

## COMMUNITY RESILIENCE SHELTER



### Intermediate Design Development Report - Feb'21

Rachana Sansad's Academy of Architecture  
Fr. C. Rodrigues Institute of Technology  
Vivekanand Education Society's Institute of Technology

<b>Table of Contents</b>		
<b>Sr no.</b>	<b>Topic</b>	<b>Page no.</b>
1	List of Figures	4-5
2	List of Tables	6
3	Executive Summary	7
4	Team Introduction	8
5	Project Introduction	9
6	Site and Context	10
7	Project Highlights	11
8	Design Approach	12
9	Optimization Approach	13
10	Pre Design Analysis	14
11	Design Approach	15
12	Architectural layouts	16-18
13	Thermal comfort	19-20
14	Energy Performance	21-24
15	Resilience	25-27
16	Innovation	28-31
17	Market Potential	32-33
18	Scalability	34
19	Types of module	35
20	Construction process and period	36

<b>Table of Contents</b>		
<b>Sr no.</b>	<b>Topic</b>	<b>Page no.</b>
21	Affordability	37
	Architectural Features	38
22	Net Zero Efficiency of water	39-41
23	Construction Ability and engineering	42-43
24	Application Interface	44
25	Project Summary	45-46

<b>List of Tables</b>		
<b>Table no.</b>	<b>Table Title</b>	<b>Page no.</b>
1	Tools Codes and Standards used	13
2	Shoe box Analysis	15
3	Monthly average performance for off grid PV for Mumbai	17
4	Material selection	18
5	EPI Calculations	19
6	Specification of Wind Turbines	20
7	Window calculations for stack effect	21
8	Ventilation rate calculations	27
9	Acceptability range and references for cut off winds using IMAC assistant tool	43
10	Sub-soil Layer profile of site	47
11	Detailed Building Program	47

<b>List of Figures</b>		
Figure no.	Figure Title	Page no.
1	Flooding prediction by 2050	1
2	Worli bus depot location	3
3	Design Site: Worli bus depot	3
4	On site discussion with the community members	4
5	Site visit and On site discussion with the industrial partner	4
6	Optimization approach and process	
7	Andrew marsh dynamic shadow Diagrams	5
8	Conceptual zoning and circulation of spaces	7
9	Sectional zoning with sun and wind direction	7
10	Sectional zoning with space division	7
11	Adaptive comfort chart for Mumbai (Source:Self)	8
12	Adaptive comfort chart For Worli Koliwada Site (Source:Self)	8
13	Desirable wind speeds (m/s) for thermal comfort conditions (Source:NBC for India 2016)	9
14	Buoyancy flow driven windows of clinic with multiple openings using LeVCaVIR	10
15	Miracle Air HEPA Home, Office, School Air Cleaner	10
16	Buoyancy Driven flow	11
17	Adaptive comfort chart For Mumbai (Source:Self)	11
18	Optimization of single container	11

<b>List of Figures</b>		
Figure no.	Figure Title	Page no.
19	Optimization of entire design	12
20	Final -EPI achieved- 53.4 kwh/m2/year	12
21	Wind speeds at site at the height of 12m above ground (Source: Self)	12
22	Power production estimates for off grid PV for Mumbai (Source: PVGIS-European Commission)	14
23	Renewable energy generation per month With wind turbines	14
24	Section showing position of wind turbines in design	14
25	Energy Consumption and energy generation per year	14
26	Generator speed and turbine speed using simulations	14
27	.isometric plan zoning at each floor	14
28	Structural Resilience in team of construction	16
29	Radiation meshes of floors Before/After	17
30	Different Typologies of Modules	18
31	Different Typologies of Modules	18
32	Different Typologies of Modules	18
33	Facade treatment	18
34	Absorption under	
35	Roof Farming - Edibles Vegetables reference image	
36	Roof Farming Detail	
37	Roof Farming - Drop in indoor temperature	
38	Shipping container port	

<b>List of Figures</b>		
Figure no.	Figure Title	Page no.
39	Shipping container construction cycle	12
40	Different Typologies of Modules	12
41	Rapid construction process	12
42	Expert multi-criteria assessment	14
43	Comparison of Project cost	14
44	Inviting and absorbing entry to community center	14
45	Community meeting halls Interconvertible into resilience wards.	14
46	Voids aiding stack effect and interactive balconies	14
47	Breathing facade with balconies oriented wrt sun path	14
48	Community meetings utilized as dwellings in resilience using foldable beds	16
49	Different Typologies of Modules	17
50	Rainwater Harvesting System	18
51	Eco-Sewage Treatment Plant (Eco-STP)	18
52	Underground runoff water treatment	18
53	Foul Smell prevention	18
54	Groundwater run-off area	
55	Column Plinth Detail	
56	Pile Cap - Micropile Detail	
57	Staircase Detail	

<b>List of Figures</b>		
Figure no.	Figure Title	Page no.
58	Fig.no.58 : Foul Smell prevention	12
59	Fig.no.59.: application interface	12
60	Fig.no.59.: application interface	12
61	Seasonal Flooding as a major problem for the city	14
62	Crowded locality of Koliwada	14
63	Modular approach makes it easy to construct and to maintain.	14

## Executive Summary

Team Stellar from Rachna Sansad Academy of Architecture, aims to strengthen the disaster response of the city of Mumbai by introducing easy to build, cost effective community resilience shelters near various disaster prone zones as demarcated by the city civic authority. The project is named VIHAAN, which means sunrise in hindi, referring to the beginning of new age sustainable housing.

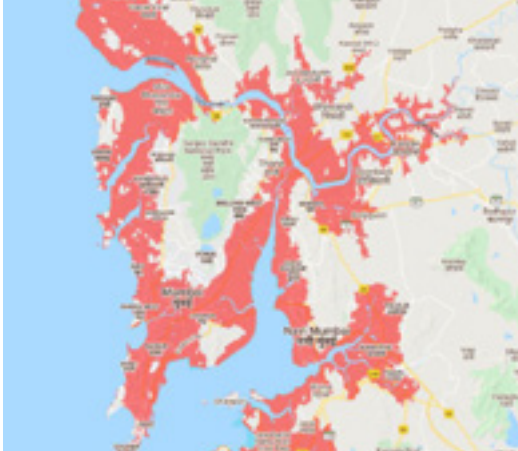


Figure 1. Flooding prediction by 2050

Mumbai, initially a group of 7 islands, developed into a city by reclaiming major portions of water bodies around these 7 islands. With the rapid industrialisation and development, the carbon emissions are increasing at a much faster rates than predicted. This thus has led to increasing annual temperature and increase in main sea levels. Mumbai, predominantly surrounded by sea on its sides and ravaged with periodic flash floods, is at a risk of submerging owing to this rise in sea levels. The following map is a prediction of areas of mumbai under sea level by 2050.(fig.1)

The now inevitable looking disaster poses a major challenge for the city and its ever growing population. In order to prepare for this future disaster, we had looked at different existing resilience shelters in the city. These basically comprise of schools, colleges and other public offices. So the idea was to introduce such shelters throughout the city near vulnerable locations such that they complement the existing disaster resilient shelters.

We approached the G South Ward office regarding the same issue and proposed the idea of collaborating on such vulnerable spots within the wards which can then be replicated in the rest of the city.

For the project, we narrowed down to the locality of Worli Koliwada and chose the bus station of Worli Gaon as our site. The main reason behind the same was to make these shelters more easily approachable and near the Koliwada so that these shelters are located within reachable distances from the locality. Our team aimed to create a modular structure which can be repeated and modulated depending on different locations within the city, with an integration of all fundamental requirements to survive during tumultuous times with efficient functioning wherein the modules acts as a community resource during the rest of the times, helps preparing community in for upcoming disasters and try to uplift communities social and economic life. The ease and speed of construction was also emphasized so that these shelters can be built within a short time frame .

To incorporate that, the use of shipping containers as modules was finalised. Shipping containers are stackable construction elements, being able to reduce the construction time, cost, and waste. The existing studies stated that the reuse of containers for buildings results into a significant decrease in embodied energy when compared with conventional buildings. Since these shelters should be able to work during extreme conditions, we aim to generate energy required for the bare minimum functioning of the centre by taking advantage of wind speeds available. Thus making the building self sufficient in all respects.

**Team STELLAR** consists of a total of 14 students from 5 different institutions. Rachana Sansad's Academy of Architecture is the leading Institution. Team has 10 members from Academy of Architecture, 3 engineering students from different departments and one post graduating student. Team has been lead by faculty Ar. Shekoba Sanap, working as assistant professor at Academy of Architecture. We have organised ourselves in 4 flexible groups, each consisting of 2 people. Working in groups of 2 helped us communicating better in these virtual designing process.

### Our Faculty Guide :



**Ar. Rohit Shinkre**  
Architect ,urbanist  
I/C Principal  
Academy of Architecture



**Ar. Shekoba Sanap**  
Assistant professor  
Academy of Architecture



**Ar. Milind Amle**  
Assistant professor  
Academy of Architecture



**Ar. Prerna Thacker**  
Assistant professor  
Academy of Architecture

### Our Team Members :



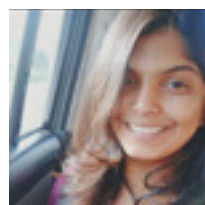
**Utkarsha Mali**  
Team leader  
Pursuing B. Arch



**Hinal Solanki**  
Water Performance  
Pursuing B. Arch



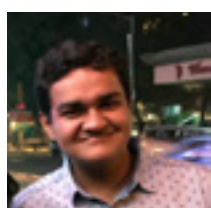
**Tanvi Pimple**  
Architectural design  
Pursuing B. Arch



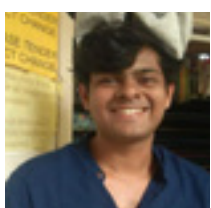
**Shruti Bhat**  
Structural Design  
Pursuing B. Arch



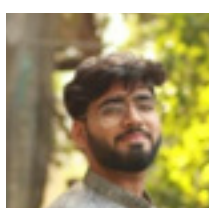
**Madhura Karad**  
Interior Design  
Pursuing B. Arch



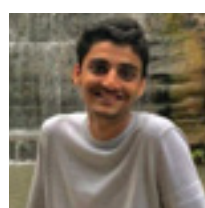
**Manav Sharma**  
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Management  
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**Varun Upadhye**  
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**Manan Seth**  
Structural Design  
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**Shreya Tenge**  
Representation  
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**Harsh Suvarna**  
Lighting and Appliances  
Pursuing B.E. Instrumentation



**Arnav Patil**  
Structural Design  
Pursuing B.E. Civil



**Steve Rodrigo**  
Energy Performance  
Pursuing B.E. Mechanical



**Minal Gajjar**  
Landscape design  
Pursuing M.Arch(Landscape)

## Project Introduction

**Project Name :** Vihaan

**Project Partner:**

G South Ward office , which comes under The Municipal Corporation of Greater Mumbai (MCGM ), are the caretaking body of the G South ward of Mumbai.



**Industrial Partners:**

**Trans Fabcon Projects limited** is a private organisation situated in Mumbai that deals with manufacture and selling of shipping container units which can be used for accommodation. The company will be aiding us by providing information regarding shipping container architecture.



**Malati Fine Chemicals** is a private limited company situated in pune that deals with manufacturing/selling of photocatalytic chemicals with various applications. The company will be aiding us by providing information Titancat and its effectiveness on controlling pollution.



## Site & Context

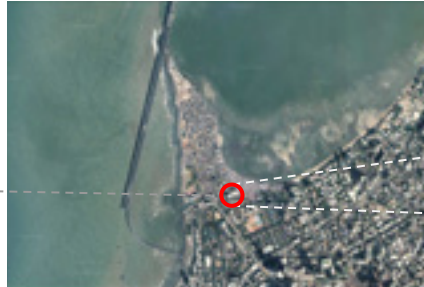
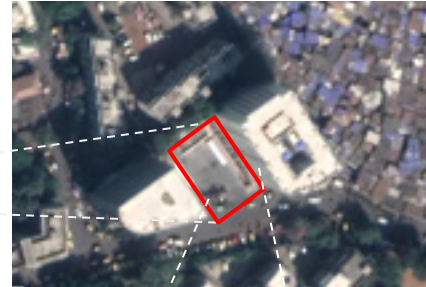


Figure 2 Worli bus depot location



Mumbai, located at  $19.0760^{\circ}$  N,  $72.8777^{\circ}$  having an average elevation of 14m. The site is located in Koliwada near xyc junction, covered by residential buildings and slums on the upper areas. The surrounding areas include mainly markets, gardens, residential buildings and the famous Bandra-Worli sea link.



Given below are the aspects of the site :

Figure 3. Design Site: Worli bus depot

- Currently the site acts as a BEST office ( as a primary function)
- A junction that becomes the central point of the circulation.
- Temples, churches and Masjids in the vicinity.
- The presence of open spaces, like worli sports club, Garden police camp
- Presence of huge scaled buildings facing the road.
- The site being a major landmark for all the users and has direct access to VB Worlikar Marg.

The site lies in the central part of adarsh nagar, koliwada. The basic necessities and amenities of the occupants residing there are hospitals, gym, spa, banks, parks restaurants and food stalls located near 0.5 km radius. The street is lined up with commercial spaces, residential buildings and koliwada communities.

- Bus Depo: 0 km
- Taxi stand :0.30 km
- Metro :1.5 km
- Prabhadevi :2.9 km
- Dadar : 3.3 km

Site Area - 848 sqm  
Latitude:  $19.00^{\circ}$ N  
Longitude:  $72.815^{\circ}$ E

Mumbai has been including the dense typography of built components. Extreme densities can intensify traffic congestion and air pollution, leading to degraded quality of life. High density growth can also lead to reduction in urban greenery thereby causing urban heat island effect requiring higher air conditioning related energy cost as well as increased water runoff due to lesser permeable spaces. High density can also decrease daylighting and natural ventilation leading to higher artificial lighting and mechanical ventilation.

## Project Highlights

### Energy Performance

To achieve energy performance with EPI 53.4 kWh/sqm/year without compromising thermal comfort by optimising mixed mode ventilation

### Reducing electrical consumption

Using Energy Efficient Appliances and providing adequate passive cooling strategies in order to minimise the use of heating and cooling devices and take maximum advantage of the natural climatic conditions that the site offers.

