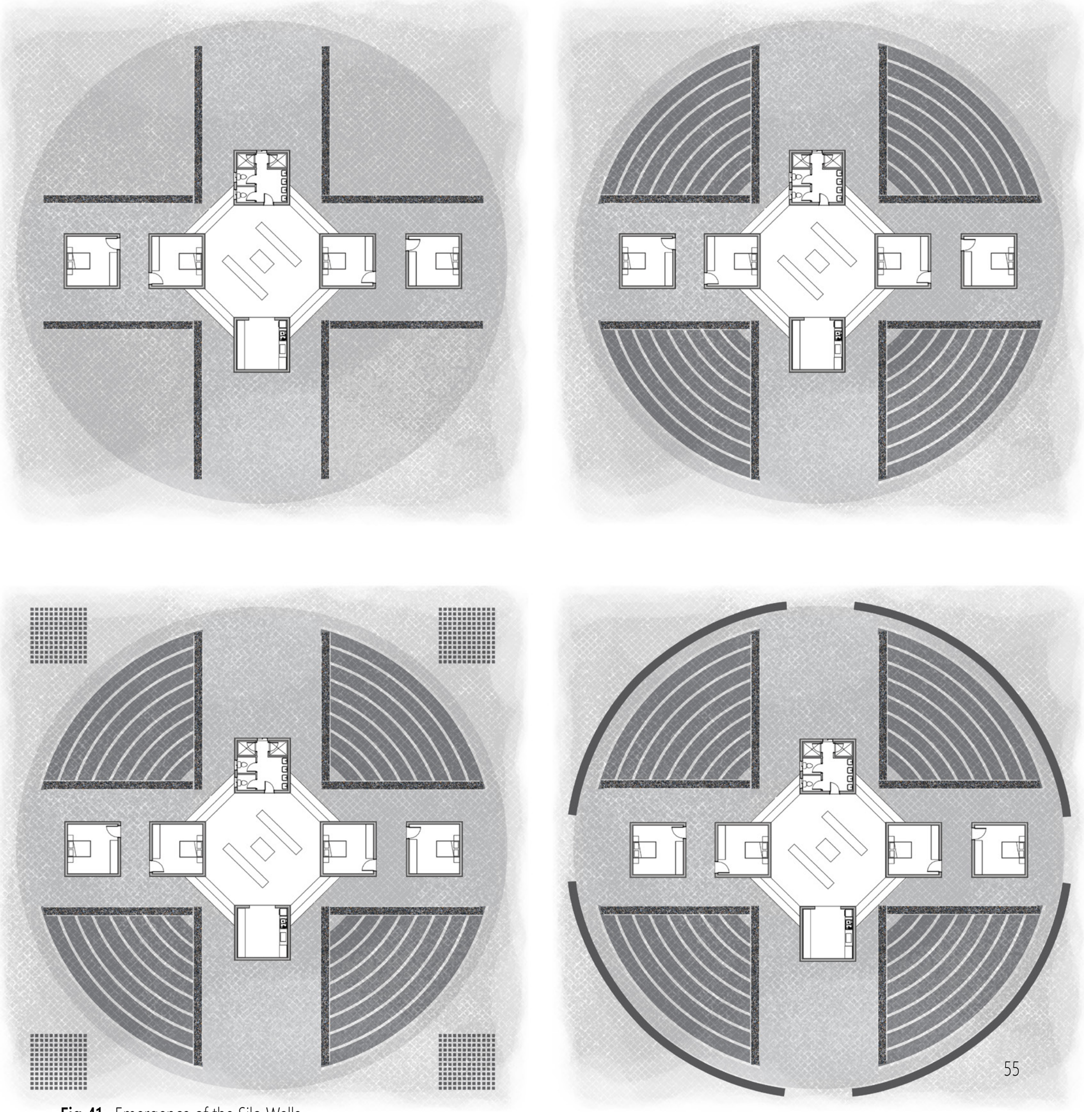


Fig 41. Emergence of the Silo Walls
Source: Author, 2022

