“OPTIMIZING BUILDING TYPOLOGIES FOR HIGH-RISE APARTMENT BUILDINGS: A GENERATIVE APPROACH FOR ENVIRONMENTAL PERFORMANCE”

Bachelor of Architecture Research Thesis dissertation

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Approval

The following study is hereby approved as a creditable work on the subject carried out and presented in the manner, sufficiently satisfactory to warrant its acceptance as a pre-requisite towards the degree of Bachelor of Architecture for which it has been submitted.

It is to be understood that by this approval, the undersigned does not endorse or approve the statements made, opinions expressed or conclusion drawn therein, but approves the study only for the purpose for which it has been submitted and satisfies him/her to the requirements laid down in the academic program.

Thesis Title: "Optimizing Building Typologies for High-Rise Apartment Buildings: A Generative Approach for Environmental Performance"

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Declaration

I, **Akil Mansuri, 18BAR018**, give an undertaking that this research thesis entitled **"Optimizing Building Typologies for High-Rise Apartment Buildings: A Generative Approach for Environmental Performance"** submitted by me, towards partial fulfilment for the Degree of Bachelor of Architecture at Institute of Architecture and Planning, Nirma University, Ahmedabad, contains no material that has been submitted or awarded for any degree or diploma in any university/school/institution to the best of my knowledge.

It is a primary work carried out by me and I give assurance that no attempt of plagiarism has been made. It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; I would be responsible.

This research thesis includes findings based on literature review, study of existing scientific papers, other research works, expert interviews, documentation, surveys, discussions and my own interpretations.

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CHAPTER 1: INTRODUCTION

OVERVIEW

In the next few decades, the number of people living in Ahmedabad is likely to grow quickly. This will make it necessary to build homes close together. But because there aren't many rules about building high-rises, many of them aren't as good for the environment as they could be. This study tries to find the best building types and groups for high-rise residential growth in Ahmedabad city by using computer and generative design methods.

The study will begin with a review of important books about high-rise growth, building typologies, and generative design. Next, it will use a creative design method to come up with and evaluate different building types and groups based on how well they help the environment. These steps will look at things like how much light gets in and how much energy is used.

Based on the results of the generative design method, the study will come up with rules for high-rise growth that meet the needs of a growing population while keeping a certain level of environmental performance.

The end goal of this study is to help make safe, liveable, and useful high-rise communities in Ahmedabad that meet the needs of their people.

Background

A lot more people live in Ahmedabad than in many other towns around the world that are growing quickly. Because there isn't much land to build on, more and more people are moving into high-rise buildings. But the effect these buildings have on the environment is a big worry, and it's more important than ever to build and plan buildings in a way that is good for the environment.

One of the hardest things about building high-rise homes is working out how to use building types and groups in the best way to protect the environment and build as many units as possible. Different kinds of high-rise buildings, like C-shaped, courtyard, and tower, have been used in different parts of the world, but their effects on the environment in those places need to be looked at. Also, building types and groups need to be improved to make them easier to live in and less harmful to the environment.

New ways to improve building types and groups for high-rise homes have been made possible by recent improvements in computer and generative design methods. By using these methods, you can compare a lot of different options and find the best ones based on things like how much sunshine comes in, how much energy is used, and how comfortable the temperature

Problem statement

"The rapid urbanization and population growth in Ahmedabad city necessitates the development of high-rise residential buildings that optimize both height and environmental performance. However, the lack of regulations for high-rise development leads to suboptimal building typologies and clusters that may not maximize environmental performance. This research aims to develop optimized building typologies and clusters through computational and generative design approaches and propose regulations for high-rise development that ensure a certain level of environmental performance while also accommodating the needs of a growing population.

Research Question

What is the relationship between building typology and energy performance of building form?

Aim

To optimize residential building typology based on energy performance in the city of Ahmedabad.

Objective

1.To explore various design parameters such as length, width, height, courtyard size, and plot size to determine their impact on minimizing direct sun exposure and maximizing daylight in high-rise buildings.

2.Investigate the correlation between building form and wind flow efficiency to identify optimal design configurations.

3.To compare the generated results to the original results.

Scope & limitation

1.Exclusion of specific design elements or strategies such as material shading devices due to resource constraints or time limitations.

2.Dependence on simulations and modeling, which may not perfectly represent real-world conditions and may have inherent limitations or uncertainties.

3. This research does not consider or incorporate specific regulations or building codes related to high-rise building design and construction in Ahmedabad or any other applicable jurisdiction.

CHAPTER 2: HIGHRISE APARTMENT

2.1 A brief history of the Highrise Apartment.

Over the past few decades, India's towns have grown a lot, and high-rise living has been a big part of that. People started to like the idea of living in tall buildings around the middle of the 20th century. This was because the population was growing, towns were getting more busy, and there was a need to build up in places with limited land.(Sood, 2016).

Figure 1: High Rise Appartment
Source: Wikipedia

At first, most high-rise housing buildings were in big cities like Mumbai, Kolkata, Delhi, and Chennai. People moved quickly into these places, and more people wanted to move there. Because of the rise of high-rise buildings, a lot of people can now live in a small area. (Basu, 2005).