### Thermal Comfort and indoor quality

To increase range of thermal comfort using natural ventilation and mechanical ventilation in few unavoidable spaces like clinic and maintain indoor air quality to meet WHO standards.

### Water Performance

All grey water should be collected and reused on site and limiting use of external water supply, ensuring maximum utilization of on site resources.

### Resilience

Resilience is achieved through utilizing structural strength of shipping containers along with customized connections to withstand diagnosed disasters.

### Affordability and Durability

The project has been aimed for lower middle class targeted end user, considering long lasting functionality which adds values of the socio cultural aspects of koliwada.

### Innovation

Effective use of shipping containers by stacking it upto 6 floors with minimum additional framework and using passive techniques to minimize solar heat gain. A common management platform is integrated with the new disaster management app.

### Scalability

The project aims at being flexible through its approach of modularity, allowing environmental stability through it's dual behaviour, before, during and after disaster.

### Efficient Constructability

The project aims at maintaining the speed and efficiency of construction, by reusing the old containers, furnishing them in factory units, such that, onsite environmental concerns are solved.

## Design Process

The Design Process started with analysing the need of community shelter.

Understanding the Worli koliwada community, with on site discussion and site visits shaped and helped us to study the user profile, community needs and site conditions. Site visits proved to be extremely useful as we gathered maximum information and studied the site from the users' eyes.



Figure No 4. :On site discussion with the community members

Team Discussions were held thrice a week which were major brainstorming sessions. 'ConceptBoard', 'Zoom' and 'Google Meet' proved to be a valuable asset for group discussion and coordination during pandemic of Covid-19 .

Having an approach for quick buildable resilient shelter with its durability during disasters, marine shipping containers understanding of construction technique and usage was understood by the visit our industrial partner, Nikhil Dalmia



Figure No 5. : site visit and On site discussion with the industrial partner

## Tools, Code and Standards Used for Design Process

Sr No.	Description	Tools/ Codes/Standards Used
1	Simulations	1.Ladybug honeybee. 2.Climate studio
2	Climate analysis	1.Ladybug honeybee ( Sun Hour,Radiation) 2.Andrew marsh Dynamic Overshadowing 3.PVGIS (Solar panel stimulation)
3	Thermal comfort	1.IMAC Assistant(India Model For Adaptive Thermal Comfort Tool Assistant  2.ANSI/ASHRAE Standard 55-2010
4	Structural system	National Building Code(NBC) for India 2016

Table No 1: Tools codes and standards used

## Optimization approach

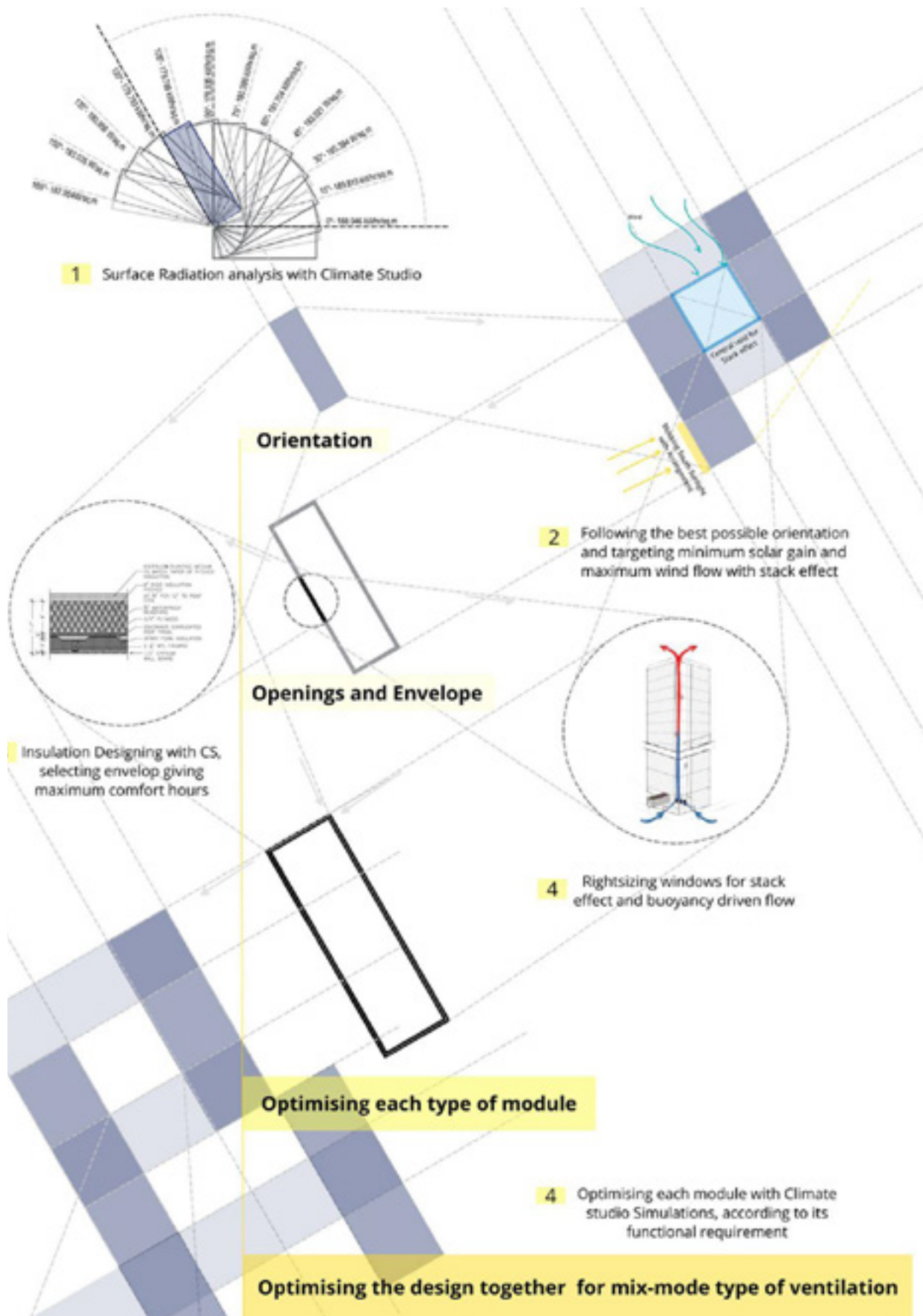


Figure No 6. : Optimization approach and process

## Pre Design Analysis

Before starting designing, we used ladybug simulation tool to find the possible build orientation along the site and Andrew marsh tool to analysis the shadow coverage on the site. Throughout the designing ,we used this software along with Climate Studio to evaluate, optimise and estimate the energy performance.

### Andrew marsh dynamic shadow analysis :

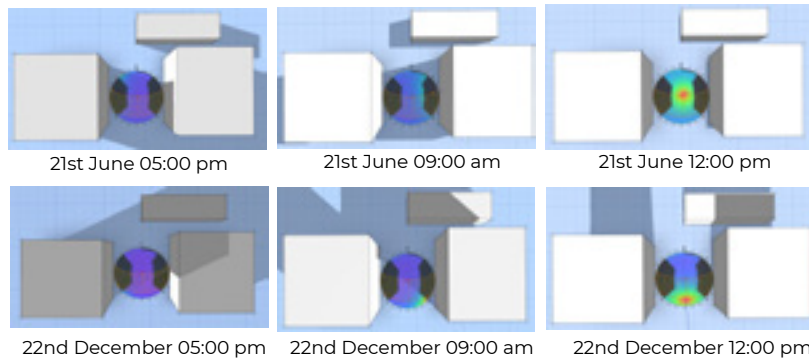


Figure no. 7. :Andrew marsh dynamic shadow Diagrams

We did the andrew marsh dynamic shadow analysis in order to understand shadow mask coverage annually on site due to the adjoining built on both sides of the site, which lead us to orient the Resilient shelter and find the hour of direct sunlight.

### Shoebbox analysis :

We did radiation analysis in order to understand the basic orientation and character of the building. The degree of orientation from east as per the site constraints, feasible option of the building degree of 0,30,90,120 was identified with minimum radiation. Minimum radiation was the governing factor along with the direction of the wind flow, which lead to the selection of appropriate building orientation.

Model				
Orientation from east (in degree)	0	30	90	120
Radiation(W/m <sup>2</sup> )	188	280	104	179

Table No. 2 : Radiation analysis

After the initial analysis was done, it was clear that the most suitable geometry was 90 degree but due to the site parameters and neighbouring built, 120 degree was the appropriate building orientation with minimum radiation which was then selected for further designing.

## Design Approach

Our design approach of vihaan disaster resilience shelter is rooted to provide a community space for the worli koliwada community along with it being efficient in disaster time to sustain this community needs and help to bind people creating a natural environment .Our innovation is in easy and quick build of community center using old marine shipping containers with durability which will be self sufficient, will give comfortable and healthier environment to community while minimizing energy use. The design approach brings together user preference in form the community behavior ,comfort disaster resilient with architectural integrity in form of detailing ,material selection,high durability and affordability .

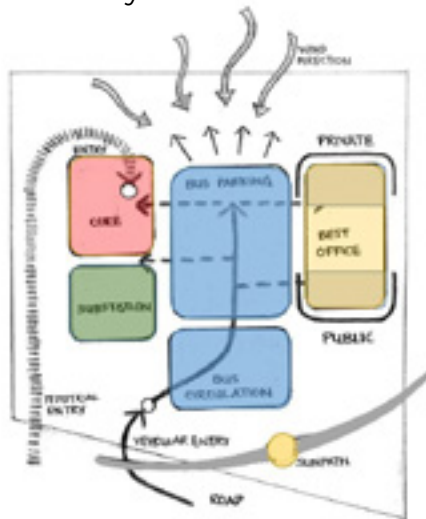


Figure No. 8 : Conceptual zoning and circulation of spaces



Figure No. 9: Sectional zoning with sun and wind direction

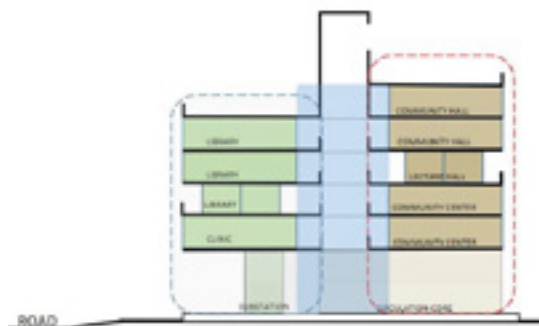


Figure No. 10 : Sectional zoning with space division

The constraints of the site are its orientation, longer north-south axis, and the setbacks along east and west due to existing build which overcast the shadow over the site.

Preliminary energy and orientation analysis gave us the angle of 120 degree from the east provide us large area to build according to the codes.

We have provided 2 entries :

community entries (pedestrian) and the entry for the bus (vehicular) for the efficient functioning of the shelter during the disaster

On the upper levels the function of spaces like clinic,library are oriented along the north side of site exposed to the sunlight as this function are light driven workspaces and requires an isolated yet visible space to the user from the road site elevation.

The function of community driven spaces are to the south of site where there is the natural wind direction coming from as these spaces are community halls ,lecture rooms were the density of people coming are more also these spaces as large voids to pass the wind and take away the foul air through the process of stalk effect creating the positive and negative pressure to drive the wind.The window openings are designed to take the advantage of the prevailing winds from the south east and south west direction throughout the year This allows the building to be operated in mix-mode system of ventilation.

We designed the a building form and spaces that uses 2 building block(private spaces and public-community spaces)arrangement connected by the circulation and transition spaces(staircases)

## Ground floor architectural layout



Community entry



Canteen



BEST office and canteen







## Thermal Comfort

Mumbai comes under hot and humid climatic zone. Adaptive chart for Mumbai shows that for around 2500 hours in a year, the building can function with natural ventilation along with maintaining thermal comfort. Whereas when we see adaptive chart for Koliwada bus depot site, for around 3751 hours in a year, building can function with natural ventilation. This is because of high rise context on north-east and south-west side and trees on north west side, site receives sunlight for average 4 hours a day.

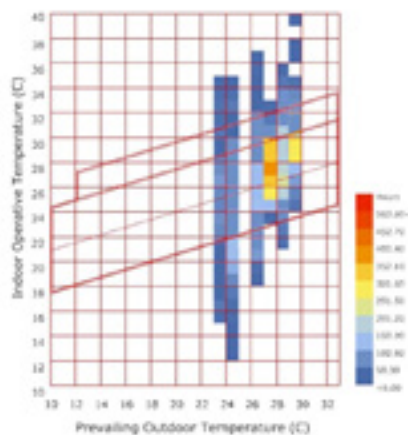


Figure 11 Adaptive comfort chart for Mumbai  
(Source:Self)

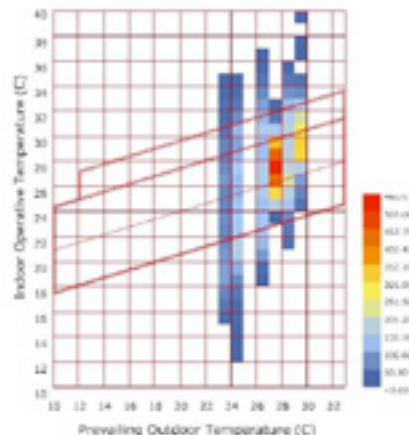


Figure 12. Adaptive comfort chart For Worli Koliwada Site  
(Source:Self)

According to NBC, for hot and humid zones, high wind speeds are desirable for achieving thermal comfort conditions at different temperatures and relative humidities. The site receives wind speeds more than 2m/s for more than 7500 hours in a year.

**Table 9 Desirable Wind Speeds (m/s) for Thermal Comfort Conditions**  
(Clause 5.2.3.1.2)

Sl. No.	Dry Bulb Temperature °C	Relative Humidity Percent							
		30	40	50	60	70	80	90	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
i)	28								
ii)	29						0.06	0.19	
iii)	30					0.06	0.24	0.53	0.85
iv)	31		0.06	0.24	0.53	1.04	1.47	2.10	
v)	32	0.20	0.46	0.94	1.59	2.26	3.04		
vi)	33	0.77	1.36	2.12	3.00				
vii)	34	1.85	2.72						
viii)	35	3.20							

Figure 13. Desirable wind speeds (m/s) for thermal comfort conditions  
(Source:NBC for India 2016)

Introducing stack effect increases the wind speeds and hence helps in broadening comfort hours band. The window sizes have been designed considering the maximum average outdoor temp 35°C so that the indoor temperature has been brought down to 32°C and humidity to 60% without using fans. By using fans indoor temperatures have been brought down to the range of 29°C to 31°C which is considered comfortable by 90% of people in naturally ventilation mode of operation.