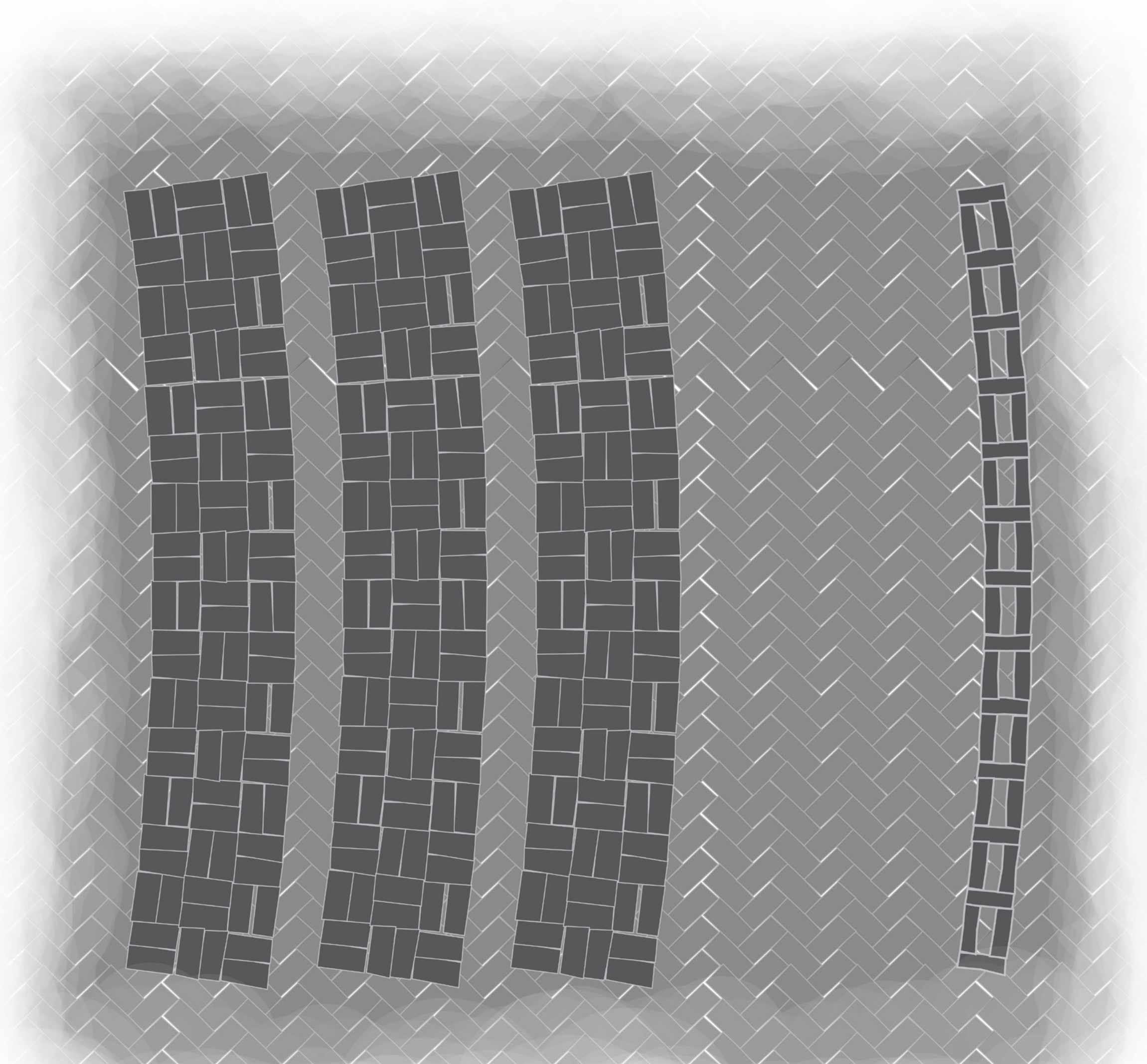


Fig 42. Brick Stacked in Silo
Source: Author, 2022

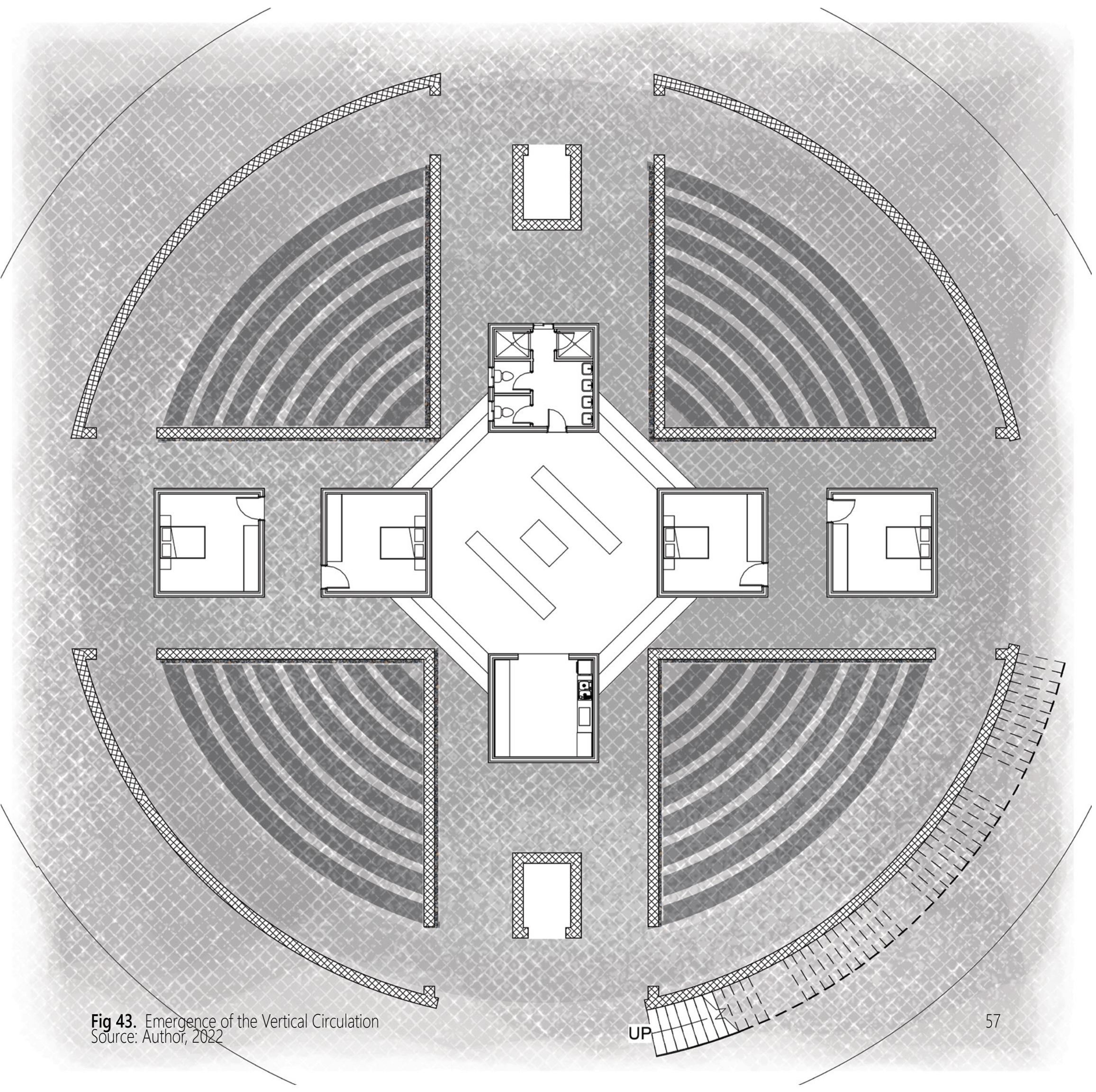


Fig 43. Emergence of the Vertical Circulation
Source: Author, 2022