The community resilience is designed for natural ventilation operation with the help of stack effects and fans to provide comfort with bare minimum resources at the time of disaster. As the design is modular, the area of openings have been divided into multiples of one size of modular window opening area which is 1.55m in width and 1.5m in height. Fans in addition help in increasing air speeds by 0.2m/s.

Outside air density (kg/m <sup>3</sup> )	1.2
Outside temperature (°C)	35
Inside Temperature (°C)	27
Outside air velocity (m/s)	2
Discharge Coefficient	0.6
Neutral Pressure Height (m)	16.5

Openings	Opening height	Pressure coefficient	Flow Rate	Pressure difference	Area of Opening
	m		m <sup>3</sup> /s	Pa	m <sup>2</sup>
	$z_i$	$C_{p_i}$	$Q$	$\Delta p_i$	$A$
1	5.2	0.25	3.24	-3.0352	2.401
2	8.1	0.25	3.24	-2.1484	2.854
3	11	0.25	3.24	-1.2617	3.724
4	13.9	0.25	3.24	-0.3750	6.831
5	15.8	0.25	3.24	0.2060	9.217
Outlet	11.5	-0.1	-16.2	-1.9488	15.175

Table No.3 Window calculations for stack effect

According to number of occupants in each function, ventilation rates have been calculated. LeVCaVIR design guide has been used to calculate opening areas for buoyancy driven ventilation in modules like clinic where cross ventilation cannot be given.

Space type	No. of occupant	$R_p$ (l/s.person)	Floor Area ( $m^2$ )	$R_a$ (l/s. $m^2$ )	Ventilation rate (l/s)
Office	6	2.5	14.86	0.3	19.458
Canteen	10	3.8	29.72	0.9	64.748
Assembly	70	2.5	72.67	0.3	196.801
Library	60	2.5	161.83	0.6	247.098
Lecture rooms	50	3.8	29.72	0.3	198.9

Table no. 4 . Ventilation rate calculations

For air purification, portable PM400 Miracle Air™HEPA filter is used. The PM400 maximizes the amount air flowing through the large HEPA filter while maintaining an optimal air-to-cloth ratio for best filter life. The operating parameters of this module are: 0-50°C, and (20-90)% relative humidity .Its Multiple units can be used for larger areas. Portable HEPA filter systems have been shown to be another effective tool in reducing viral load. PM400 uses proven hospital grade HEPA filtration to remove potentially harmful microscopic particles. Therefore, there are no ozone emission concerns such as those found in some ionizing units.

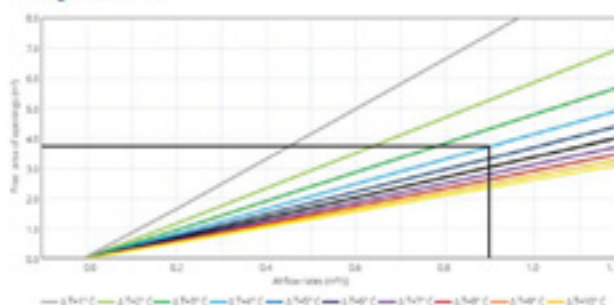


Figure 14. Buoyancy flow driven windows of clinic with multiple openings using LeVCaVIR

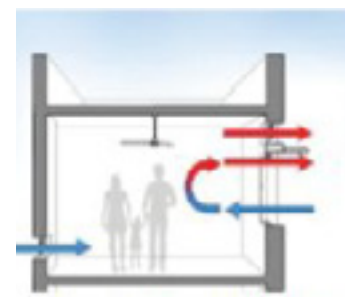


Figure 15 Miracle Air HEPA Home, Office, School Air Cleaner

Months	Min.Temp	Max Temp.	Humidity	Precipitation (mm)	Acceptability range	Ventilated	Set points for mix mode
January	18.8	29.4	58%	0	90%	24.12 - 28.88	21.50 - 28.42
February	19.6	30.2	59%	1	90%	24.13 - 8.89	21.50 - 28.42
March	21.7	32	60%	0	90%	24.50 - 29.26	21.70 - 28.62
April	24	32.8	68%	0	90%	25.34 - 30.10	22.13 - 29.05
May	26.2	32.4	72%	27	90%	26.37 - 31.13	22.66 - 29.58
June	25.9	29.5	83%	487	90%	26.52 - 31.28	22.74 - 29.66
July	24.9	27.3	89%	661	90%	25.95 - 30.71	22.44 - 29.36
August	24.5	27.2	89%	459	90%	25.4 - 30.22	22.20 - 29.12
September	24.4	28.2	86%	300	90%	25.48 - 30.24	22.20 - 29.12
October	24	31	74%	66	90%	25.63 - 30.39	22.28 - 29.20
November	22.4	31.8	60%	6	90%	25.45 - 30.21	22.19 - 29.11
December	20.1	30.5	57%	5	90%	24.56 - 29.32	21.73 - 28.65

Table no. 5 Acceptability range and references for Set points using IMAC assistant tool

## Energy Performance

To understand basic configuration in terms of energy requirements, we simulated a single shipping container using parametric design analysis tool. That helped us giving first insights of total discomfort hours in unmodified shipping container along with energy requirements to maintain thermal comfort in a closed container. Total number of discomfort hours were very high, 8350 out of 8760 hours.

To reduce down those hours, we then simulated the same model considering 3 sets of wall to window ratio, 1:10, 1:20 and 1:30, taking single glazed metal framed window on shorter side of container keeping in mind the structural stability of it. Hollow-core plywood (2.2 × 1 m) door is taken.



Figure 17. Adaptive comfort chart for Mumbai  
(Source:Self)

WWR ratio of 1:30 gives 7103 discomfort hours. The same module was then used to decide the insulation materials. Out of 6 types of insulations, 2 with best performances were shortlisted, closed cellular spray foam (ccSPF) and cellulose. Cellulose with less carbon footprint was then finalised as insulation material for roof, walls and then the rest simulations were carried out as described in table below. Out of the two sets, set 3 with performance slightly less than set 2 was finalised considering cost factor.

	Set1	Set 2	Set 3
Description	Unmodified	Shipping container with Internal Insulation ccSPF	Shipping container with PUF insulations
Walls	2 mm corrugated corten steel sheets	2 mm corrugated corten steel sheets, internally insulated with 100 mm medium-density ccSPF, covered with 12mm acoustic panel	2 mm corrugated corten steel sheets, Internal PUF insulation 100mm with galvanized steel studs, Particle Medium board 25mm, Gypsum board 30mm
Roof	2 mm corrugated corten steel sheets	2 mm corrugated corten steel sheets, internally insulated with 100 mm medium-density ccSPF, covered with 12mm acoustic Panel	2 mm corrugated corten steel sheets, Internal PUF insulation 150 mm with galvanized steel studs, Particle Medium board 25mm, Gypsum board 30mm+ Green roof
Floor	28 mm marine-grade plywood floor on steel cross member	28 mm marine-grade plywood floor on steel cross member with 12mm Acoustic tile	28 mm marine-grade plywood floor on steel cross member with 12mm vinyl tile
Discomfort Hours	7103	3954	4125
Cost	100000	135000	122000
Thermal lag(hours)	0.023	4.5	6.2
EPI	79	33	35
Performance	Worst	Temperate	Best

Table No. 6 :Material selection

Insulation	U-value ( W/m2K)	EE (MJ/kg)	EC (Kg CO2eq/kg)
PUF	0.18	88.7	2.34
ccSPF	0.16	101.5	3.48

Table No. 7 Selection of Insulation  
(Source:Self)

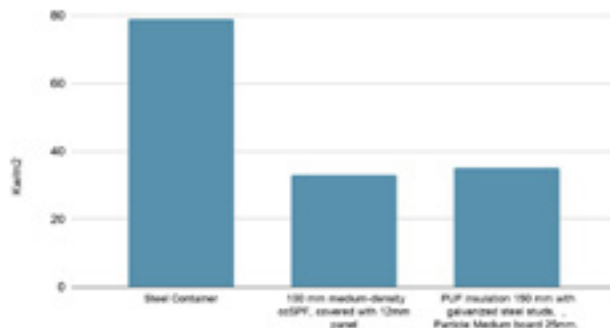


Figure 18. Optimization of single container

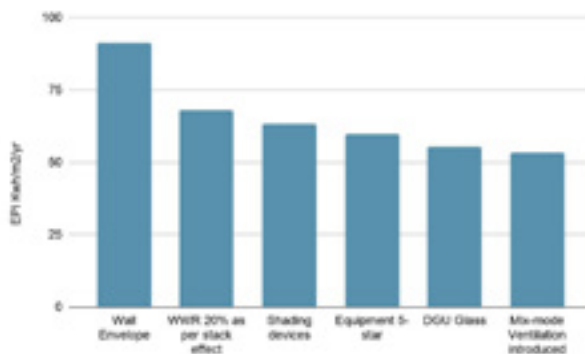


Figure 19. Optimization of entire design

The EPI simulated using climate studio energy simulations for 3rd finalised set of envelop came out to be 63.1 kwh/m2/year. For that the wall window ratio was taken as per the calculations for stack effect (refer figure 11) .

For this simulations, HVAC system used was Split Acs with central VRF systems of 1 ton at required spaces without any compressor. Also this set was simulated without fins, chajja .

In order to reduce down the energy consumption, chajja and fins were designed in set 4 in addition to the set 3 requirements as explained further.

The EPI simulated using climate studio energy simulations for 3rd finalised set of envelop came out to be 63.1 kwh/m2/year. For that the wall window ratio was taken as per the calculations for stack effect (refer figure 11) . Simulations varied by 4.2 kW/sqm/hour than the calculated set of consumption which was 67.2 kWh/m2/year. For this simulations, HVAC system used was window ACs at required spaces without any compressor. Also this set was simulated without fins, chajja .

In order to reduce down the energy consumption, chajja and fins were designed in set 4 in addition to the set 3 requirements as explained further. 4th set was then simulated using climate studio parametric simulation tool for set3+ parametrically designed modular fins + Chajja calculations with andrew marsh . The EPI for set 4 came out to be 56.257kWh/m2/year which was 6.85kWh/m2/year less than that of set 3.

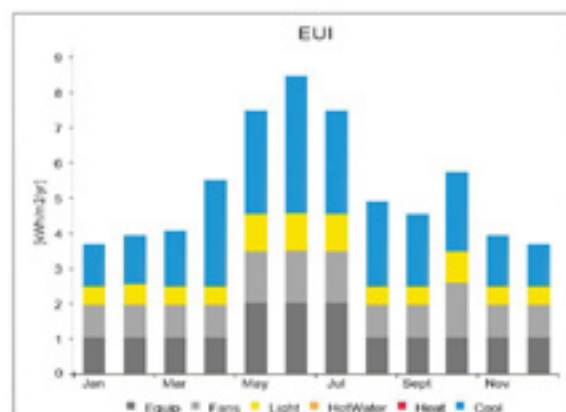


Figure 20 Final -EPI achieved- 53.4 kwh/m2/year

## Use of Wind Turbines

Mumbai comes under warm and humid climate zone, along with great air speeds because of the sea. The chart in figure no. 1 shows that for more than 60% of the year, wind speeds are above 2m/s. Also in monsoons, when the shelter will be full of occupants and interrupted electricity supply, greater wind speeds are available. Start up speeds required for micro wind turbines are in the range of 2m to 2.4m which are available on site at majority times. More or less same for entire Mumbai giving average wind speeds of 4.6m/s. Hence we decided to use micro wind turbines on the roof of our design.

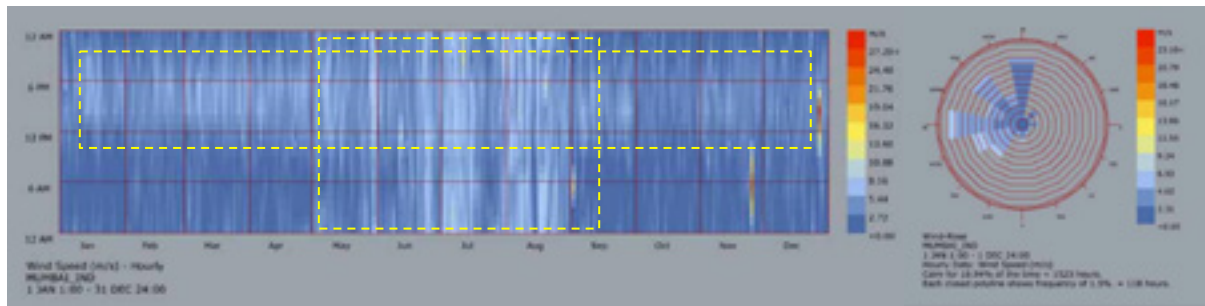


Figure 21. Wind speeds at site at the height of 12m above ground (Source: Self)

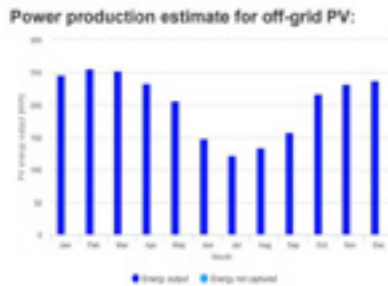


Figure 22. Power production estimates for off grid PV for Mumbai (Source: PVGIS-European Commission)

### Monthly average performance

Month	E <sub>d</sub>	E <sub>i</sub>	f <sub>f</sub>	f <sub>e</sub>
January	244.8	0.2	0.3	98.9
February	256.0	0.0	0.0	100.0
March	252.7	0.0	0.0	100.0
April	231.9	0.0	0.0	100.0
May	206.3	0.0	0.0	100.0
June	147.5	0.0	0.0	100.0
July	121.7	0.0	0.0	100.0
August	132.8	0.0	0.0	100.0
September	157.8	0.0	0.0	100.0
October	216.1	0.0	0.0	100.0
November	231.8	0.0	0.0	100.0
December	236.8	0.0	0.0	100.0

E<sub>d</sub>: Average energy production per day [Wh/day]  
 E<sub>i</sub>: Average energy not captured per day [Wh/day]  
 f<sub>f</sub>: percentage of days when battery became full [%]  
 f<sub>e</sub>: percentage of days when battery became empty [%]

Table 8. Monthly average performance for off grid PV for Mumbai (Source: PVGIS-European Commission)

In order to generate on site electricity, we researched on the renewable sources of electricity. Since the site is near the sea, cut in wind speeds required for the Wind turbines are easily achieved. The structure is able to generate approximately **17520 Kwh / Year** by using wind turbines. PV panels for solar energy were found out to generate quite less energy as compared to wind. This is because the site is surrounded by two buildings , the shadow of which is casted on our site. Owing to this situation, an effective sunlight of approximately only 4 hrs is available on the terrace. Thus , wind energy would be the most efficient renewable energy source for the resilient structure.