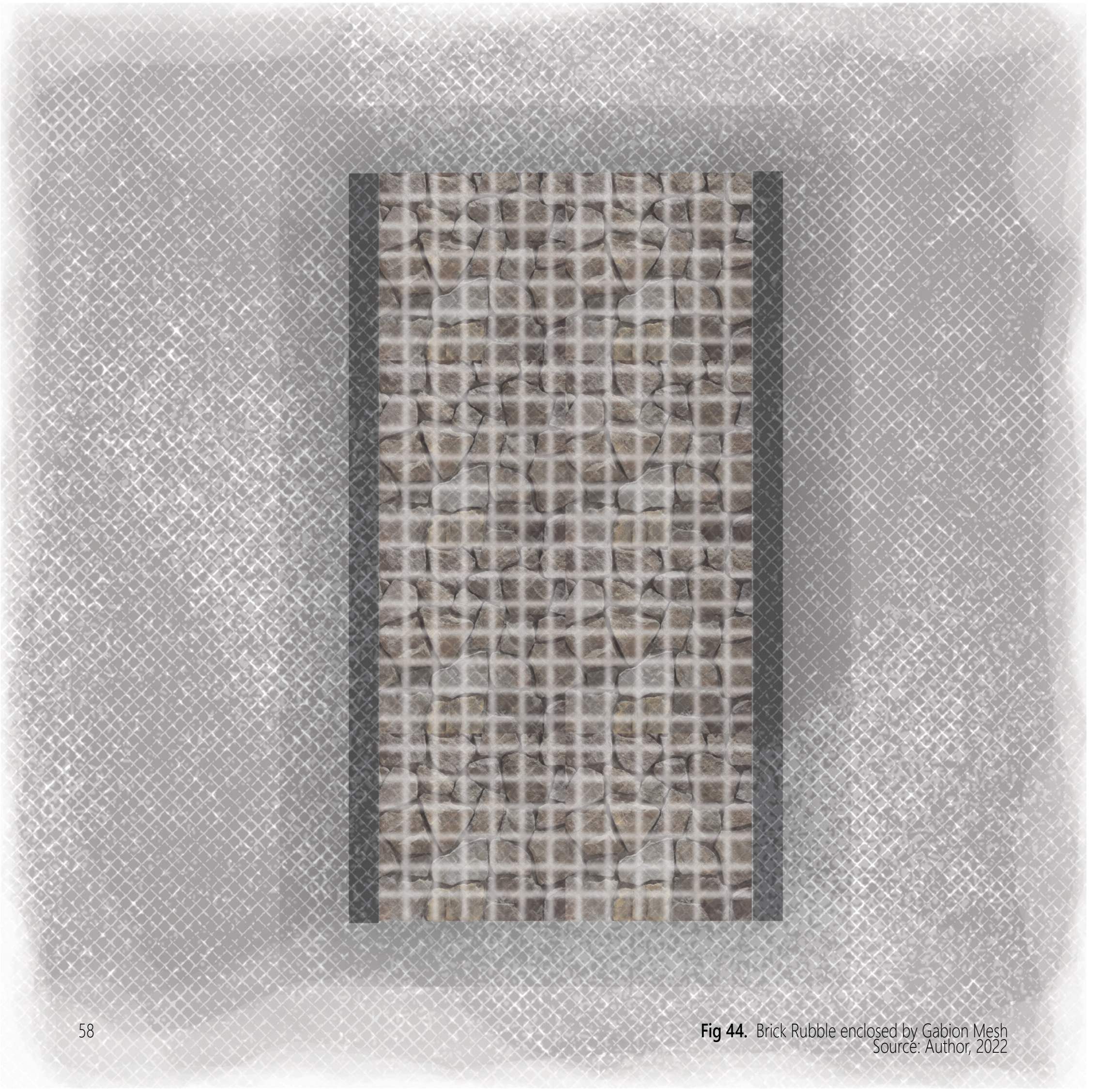


Fig 44. Brick Rubble enclosed by Gabion Mesh