WIND TURBINE SPECIFICATIONS ( by KVIANT GARDE INNOVATIONS)	
MODEL	AVATAR™-4
CAPACITY	3 kw equivalent, Multi Phase, Multi voltage System,
MAKE AND MODEL	AVATAR™-4
SYSTEM VOLTAGES	48V, 230V
AXIS	Horizontal
PEAK POWER	3000W
STARTUP WIND SPEED	17 m/s
CUT IN WIND SPEED	2.3 m/s
SURVIVAL WIND SPEED	60 m/s
DAILY WIND AT 5.5 m/s	15 kWh
BLADE MATERIAL AND NO. OF BLADES	FIBER Material & Three Blades
ROTOR DIAMETER	16 feet
GENERATOR	Brush Less, Gear Less (PMG) with high performance Neodymium Magnets
DRIVE SYSTEM	Direct Drive
CONNECTION OF GENERATOR	50v: ring, less
TURBINE WEIGHT	90 KG Approx.
VOLTAGE CONTROLLER	Auto Electronics
SOUND	Not more than 10 % of the wind speed at foundation level
OVER SPEED PROTECTION	Dump switch manual and Auto Putting Tail
WARRANTY	2 Years
OPERATION LIFE	20 Years

Table No. 9 : Specification of Wind Turbines  
 Source: self



Figure 24. Section showing position of wind turbines in design

The horizontal axis wind turbine (HAWT) whose rotor rotational axis is parallel to the ground and wind stream has been used. Wind Turbines are attached to the pedestals provided by vendors itself. There are 8 wind turbines placed which are held in position by 4mm dia GI rope wires and a pedestal of 5ft\*5ft attached to the roof slab.

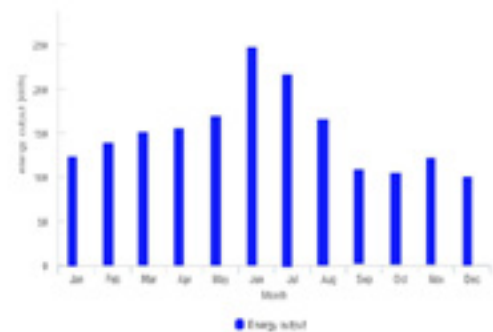


Figure 23.. Renewable energy generation per month With wind turbines

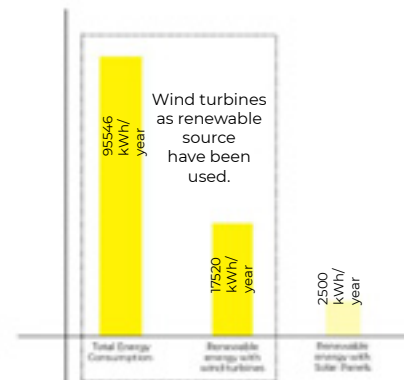


Figure 25.. Energy Consumption and energy generation per year

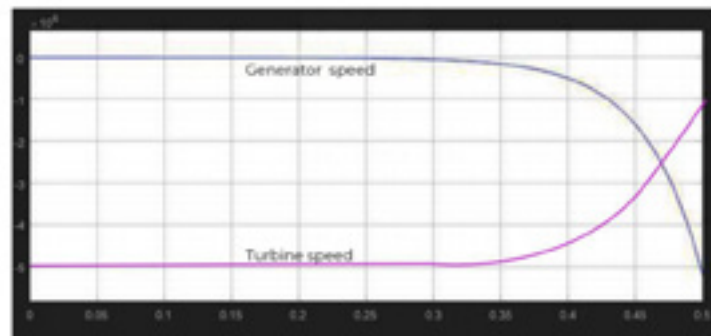


Figure 26.. Generator speed and turbine speed using simulations

The turbine speed starts increasing gradually as the system generates power, it moves in the positive direction. The higher the speed, the more power that will be generated. Hence the generator speed is proportional to the turbine speed. The speed from the wind is not sufficient to move the turbine blades until around 0.2 s when the speed starts progressing gradually, leading to a proportional decrease in generator speed. The turbine generates fluctuating values of electrical power peaking at about 79 W at 0.25 s in the simulation. These results are gotten at rated wind speed of 2.9 m/s and zero pitch angle.

Parameter s	Air density ( $\rho$ )	Gear ratio ( $n$ )	Aerodynamic coefficients $c1-c6$	Damping ( $D$ )	Stiffness ( $K$ )	Rotor inertia ( $H_m$ )	Generator inertia ( $H_g$ )	Pitch angle	Stator resistance ( $X_s$ )
Value	1.225 kg/m <sup>3</sup>	65.27	$c1 = 0.5176, c2 = 116, c3 = 0.4, c4 = 5, c5 = 21, c6 = 0.0068$	1.00E+06	6.00E+07	1.60E+06	35.184	0	0.0121

Table No.10. Input parameters for Simulation

## Resilience

### Redundancy

After their primary use, the dimensions of various shipping containers, allows to maintain structural integrity.

### Resourcefulness

The unused containers after shipping become an asset for construction industry.

### Reformability

The amenities of electricity, communication, water are provided such that even if one of the module is replaced, it will still work with integrity.

### Recoverability

It's flexibility allows it to assemble and disassemble easily, allowing easy recoverability.

### Rapidity

In terms of construction, most of the work is completed in factories, it helps in simultaneous construction onsite.

### Prevention and mitigation

The structure prevents disasters by elements such as raised plinth, cross bracings.

### Preparedness

The design includes aspects that increase interaction through courtyards such that users can stay prepared during disasters.

### Disaster

The team has come up with an App that keeps the users updated with the required things during the disaster.

### Response

The programme contains dual benefit of using the space with folding furniture such that users will be able to stay during the disasters.

### Rehabilitation and recovery

The modules being flexible, can be easily dismantled.

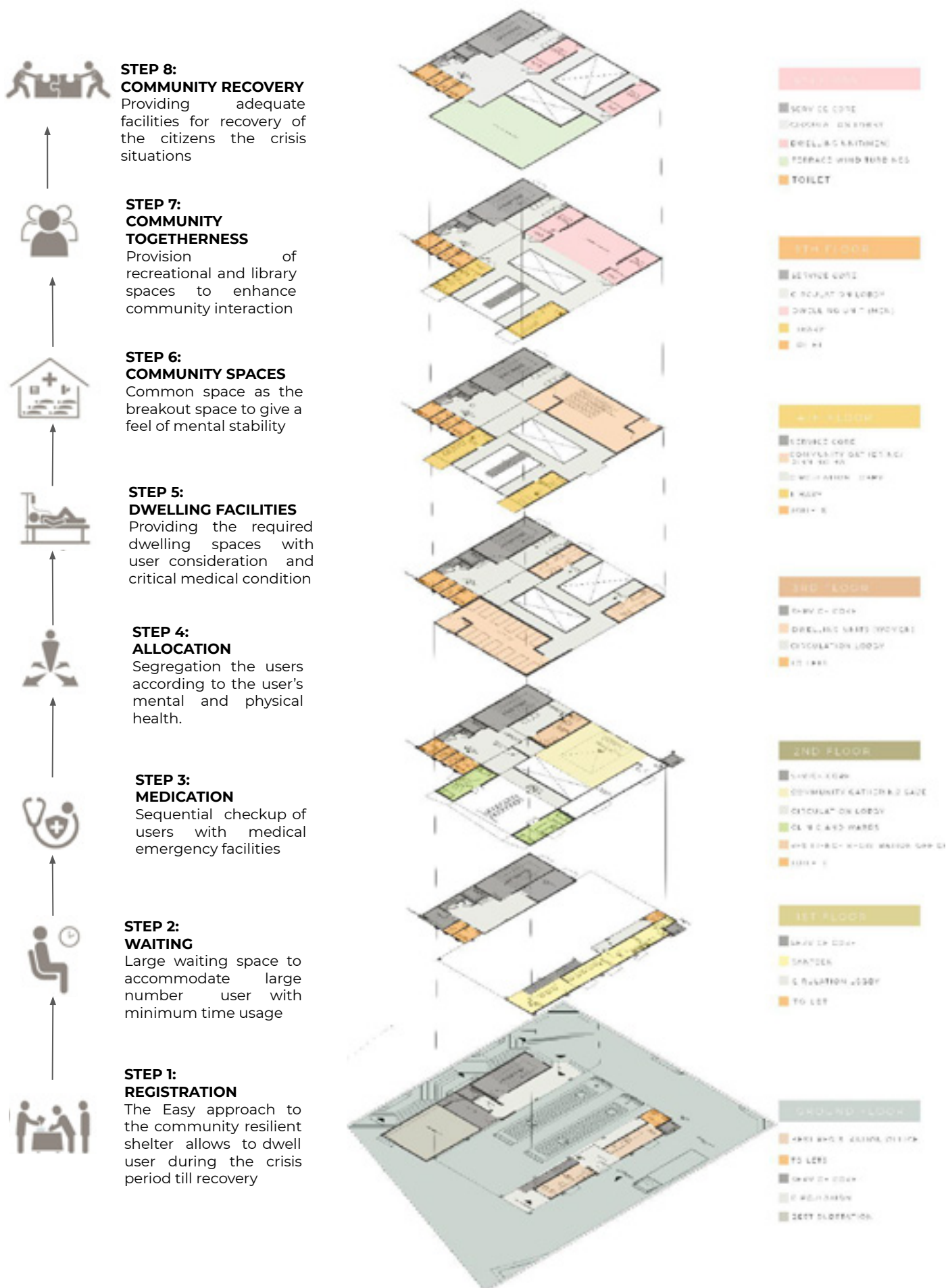


Figure 27..isometric plan zoning at each floor

## Resilience of the structure to tackle the disaster

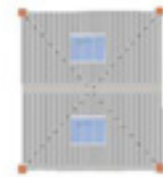
The community resilience shelter is design to aim for the maximum protection provide to the make the build habitable during the crisis period and emergency. Use of shipping container as the build material helps to provide the resistance against the wind loads and earthquake magnitude to maintains its structural integrity under this conditions.

Use of addition design strategie also make it more resistant in adverse climate and crises condition.



### Roof and wall insulation

The insulation layer within the container help to keep the heat out and provide a comfortable temperature within every module thus reducing the electric loads



### Structural framing

The structural corrugation of shipping container are itself resistant to heavy loads, providing a cross bracing system, anchor and allows free movement of connection to make it act like one unit of build making it more stable during natural disaster



### South facade skin

Modular designed Fins along the south facade of build deals with the harsh sunlight penetration making more comfortable within the build spaces



### Heat barrier Wrapping

The opening for the light and ventilation are heat barriers by incorporating the glass which are heat barriers

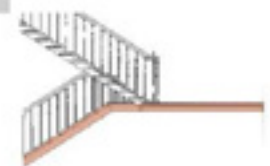


Figure 28..Structural Resilience in team of construction.



### Elevated plinth

Elevated plinth above the high tide level during floods can also house essential service equipments which will never get damaged by floodwater



### Staircase mid landing refuge

The extended midlaning of staircase allows large capacity of user to accommodate and ease out he the circulation

## Innovation

The base of our principles is modular architecture, where beauty meets efficiency, where standardisation meets customisation, is a modular system that is characterised by functional partitioning into discrete scalable and reusable modules, rigorous use of well defined modular interfaces making use of industry standard interfaces.

Strategies that are aimed for reducing energy consumption and maximising energy generation are as follows:

The objective here, is to capture the imagination of the end target users through a mix of innovative use of technology and Indian socio cultural elements, it also invites all kinds of users during disasters retaining the value systems and cultures of koliwada. The users adapting the programme flexibly are as follows:

1. Students of Koliwada
2. Families for community gatherings
3. Chefs of koliwada contributing to fish delicacies in the kitchen
4. Fishermen Of koliwada, teaching fishery techniques to the future fishermen

**Needs :** An open space of larger dimensions is the need of the hour as the community gathering spaces of koliwada are quite narrow because of less fsi of the lanes of koliwada.

**Demands:** After having a detailed enquiry from the youth of koliwada we received an enthusiastic response regarding an education hub and a library.

### Ease of operation

The modularity allows ease in terms of assembling and reassembling every system, standardised elements easily repairable and available from the market, the process of fabrication is simple.

### Transportation And Labour Cost

The labour cost has been reduced because of the modularity, but the transportation will be comparatively higher than the labour cost, allowing less maintenance, and lesser time to build.

### Qualitative Approach

Industry agencies are both public and private in order to create confidence in user's purchasing approach. A public entity will guarantee the product is certified.

While a private entity will be able to enhance quality and create a **profitable, yet affordable solution**. The expertise provided by the team here becomes the middle link in the **seller buyer hierarchy** creating a cost effective solution of the prototype.

Innovation

Modular Fins Facade

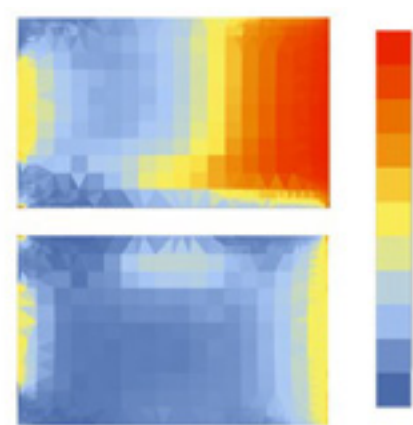


Fig.no 29+ :Radiation meshes of floors Before/After

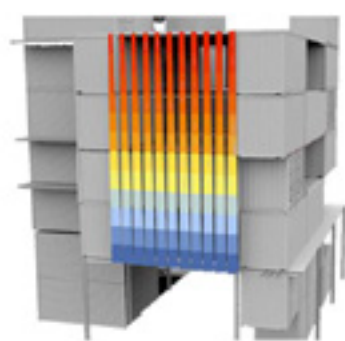


Fig.no. :30 Different Typologies of Modules

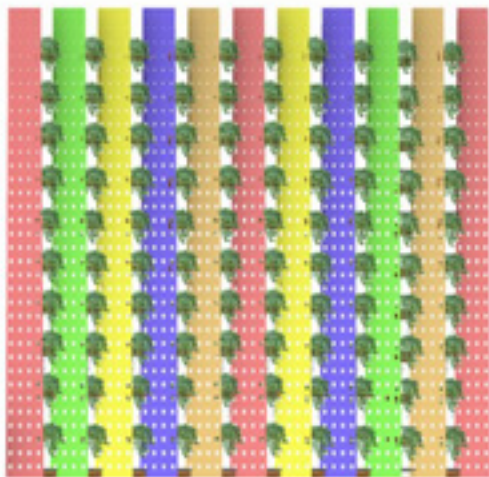


Fig.no. 31.:Different Typologies of Modules

	CO	C <sub>7</sub> H <sub>6</sub>	NO	Toluene
CONVERSION	98%	100%	100%	100%
DEGRADATION EFFICIENCY	3840 µg/m <sup>3</sup> /h	5700 µg/m <sup>3</sup> /h	3100 µg/m <sup>3</sup> /h	23000 µg/m <sup>3</sup> /h

Table no.13. :.Different Typologies of Modules

For the design of shading device (facade), the radiation of floors, amount of daylight and minimum surface area of the material were put as parameters for the optimization of louvres.  
This resulted the total radiation to fall 10% and drop of 4 deg.C at the hottest hour of year.

Louvres end section	ORIENTATION	Radiation Kwm2
DN	160 DEG	28834
UP	67 DEG	

Table no.11 . Optimised louvre orientation

Radiation analysis of the resultant louvres was done to understand the most exposed surfaces. According to which the louvres were added with square openings , with radius inversely proportional to radiation.

R x 1/degrees

Former helped in increasing the daylight amount by 4.3% and also a considerable increase in cross-ventilation was observed. The aluminium louvres are coated with high SRI , Titancat photocatalytic paint. With TiO2 (Titanium dioxide) being a constituent, it reacts with carbonaceous constituents( in fine particulate matter (PM 2.5 & PM10) under UV radiation to form water and carbon dioxide as a byproduct.



Fig.no.32 :Different Typologies of Modules

The louvres are separated by 500 mm gap , with vertical plantation in it, the facade is bio-wall that is self-sufficient , also acts as air filter, and dehumidifier.

As water and carbon dioxide are byproducts of the photocatalytic reaction, the plant used on facade ( English ivy, a hydrophilic plant) is able to use thee by-products which are sufficient for it.

However Super absorbent polymers(SAP) are also mixed with soil to eradicate worst cases of dehydration. SAP is also responsible for decrease in the relative humidity levels by 8%.

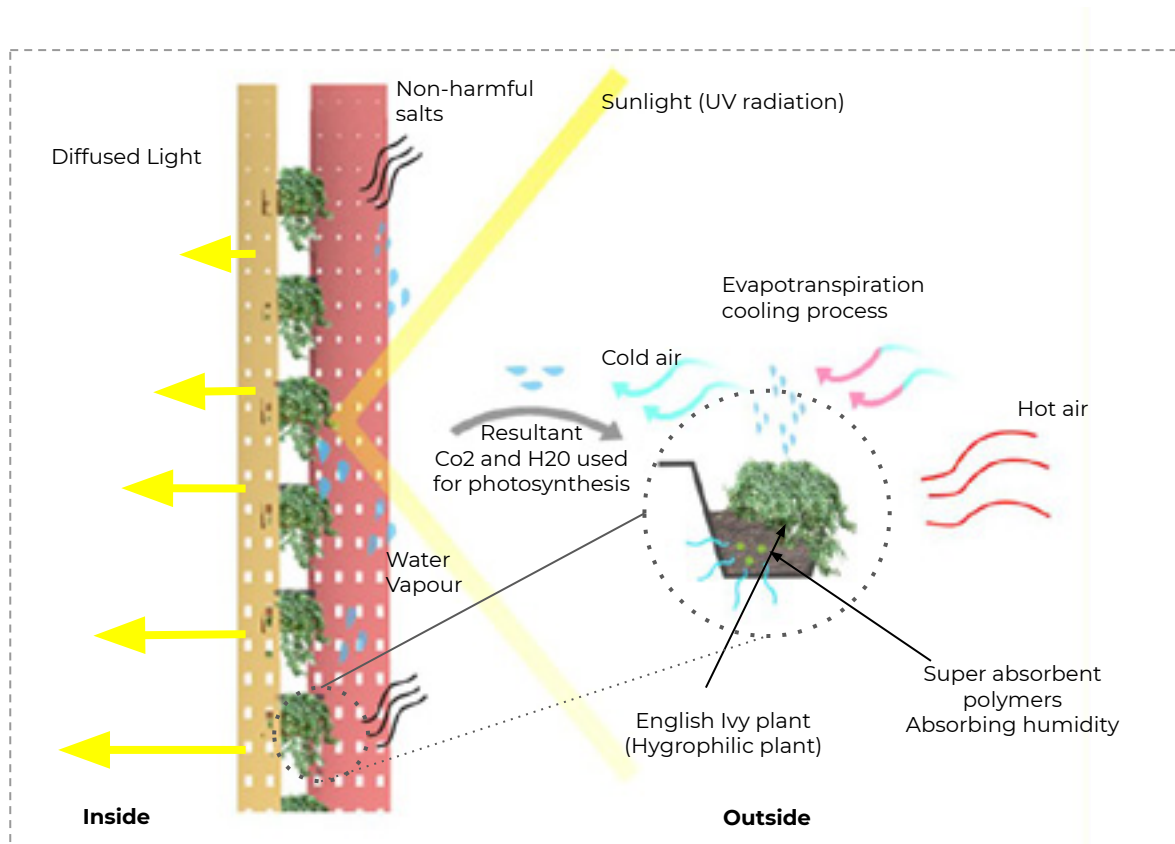


Fig No. 33: Facade treatment

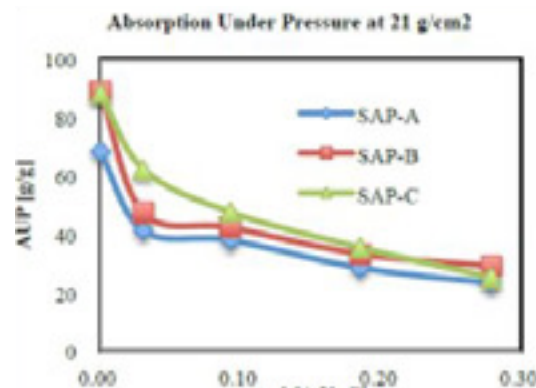


Fig No. 34: absorption under

## Vegetable garden on roof

Vegetable garden is located at the roof which is facing southern side as shown in figure . It is located 18m above the ground level. The higher is the garden, the more likely it will be exposed to wind. Choosing wind-tolerant crops—generally low-growing vegetables such as lettuce and greens, carrots, potatoes, and dwarf bush beans which are commonly used in Indian culinary can be grown on the roof of this resilience shelter . Screens are provided to stifle wind and protect plants. High-walled containers and plants set down in soil that does not fill the container can help limit wind exposure.



This garden will act as food reserve during emergencies as well as it will serve the BEST canteen throughout the year. This vegetable garden also helps in reducing humidity as well as it restricts direct sun radiations on roof thus keeping the lower floors at slightly lower temperature than usuals.

Figure No.35 . Roof Farming - Edibles Vegetables reference image

## Energy-efficiency

It's not only driven by the need to reduce energy bills, but also by growing eco-consciousness and often by necessity. Green roofs isolate the roof from direct exposure to the sun can minimize the need for an energy consuming A/C cooling process. The roof serves as a Sun-Barrier. It's designed as a low maintenance one, planted with horizontally expanding vegetation that eventually will overgrow the roof providing a sort of living sunbrella.

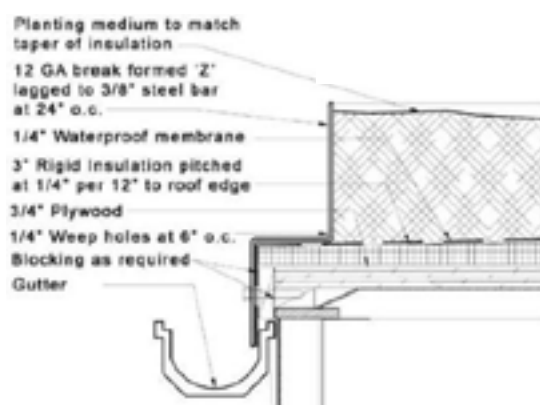


Figure No.36 . Roof Farming Detail



Figure No.37 . Roof Farming - Drop in indoor temperature

## Market Potential

Shipping characterized by the re-use of steel shipping containers as a structural element and Architectural envelope that can host a specific function or a human activity. Shipping containers are known for their low environmental impact in comparison to traditional houses taking also in consideration the short time required to erect a building in this way, with future possibilities of moving these buildings to other locations or adding extra spaces or volumes. Containers are made to be extremely resilient and secure to facilitate safe cargo transit through a long distance. Most containers in use these days are expected to have finished a one-decade lifespan. Through application of reasonable maintenance, a lifespan far exceeding the anticipated figures can be expected.

Container exchange provides transparency to more than 300 container owners and users. They type in their locations and get a list of potential partners within seconds. Our one-way online platform facilitates the whole deal from negotiation, tracking, payment handling and integrated third-party services such as container insurance or container surveying.

Knowing that geometrically any space could be defined by different planes, horizontal and vertical, with a spatial relationship that organizes this space, defines it, and represents the human function that this space was created to be performed in, with the scale and dimensions, another value is added, thus leading to a better performance in this function, or another function that could be added or performed. so looking at any steel shipping container, the main and basic conditions of a space exists, with some modifications it can host various human activities of functions, thus creating not only functioning spaces but also interesting spaces for people to live, use and enjoy.

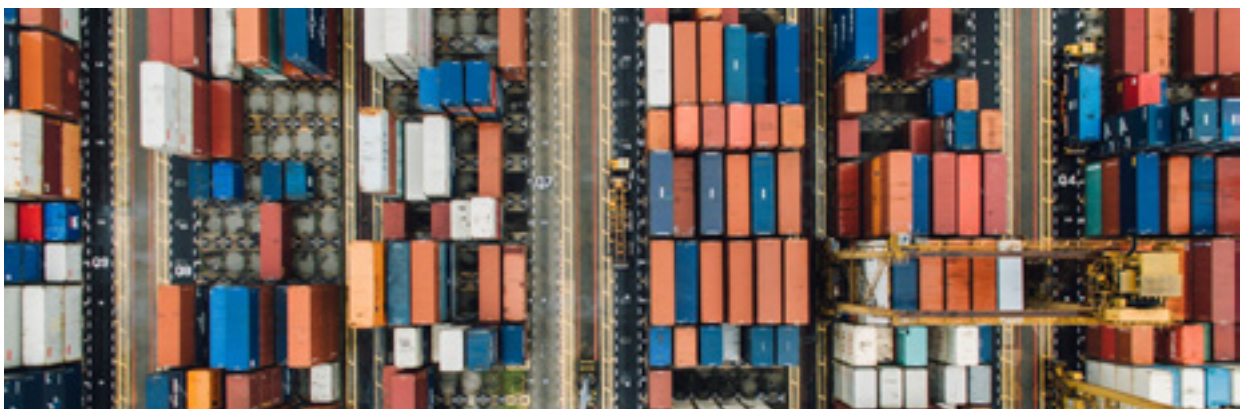


Figure No.38 . Shipping container port

Once the shipping container leaves the port towards destination, it is not affordable for companies to ship back empty containers to its original destination. So, instead of reusing those containers, buy new once and discard the old once. Some of these old containers are either melted down or left unused, which uses vast amount of energy and is hazardous for environment. Instead, reuse of these shipping containers for construction purposes will reduce the impact on the environment and make a good use of energy. Using these containers for urbanism will not only increase the livability of the cities but also will help in nullifying the urban decay.

## Sustainability

The first and very biggest advantage of building while construction using shipping container is that the basic and main structural component is reused rather than left unused and melted down, which saves lot of energy. As the basic component is ready, other structural material like concrete, wood etc. can be saved. Also, aesthetic materials like timber, bricks and glass can be used in less while construction. A shipping container construction facility has capability to outperform and outlast most of the wood construction. Overall, any shipping container construction facility can be very sustainable if planned and insulated well, which will help to save lot of money and energy.

## Transportability

Shipping containers have been used for worldwide transportation since 1956, so global network is already established. Depending up on the size and type of shipping container construction facility and final destination, it can be transported either via sea, rail, road or air. Sometimes it is difficult to transport the whole unit at a time, so parts of the modules are transported to site for assembly. In most of the case cranes might be needed for installation purposes, forklifts also can be used for small modules, which will ultimately saves laborer and time cost.

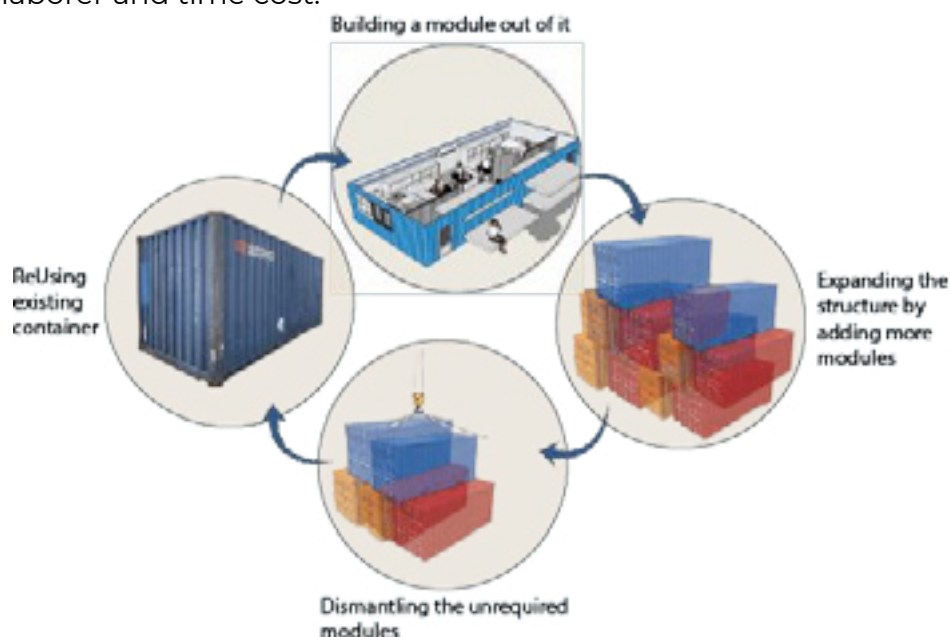


Figure No.38 . Shipping container construction cycle

## Scalability

### Potential for Concise construction as required

Our design offers 9 types of modules as shown. These modules are made up of shipping containers as well as prefabricated steel sections like in case of staircase. The requirement of each site will be different, accordingly in each case only the required type of modules can be brought on site and assembled. For example, in this case of Worli Koliwada, this site has specific requirement of library as it lacks it. People living in Koliwada have very small dwellings but dense population so a place to study and share their knowledge was a priority which has been solved with the two modules of library along with other functions. But every site comes with different requirements so this modular approach with variety of designed modules fulfill those requirements and holds a great market potential.