Source: Author, 2022

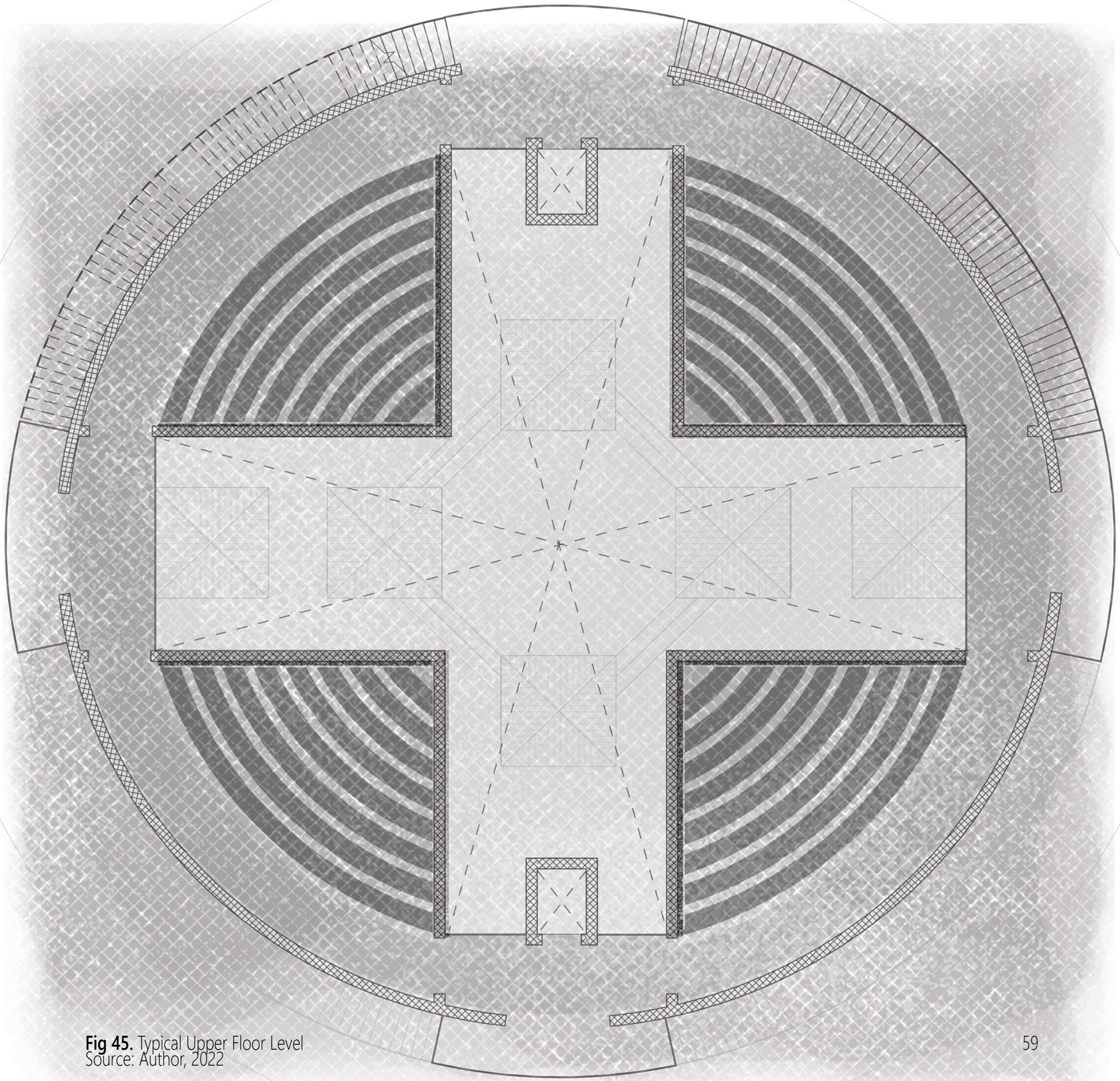
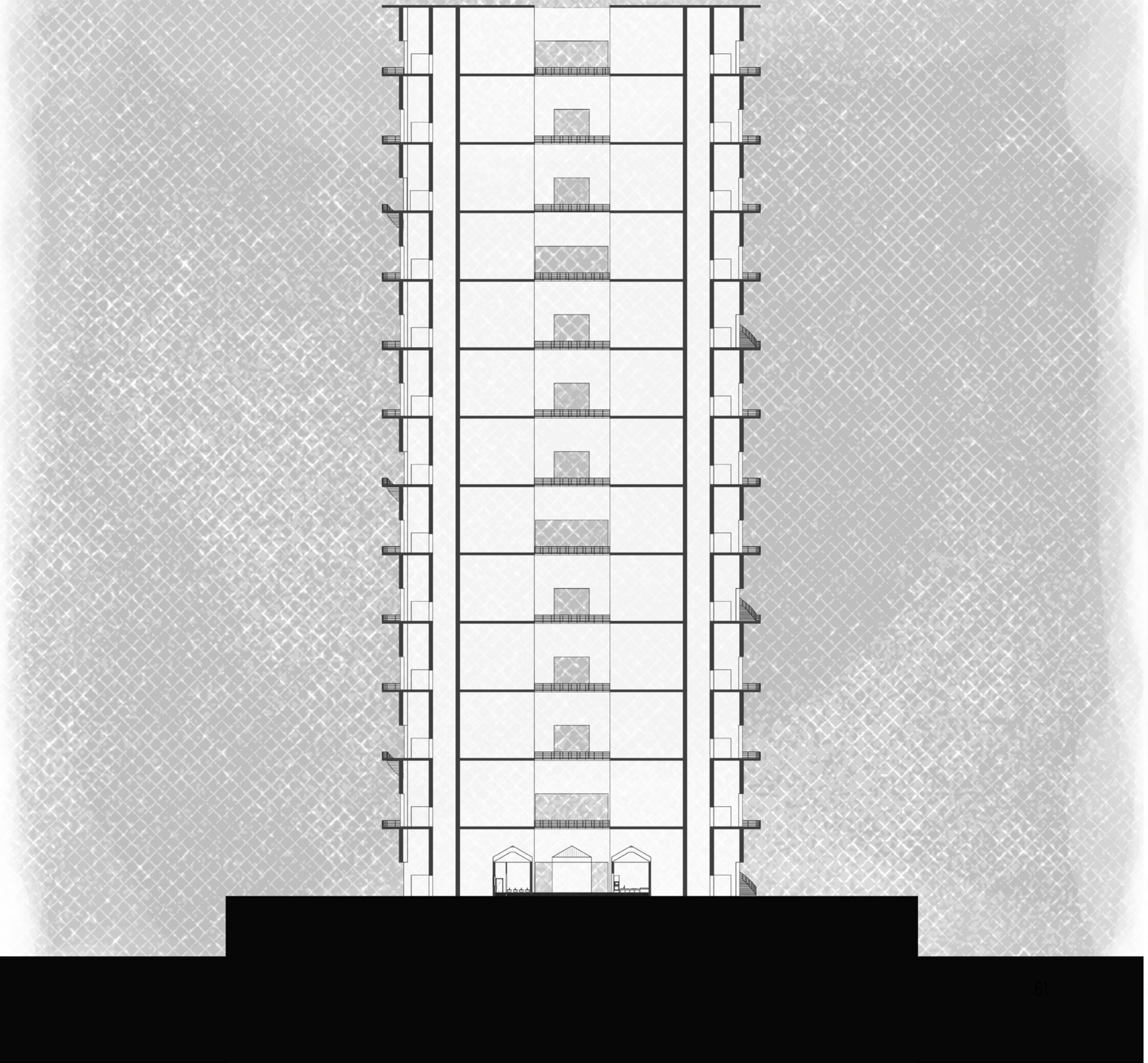