Number of containers are discarded by companies and are left unused, which concludes that these containers are cheap in price. Shipping containers are designed with all sides intact and capable of handling loads, which can be used as structural base for construction. Huge saving can be done in other costs like transportation, insulation, electricity and plumbing as compared to typical construction.

### Stacking strategy

According to the ratio of the two types of modules they are stacked such that, not only the structural integrity is maintained, but the voids formed are functional and interactive balconies are created.

$$x:y:z = 1:1.5:4$$

Where x= breadth of the shipping container

Y= height of the shipping container

Z= length of the shipping container

Void 1 = Corridor      Void 2 = courtyard      Void 3 = Folding furniture

Cost of Module 1 = Rs 1 lakh

Weight of Module 1 Before stacking = 2 tonnes      Cost of Module 2 = Rs 1.3 lakh

Weight of Module 1 After stacking = 2.5 tonnes

Cost of the plot= Rs 250000000

Weight of Module 2 Before stacking = 3 tonnes

Weight of Module 2 After stacking = 3.5 tonnes

Cost of 1m.sq in koliwada = Rs 176000

## Types of modules



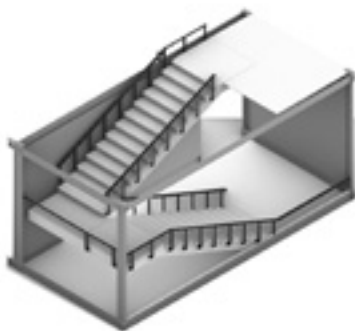
*Library - Unit A*



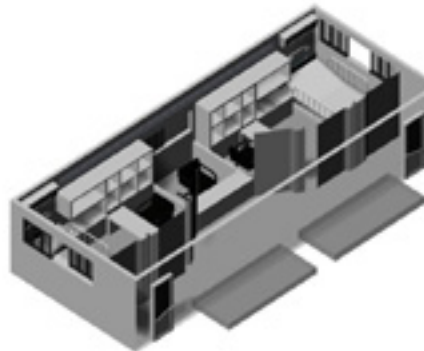
*Toilet- Unit B*



*Lift- Unit C*



*Staircase- Unit D*



*Clinic- Unit E*



*Office- Unit F*



*Passage - Unit G*



*Dwelling- Unit H*

*Fig.no 40. :Different Typologies of Modules*

There are 8 different types of modules designed according to the diverse functions . Those modules creates variety of combinations and offer us a choice whether to use all or specific few according to site requirements hence increases its market potential and make it scalable for industry where client gets freedom according to finance as well as requirement. More potential is present in exploration of the modules such as In urban agriculture, commercial units etc....

## Construction Process and Period

Use of shipping containers for construction purposes saves up to 8000 Kwh (new) and 410 Kwh (second hand). The process aims to minimise waste and reduce the project's carbon footprint, as fewer people are travelling to the site and modules are produced directly to spec using Computer Aided Manufacturing.

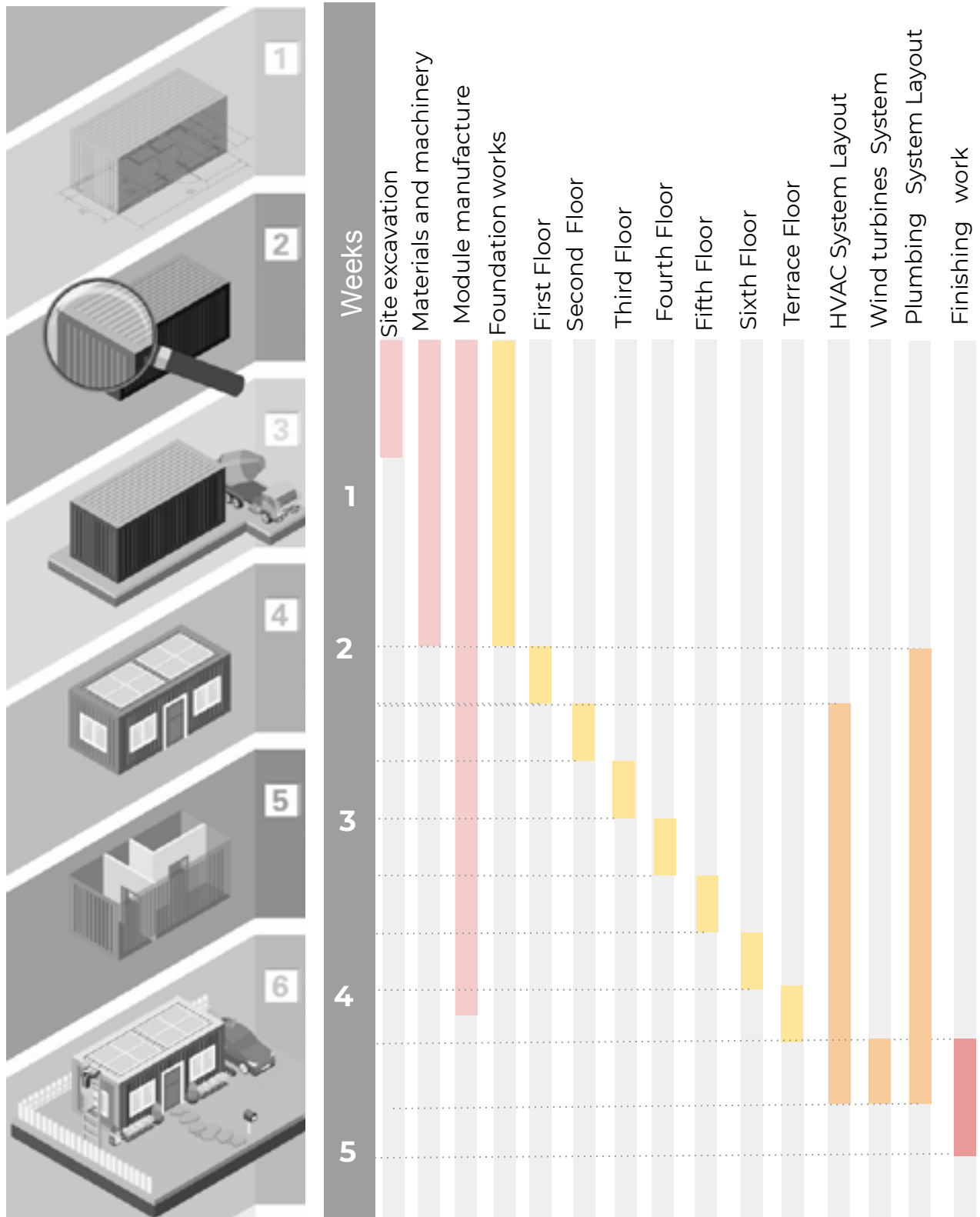


Figure No 41..Rapid construction process

## Affordability

Modular is standardisation. Essentially, it is developing a streamlined process that can be repeated time and time again for each project. Once this is created, costs are saved through economies of scale and lowered design costs. Not only are the savings related to the hard construction, it also runs through to the associated professional costs.

Using modular construction methods also minimise disruption on site. The site is essentially cleared up until the point the modular units are delivered from the factories where they are assembled, and the disruption happens in one swift move. Having said that, detailed planning is essential. For example: access to the site is an important factor. A narrow muddy track may not suffice for logistics!

Despite these considerations a developer can reasonably assume a lower contingency on the build as most of the construction can be conducted off site with a higher degree of certainty. This will result in improved profit margins.

The same is applicable to property development. Modular construction, put simply, is much quicker than traditional construction methods. This affects the cash flow in a number of ways:

1. Sales of the completed buildings start much sooner
2. Construction timeframe is reduced, thus reducing project life span
3. Peak borrowing is reduced
4. Reduced interest costs on development finance

The aspects of our program benefits in the following ways:

- It can be rented, as well as transported.
- Mass production, standardised the elements , easy to recover
- Rightsizing hvac reduces the cost factor making it affordable
- The site becomes an interface between koliwada and adarsh nagar, aiding secondarily for canteen, educational facilities.
- Another attractive feature in prefabricated construction is reusability. When we dismantle the RCC structure then the materials can rarely be reused but in prefabricated structure materials are mostly reusable.

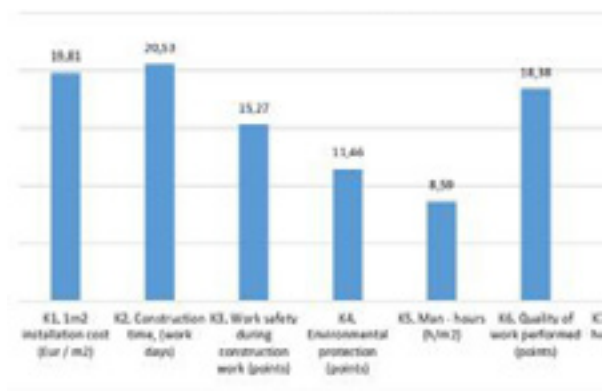


Figure No.42 Expert multi-criteria assessment

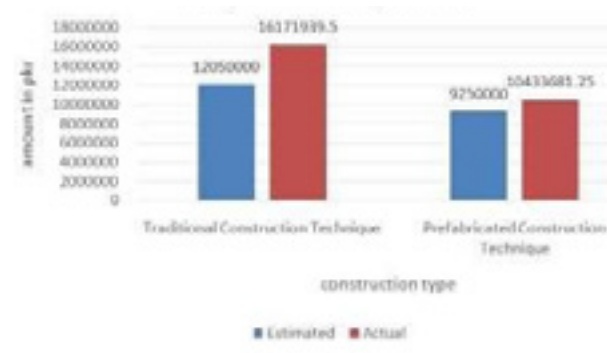


Figure No. 43 Comparison of Project cost

## Architectural design

The entry of resilience shelter should be inviting as well as it should have absorbing spaces in order to accommodate large number of people within and calm them down during tough times. The entry is designed in such a way that it invites all through the pavement pattern designed out of semi permeable pavement. There are enough seating spaces provided to come and sit which again invites people. It also resemble the way entire koliwada sits around, the narrow but yet attractive lanes. The cross bracings ensure structural stability as well as make face patterns.



Figure No.44 . Inviting and absorbing entry to community center

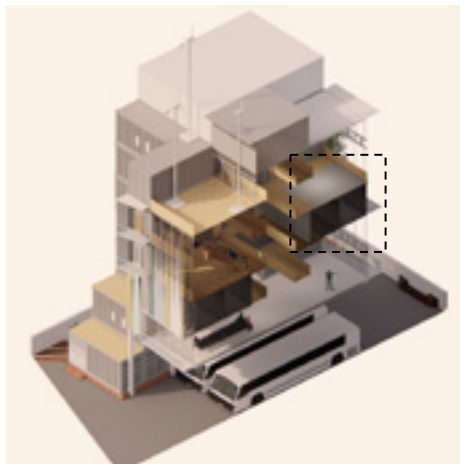


Figure No.45 . Community meeting halls Interconvertible into resilience wards.



Figure No.46. Voids aiding stack effect and interactive balconies



Figure No.47 Breathing facade with balconies oriented wrt sun path



Figure No.48. Community meetings utilized as dwellings in resilience using foldable beds

## Net Zero Efficiency Of Water

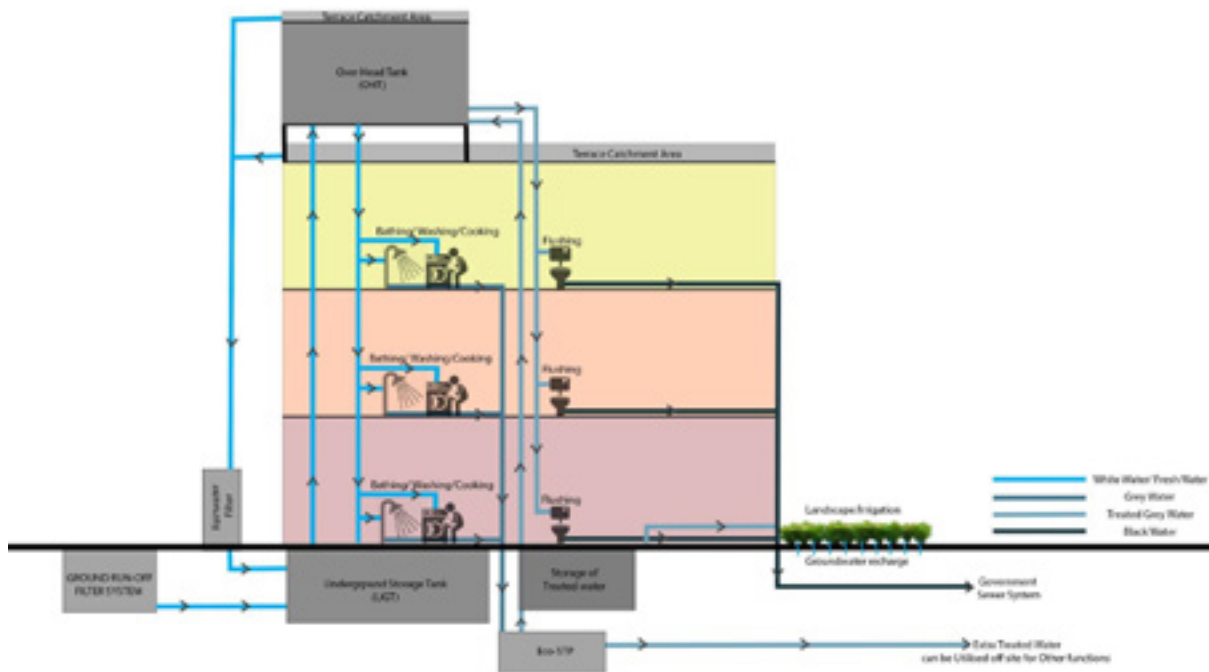


Fig.no 49 :Different Typologies of Modules

The water system used, aims to efficiently utilize rainwater runoff from the site for the purposes of freshwater usage and allows certain amount of water to seep through the ground in order to recharge the groundwater table.

The water collected from the surface run-off of the terraced space is harvested and filtered through a low-cost ,combined system of sand filters and activated carbon. The surface from which the water is collected greatly determines the quality of the water. Steel surfaces (like those on top of the steel containers used in this project) yield the best quality of water followed by asphalt lined roofs, galvanized iron, concrete blocks,etc. The fact that there are no industries in the immediate context has been exploited to obtain a higher quality of rainwater having lesser amount of impurities and dirt.

During collection of the rainwater it is to be ensured that the first 3mm-5mm of the rainwater (first rain) is discarded for maintenance of quality of water even prior to the filtering of the same.The detail section of the rainwater filtration system is shown in the figure ahead.The low-cost, self-prepared combined activated carbon and sand filtration (CACSF) system uses activated carbon that is self-prepared using locally sourced coconut shell and activated using commonly available salt rather than a high-tech procedure that requires a chemical reagent is used in the system. The filtration chamber was comprised of local, readily available sand.

The CACSF system manages to produce effluents complying with the drinking water standards for the parameters pH, dissolved oxygen (DO), biochemical oxygen demand (BOD5), COD, total suspended solids (TSS), and ammonia nitrogen (NH3-N). The CACSF system successfully decreased the population of (*E. coli*) bacteria too. Thus making it safe for usage for functions of freshwater.

The groundwater runoff is collected from the surface which is sloped towards the underground filtration system which has an approximate depth of 1.5m. The groundwater runoff filtration system has 20 cm of gravel on the top followed by 20 cm of charcoal and then 40cm of sand layer and 40 cm of gravel which purifies the ground water runoff so that it can be used for the freshwater functions .

All the piping from the rainwater filtering system and groundwater filtering system is connected to the Underground Storage Tank (UGT) where the water storage can happen for a longer period of time so as to suffice the water requirement for the whole year.

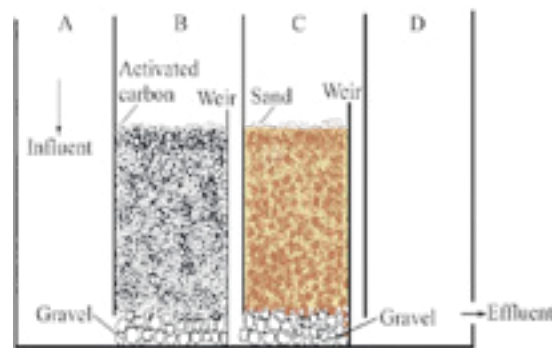


Figure No.50 : Rainwater Harvesting System

The freshwater is transferred from the UGT to the overhead tank (OHT) and then supplied through pipes which can carry hot water if required. Water from the freshwater functions are converted to greywater and are taken down to the underground located “Eco-STP” for filtration of greywater. The process of conversion of grey water to usable water is explained ahead. The following steps are followed in the Eco-STP which is a 4 step process (like 4 Stages of digestion a cow) :-

1. Greywater is collected in the first chamber where solid matters and materials with solid consistency settle at the bottom.
2. Using gravitational force, water travels to the second chamber through a series of baffle pipes. The wastewater is processed by anaerobic bacteria (derived from cow dung). The bacteria feeds on all the contaminated materials.
3. The relatively clean water then travels to the third chamber (Rumen digestion) where it passes through multiple filter mass.
4. The final chamber is filled with horizontal wetland with no roots, only gravel. The vascular plants and algal colonies remove pathogens and nutrients (nitrogen and phosphorus) from the water. The final result is clean non-potable water (which conforms to the Pollution Control Board norms).

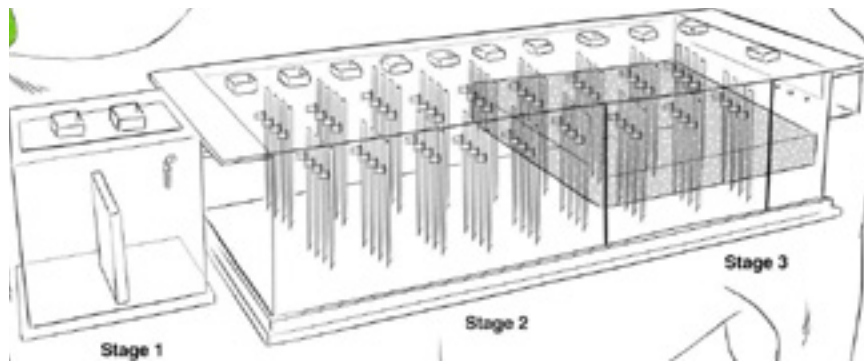


Fig.no.51 :Eco-Sewage Treatment Plant (Eco-STP)

This water can then be used for flushing of the toilet water and can also be used for irrigation purposes and supply water to the landscaped space. Treated grey water is stored in a separate underground tank that can store 6 days of treated grey water at once. Rest of the grey water when produced during disaster times can be used to recharge the groundwater table and also be used for off site for functions like cleaning, washing of vehicles and flushing of portable toilets which are often used in slum areas of Mumbai. This will not only act as an extra source of income but will also allow government body to utilise the disaster situation for good of the city.



20 CM GRAVEL  
20CM CHARCOAL  
40CM SAND  
40CM GRAVEL

Fig.no.52: Underground runoff water treatment



Fig.no.53: Foul Smell prevention

Higher capacity of water tanks have been provided taking into consideration the inflow and usage of the structure by the public during resilient times. Though the structure functions as community centre during non-disaster times the system aims to fulfill its water utilisation role. The treated greywater after being used for flushing of toilets is converted to black water and this black water is connected back to the government sewer system for treatment..



Fig.no.54 : Groundwater run-off area

## Constructability of a single container

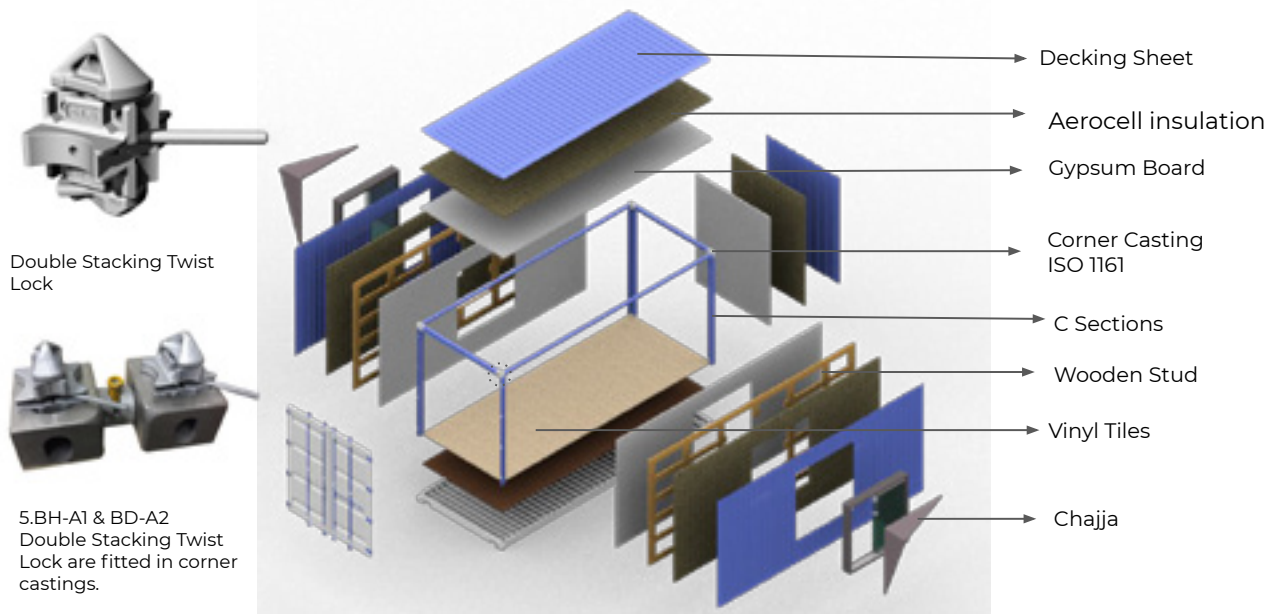


Figure 32 . Steel container Exploded

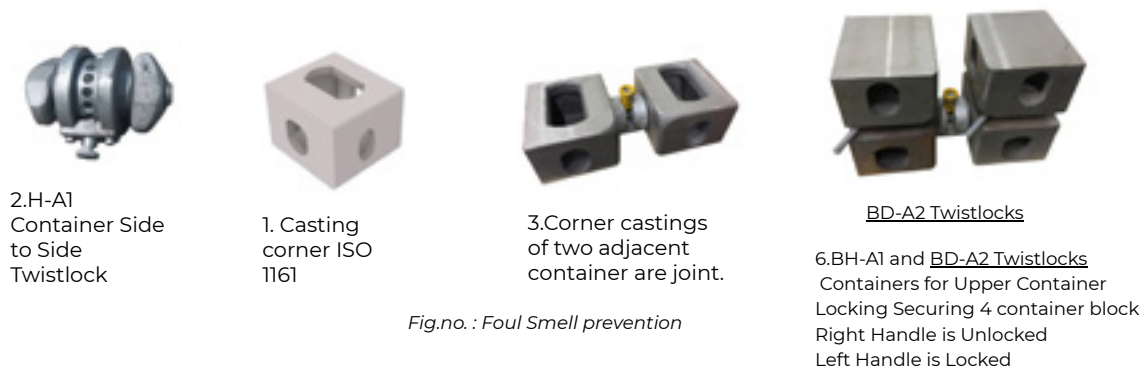


Fig.no. : Foul Smell prevention

## Operate cycle and flow

For modularity , shipping containers have been used. Making use of shipping containers that are already built saves an ample amount of time as well as money. The availability of these containers makes it easy to construct required modules in them and expand the structure on site. These helps in catering more amount of people at tumultuous time. Modules that are not being used can easily be dismantled and reused for some other purpose. This makes the structure sustainable as well. The amount of pollution it adds to the environment is a lot lesser compared to conventional concrete construction. The modules having high amount of strength increases the lifespan of the overall structure.

Constructability And Engineering

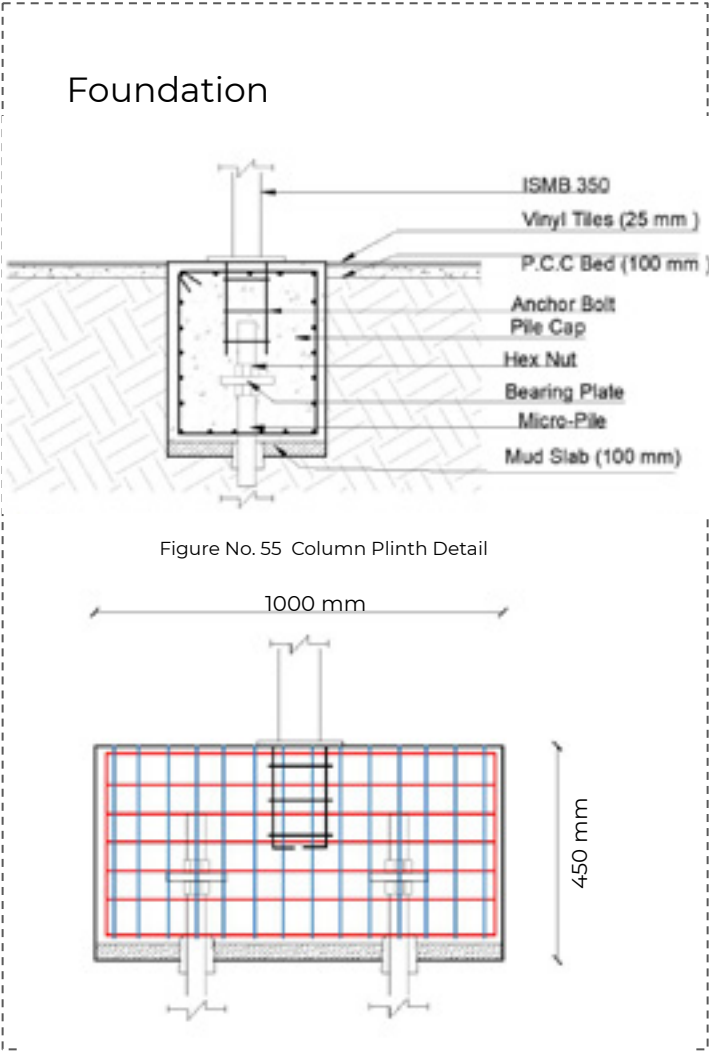


Figure 56. Pile Cap - Micropile Detail

Depth (m)	Log	Strata Description	Sample	SPT "N" value
			Depth	
1		Back Fill	1.50	10
2		Yellowish loose sand		
3			3.00	12
4				
5			4.50	13
6			6.00	16
7		Black Clay Soil		
8			8.00	
9		Yellowish Clayey Soil		
10			9.50	
11		Grayish Hard Rock		
			11.00	