Fig 45. Typical Upper Floor Level
Source: Author, 2022

Fig 46. Silo Soaring High in the Neighborhood with the Influx of Reclaimed Bricks
Source: Author, 2022



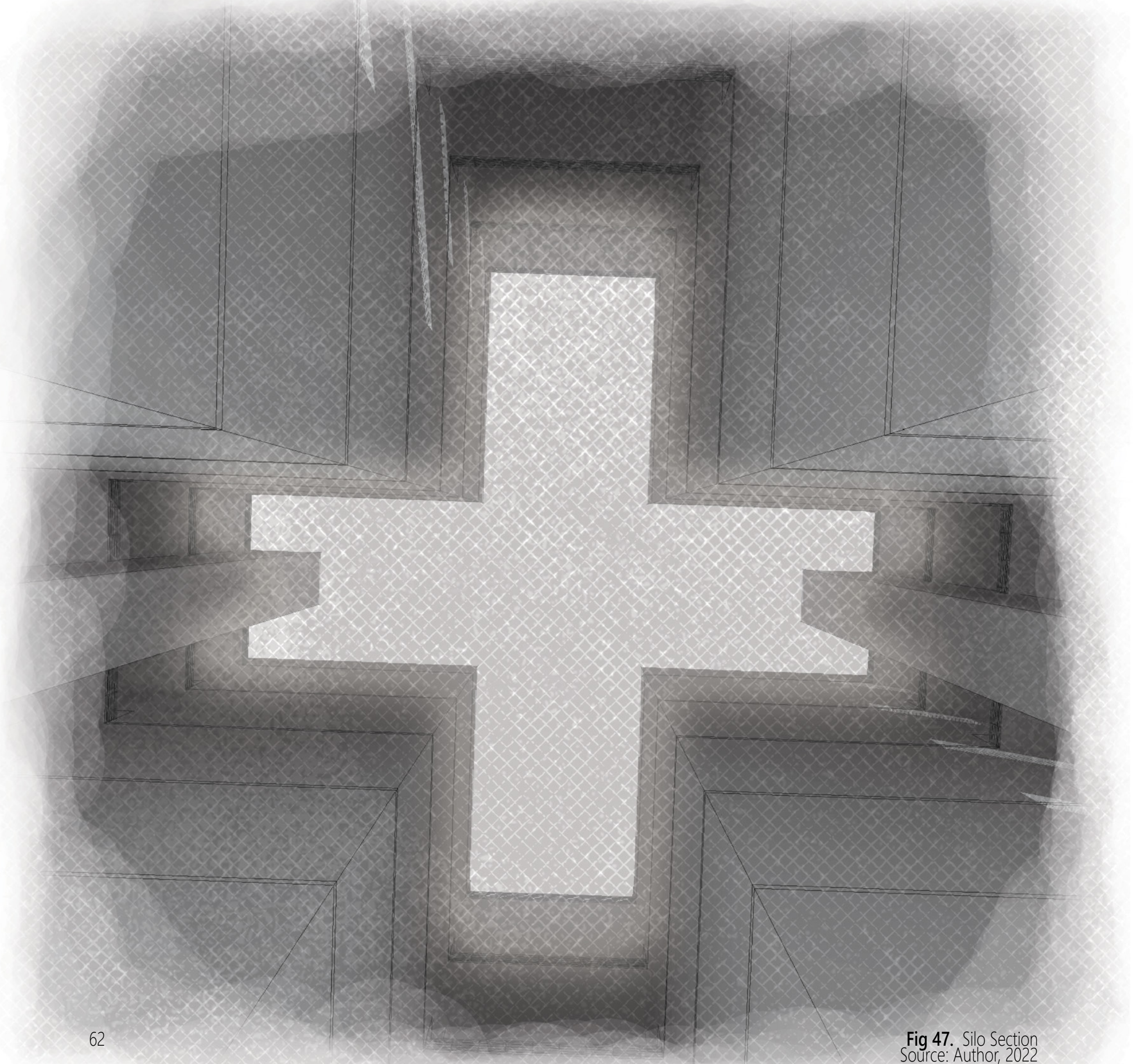


Fig 47. Silo Section
Source: Author, 2022

Fig 48. Daylight from the Roof
Source: Author, 2022

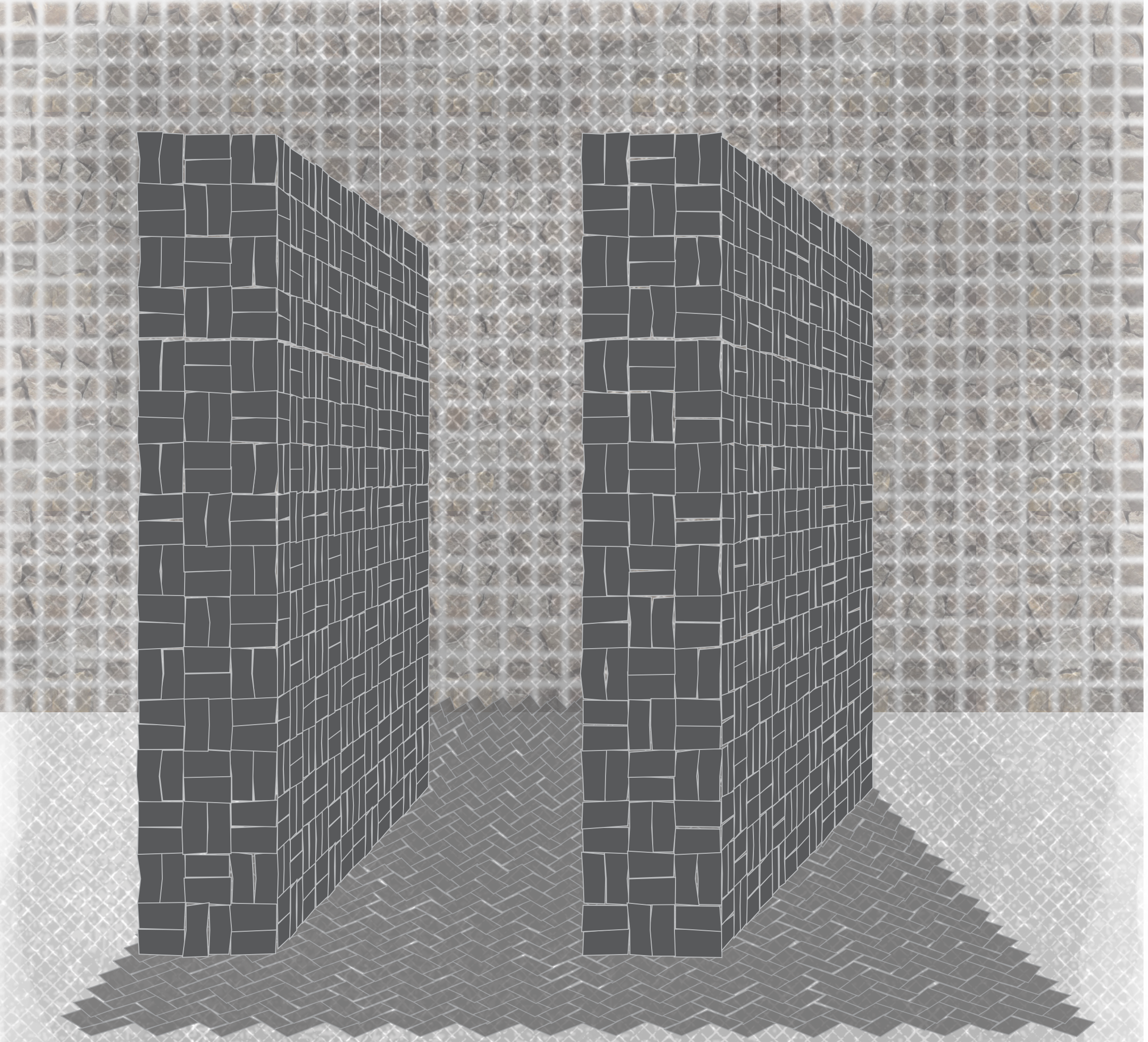


Fig 49. Amongst the Brick Stacks
Source: Author, 2022

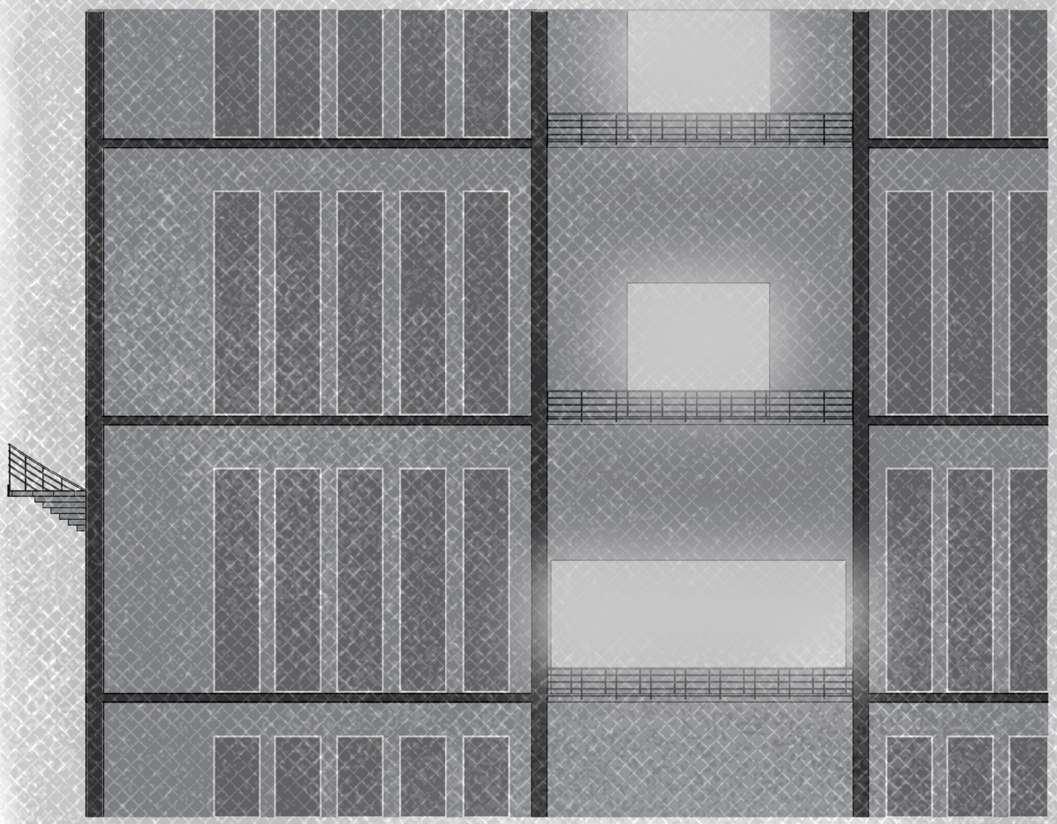


Fig 50. Bricks Stacked in Levels
Source: Author, 2022

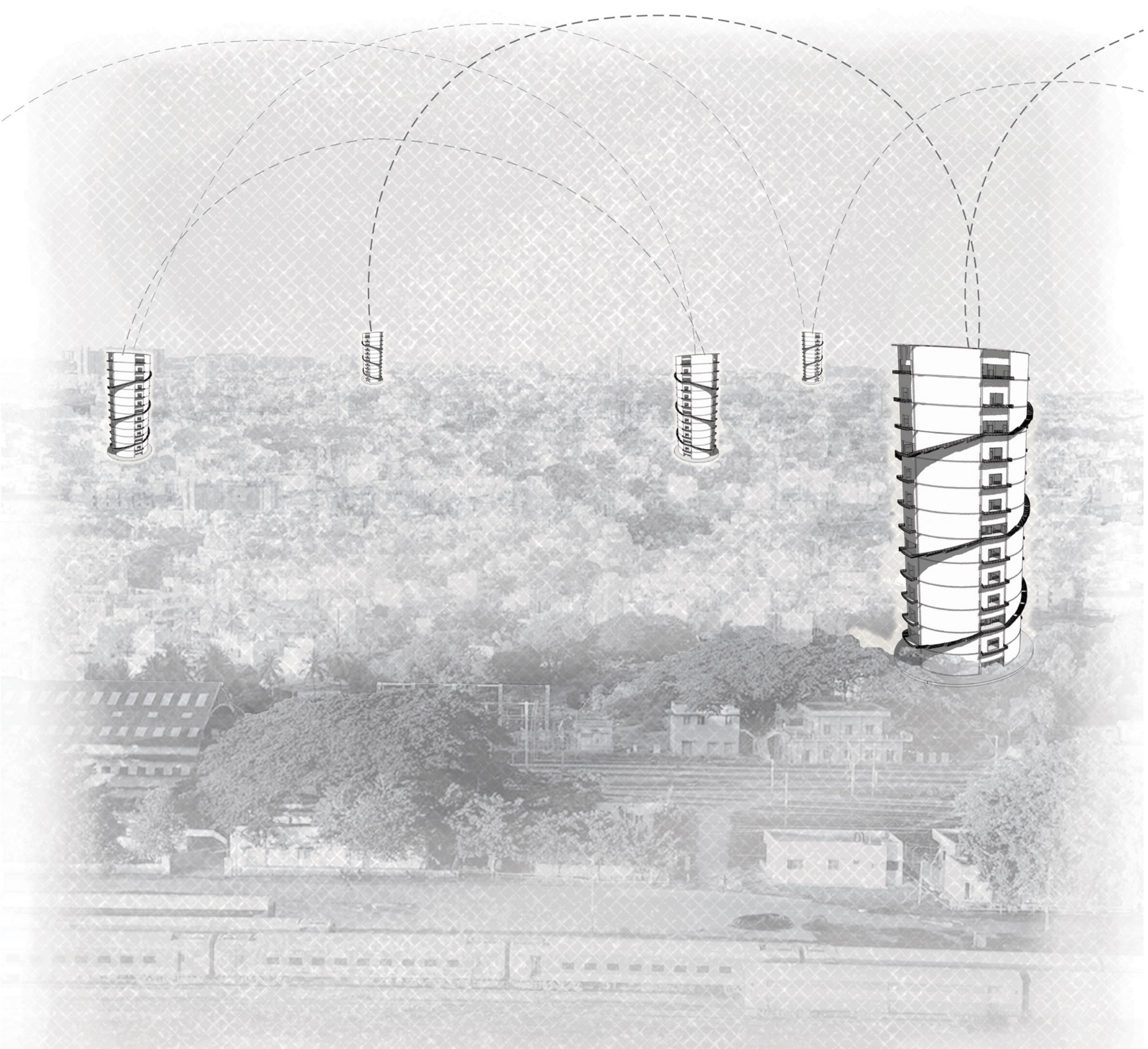


Fig 51. Silos as a Place of Trade
Source: Author, 2022

Fig 52. Projected Future of Brick Trade
Source: Author, 2022

NOTES

i. Herrington, "Update to Limits to Growth."
ii. Hebel, Wisniewska, and Heisel, Building from Waste: Recovered Materials in Architecture and Construction.
iii. Hebel, Wisniewska, and Heisel.
iv. Bhaskar |, "Fighting Mountains Of Garbage."
v. "Bengaluru."
vi. Cassella, "India's 'Mount Everest' of Trash Is Growing So Fast, It Needs Aircraft Warning Lights."
vii. "Bengaluru."
viii. "Bengaluru."
ix. Addis, Building with Reclaimed Components and Materials.
x. "About Us."
xi. Addis, Building with Reclaimed Components and Materials.
xii. McDonough and Braungart, Cradle to Cradle : Remaking the Way We Make Things.
xiii. Guy, "Design For Deconstruction and Material Reuse."
xiv. Addis, Building with Reclaimed Components and Materials.
xv. Addis.
xvi. Addis.
xvii. Berge, The Ecology of Building Materials.
xviii. Guy, "Design For Deconstruction and Material Reuse."
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The University of British Columbia,
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