Table No.10.. Sub-soil Layer profile of site

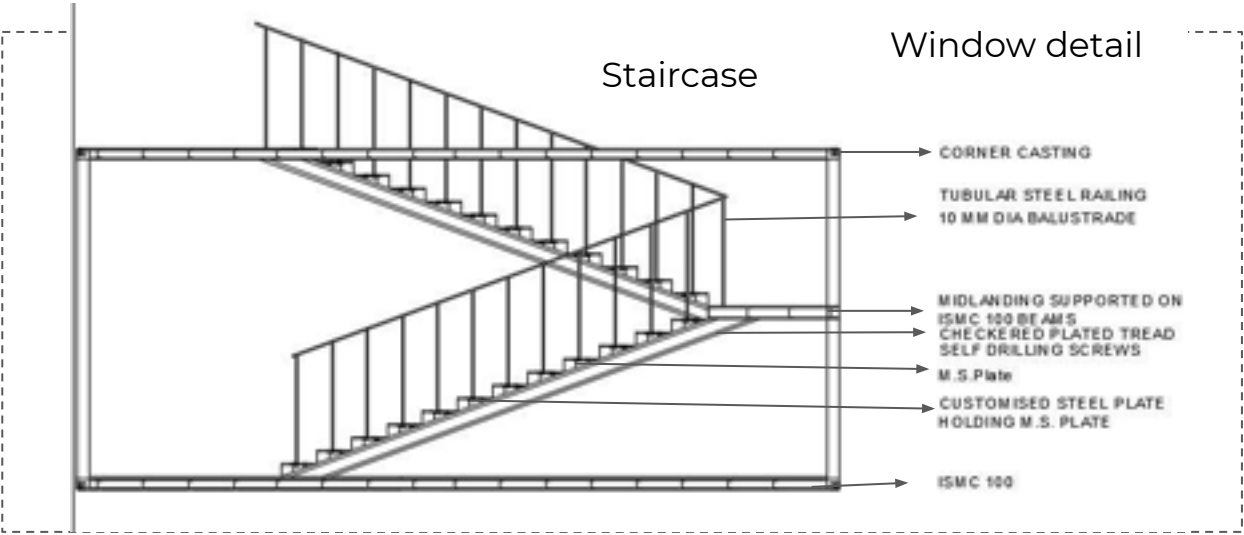
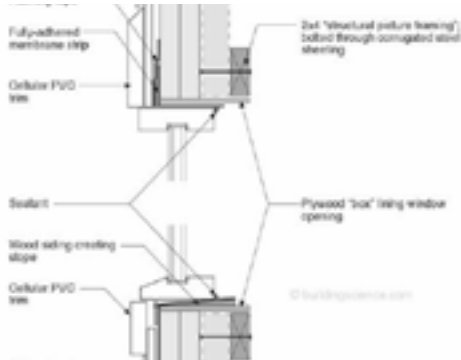
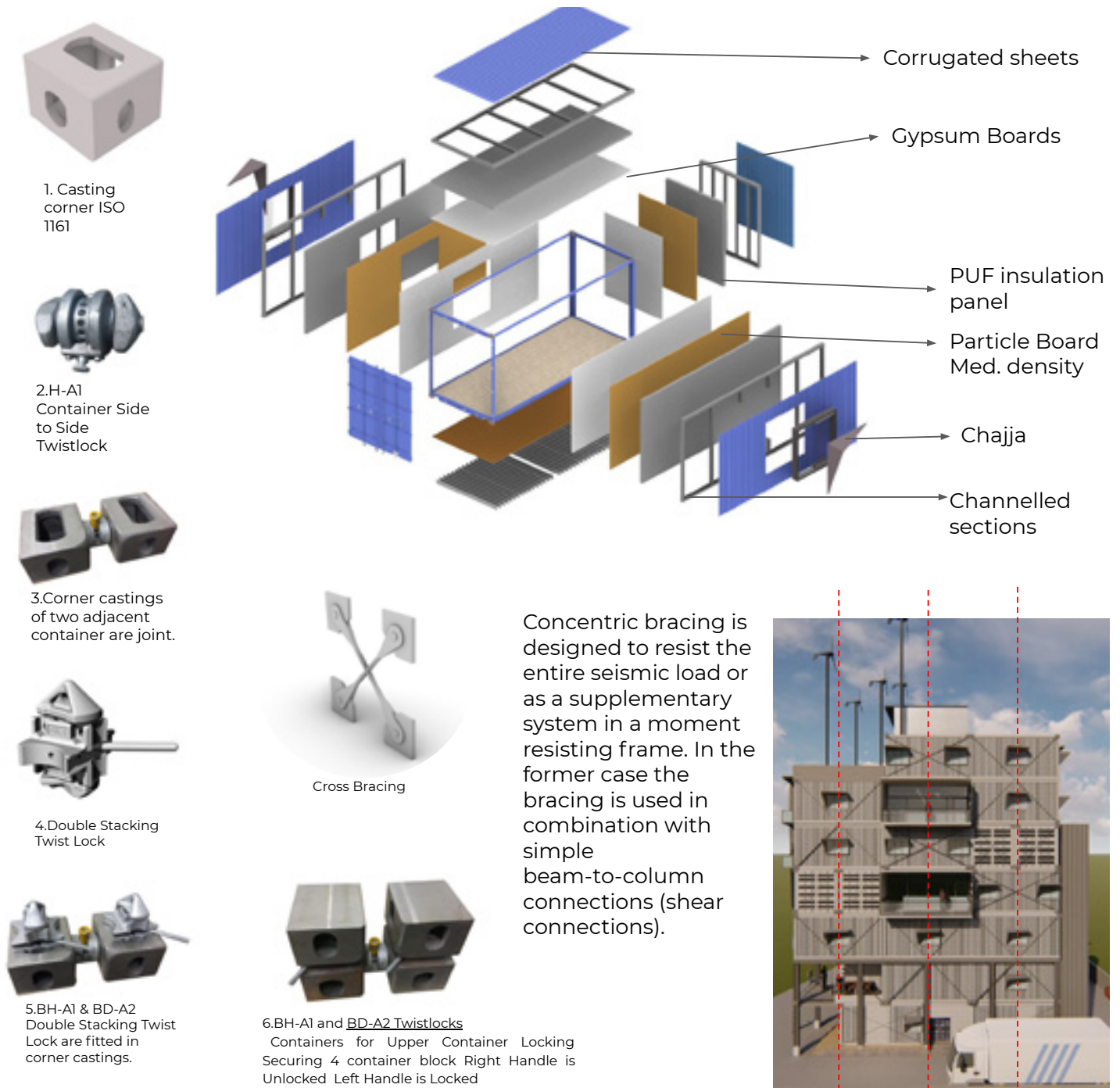


Figure 57 . Staircase Detail



## HORIZONTAL CONNECTION



A

Upper corner casting detail



B

Lower corner casting detail



C

Chajja detail

Fig.no.58 : Foul Smell prevention

## Application for disaster management- common management platform-Interface

### M.C.G.M. Disaster Management Application

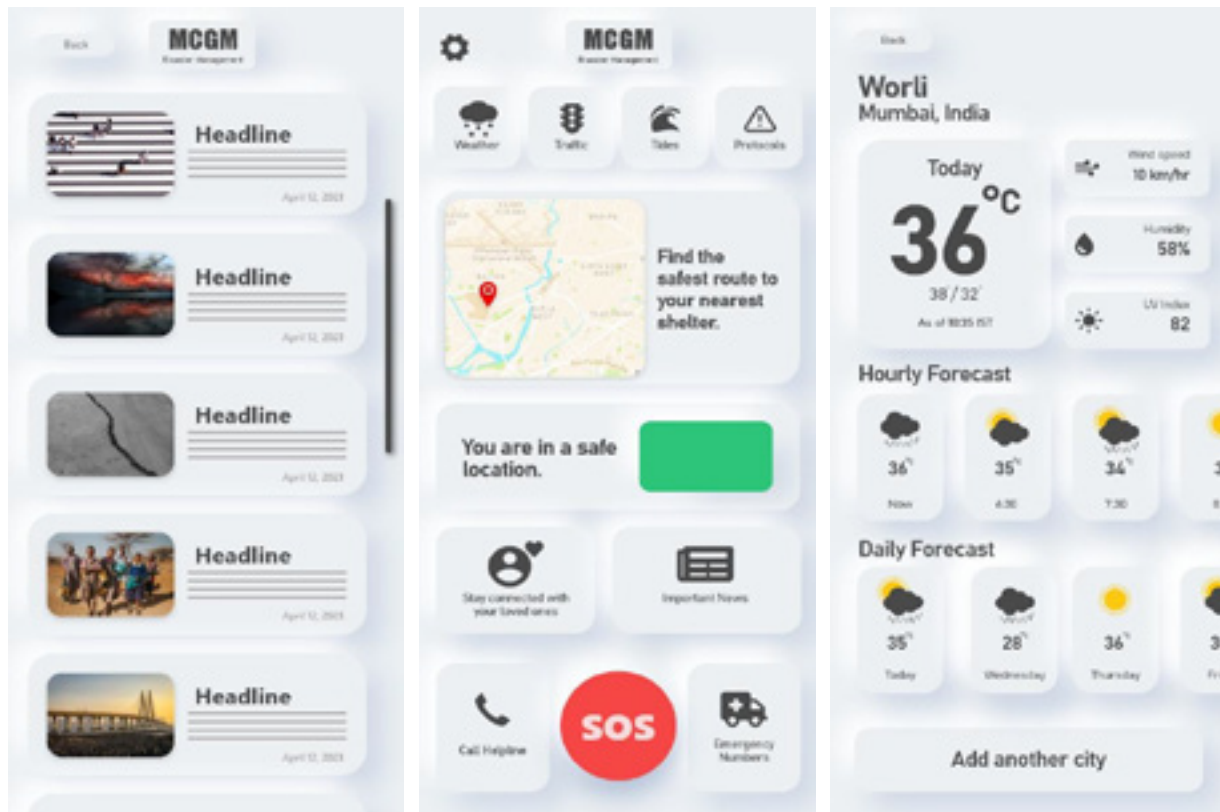


Fig.no.59.: application interface

Here, we have tried to address the need of awareness and communication, through an app, allows active members (Government, NGOs , and community of koliwada) to work together during the disaster,providing adequate amenities as well as tracking those amenities through this app.

There are three interconnected challenges to embedding disaster risk reduction measures in development programs. There is limited coordination among relevant ministries such as the National Disaster Management Authority and the Ministry of Environment, Forests and Climate Change. The second issue is that amid competing demands on their human and financial resources, government departments and institutions have not prioritized the need to embed disaster risk reduction measures in development structures and processes. While some ministries such as Water Resources have traditionally embedded risk reduction elements which can be updated based on recent events and climate projections, most ministries do not have risk reduction embedded in their programs.



Fig.no.60: Management platform interface

. Promote an integrated approach that addresses multiple risks Building the resilience of the poor and marginalized requires holistic approaches that integrate multiple solutions rather than addressing disaster-related risks as an isolated problem. There are numerous cases of small and marginal farmers, including grassroots women's groups, prioritizing economic activities that increase their incomes while reducing disaster risks. These farmers are diversifying crops to include growing low input, climate-resilient food crops that conserve water, improve household nutrition and stabilize or enhance incomes in the face of falling agricultural productivity.

While disaster management has historically been approached from a techno-managerial perspective, it needs to invest in dismantling structural inequity and inequality as much as in creating technical solutions for disaster resilience. Building solidarity networks of vulnerable groups, enabling them to gain access to new technologies, innovate together, demonstrate solutions and gain institutional recognition empowers communities to voice their priorities in public decision-making forums such as gram sabhas or ward-level meetings and influencing programs. This begins to transform the social and political processes that produce vulnerability

## Project Summary

Mumbai, one of the major coastal cities in India, has been prone to seasonal and recurring flash floods. With the rise in sea levels due to global warming, there is a threat to lower lying areas of the cities which are predominantly inhabited by slum dwellers and Lower income group. As a response to the problem which is being faced and the ones which will be faced in the near future, creation of Energy efficient Community resilience shelter in and around identified vulnerable points within the city are one of the solutions to the specified problems.



Figure No 61.. Seasonal Flooding as a major problem for the city



Figure No 62 Crowded locality of Koliwada

G South ward comprises of one of the most famous landmarks of Mumbai. It also includes one of the oldest settlements in the city. During the monsoon season, these older localities often become vulnerable to flash floods. The use of the proposed Community resilience shelters around localities of Worli Koliwada, BDD chawl amongst others will have a great market potential and also a good investment in building Mumbai's resistance against disasters. Alongside these primary functions, these shelters can be used as spaces for community gatherings, vaccination drives, polling booths and other functions for the given particular area.

For the target community of Worli Koliwada, a resilience shelter will serve as an important point for learning, community interactions and as a shelter during disaster.

The Worli Gaon Bus Station was chosen as the site for our community resilience shelter. There were two primary reason for the same.

- During disasters, people often follow their instincts and think of the easiest and simplest way out of the affected area. The Worli Gaon bus station, which provides with transit options for the citizens, is an important location for people living nearby. Thus having a community resilience shelter at this focal point will ultimately draw people towards itself during vulnerable times.
- The bus station is near the Worli Koliwada Market which is full of shops and stalls throughout the day. Thus creating something in vicinity of such a lively market which can be used by the community throughout the year as an Educational centre / Public transport terminal/ Community gathering and development centre would benefit the locality and will act as a value addition for the same.

It is well known that the city of Mumbai is the financial centre of the country with it being a major port connecting India with the world. The use of shipping containers as building blocks for the project can be justified using following points -

- The acute shortage of space in Mumbai has posed many challenges for the city. Thus creating a shelter that follows modularity which aides in easy and quick construction of the building. Modularity also ensures that the shelter can be modulated with respect to the site context in case these shelters are to be replicated. As mentioned in the report, major part of island city of Mumbai, is at a risk of submerging under water due to rising sea levels, structures which can be dismantled and assembled on another site without any hindrance.
- Our aim was to reflect, through our design a connection to Mumbai. Since Mumbai was initially built due to its excellent conditions to form a harbour for ships. A structure which related to that origin would fit in the macro context. Mumbai Port Trust and Jawaharlal Nehru Port Trust (JNPT) handle 55% of total cargo that the country receives. The shipping containers after their use are either recycled or used as temporary residential blocks. Thus by using these containers we aim to establish that relation between the origin of the city with the contemporary touch to it in the form of these shipping containers.

The future of construction calls for sustainable development. Sustainability is often related to higher standard of living. This relation needs to be forgotten and modulated in order to make the citizens, i.e. , the users understand the concept of sustainable development. The proposed shelter has been designed to be a self sufficient public building. A net zero Energy building thus becomes an ideal choice for a place and function like community resilience shelter. The building will be able to function independently throughout the year, even during vulnerable times. This will in turn give rise to similar sustainable centres around the city thus adding to the progress towards sustainable development.



Figure No 63.. Modular approach makes it easy to construct and to maintain.