The Usha Kiran building, which was built in Mumbai in the 1950s, stands out as one of the first high-rise apartment buildings. At the time, it was one of the biggest places to live, and it had lots of modern features and nice places to live. This was the first time that people in India started to move into big buildings. (Mani, 2012).
In many Indian towns, more high-rise flats were built over the next few decades. High-rise buildings came about because people's lives were changing, the middle class wanted more, and cities needed to use space more effectively. (Kumar et al., 2019). Because they had lifts, parking spots, security systems, and places to play, high-rise apartments became a sign of progress. (Bhalla, 2010)

In India, the number of high-rise flats has grown a lot in the past few years. This is because India's population is growing quickly and its cities are getting bigger. In both big cities and new urban areas, high-rise housing buildings have been built for different types of people, from those who need cheap housing to those who want to live in luxury. (Das, 2021).

But the rise of high-rise flats in India has also raised concerns about infrastructure, urban planning, the environment, and social issues. More and more attention is being made to the need for sustainable planning, good use of resources, and consideration of social and community needs in high-rise residential projects. (Singh, 2018).

India's towns still have a lot of high-rise apartment buildings. People are always trying to find a balance between the need for towns to grow up and the need for them to be safe and easy to live in. (Sharma et al., 2020).

2.2 When does a building become a Highrise ?

Different towns and states in India have different ideas of what a high-rise building is. The National Building Code of India (NBC) tells people how to make and classify houses. The NBC says that a building is usually a high-rise if it is higher than 15 metres (49 feet) or has more than four floors.(Indian Bureau of Standards, 2016).

But it's important to remember that high-rise buildings may be governed by different rules and have different meanings in different parts of India. Some states, like Maharashtra and Tamil Nadu, have their own building codes that have more specific rules for building big buildings.

2.3 Evolution of Highrise Apartment

The development of high-rise flats in India shows how urban life and architecture have changed in a big way. Over the years, many things have led to the growth and spread of high-rise apartment buildings in the United States.

Figure 2: Highrise Appartment
Source: Wikipedia

•People in India have lived in tall buildings since the middle of the 20th century. As the number of people living in cities grew, the first high-rise apartment buildings were built in places like Mumbai, Kolkata, Delhi, and Chennai (Basu, 2005). These buildings, like the Usha Kiran building in Mumbai, were the first in India to have modern services and start the trend of living in tall buildings (Mani, 2012).

•Rise of Middle-Class dreams: As the economy grew and middle-class dreams grew, more people wanted to live in modern houses. (Bhalla, 2010) Living in a high-rise apartment became a sign of success and a sign of a better place to live. As the middle class grew, more and more high-rise housing projects were built to help people live in cities in a more comfortable way.

• Rapid development and a lack of land in cities made it necessary for people to build their homes up instead of out. (Kumar et al., 2019) Buildings with many stories let more people live in a small area. High-rise homes helped people make the most of the space they had as towns got more crowded.

•Technological changes: Changes in building methods and materials have made it easier to make buildings that are bigger and stronger. Better building methods, reinforced concrete, and better technical practises made it possible to build bigger apartment buildings (Das, 2021).

•Changing lives and amenities: Over time, high-rise apartments have changed to meet the needs of people with different tastes and ways of living. Modern high-rise buildings have places to play, places to relax, parking, and safety measures, among other things. The goal of these projects is to make a tall town where people can live in a variety of ways.

•Sustainable design and green building practises: As people learn more about how to protect the environment, there is more of an emphasis on putting green building practises into the plans of high-rise homes. (Sharma et al., 2020): Open spaces, energy-efficient systems, materials that don't hurt the environment, and ways to save water are being added to high-rise buildings to make them less harmful to the environment.

CHAPTER 3: CLIMATE AND ARCHITECTURE

3.1 Environmental factors influencing the architectural built environment

When designing a building, it's very important to think about and work with the environment. It is important to understand and estimate the natural factors that have changed a region's climate over a long period of time. Most people agree that all living things and actions rely on good weather conditions for their growth, evolution, and survival. So, it is important to take environmental factors into account when designing buildings to make sure they are healthy and work well. (Biket, 2006)

Analysis of climate is a key part of both designing buildings and planning cities. Before making any design choices, it's important to find out, understand, and evaluate how the weather affects the building site. Geology, altitude, terrain, and flora all have an effect on the environment of a certain area. These things help make certain climate zones, which need designs that are custom-made and friendly to the environment. Figure 3.1 shows how different external factors have an effect on the built world. By taking these things into account, builders and managers can make designs that work well with the climate of a certain area.

During the planning process, it is important to think carefully about environmental factors and requirements in order to save energy, improve thermal flow, and use natural cooling and heating methods that work with the weather in the area. By carefully looking at and taking into account these factors, planners can make the best use of how heat moves through the built environment. This leads to better energy efficiency and thermal comfort. This method makes it possible to create a building that is more durable and kind to the environment and uses natural elements to make it work better.

Figure 3: Environmental Factors
Source: Center buildings redevelopment

According to (Biket, 2006), the main factors that affect the fundamentals of climate, which control the effects of the environment and act as a link between all weather variables on the world for a long time in a certain area, can be studied in three main groups:

- Sun and temperature
- Wind and pressure
- Precipitation and humidity

3.2 Sun and temperature

The sun and heat are important parts of the weather and have a big effect on how comfortable the setting is. People often use the air temperature and relative humidity to figure out how comfortable they are. In building construction, the sun is a very important source of energy for both lighting and warmth. It gives light to the shapes and sides of buildings and also helps heat gain. The amount of energy that comes from the sun changes throughout the day and throughout the year. This affects the general temperature and lighting conditions in built environments. Understanding and using the changing nature of solar energy is important for making buildings that are both comfy and good for the environment.

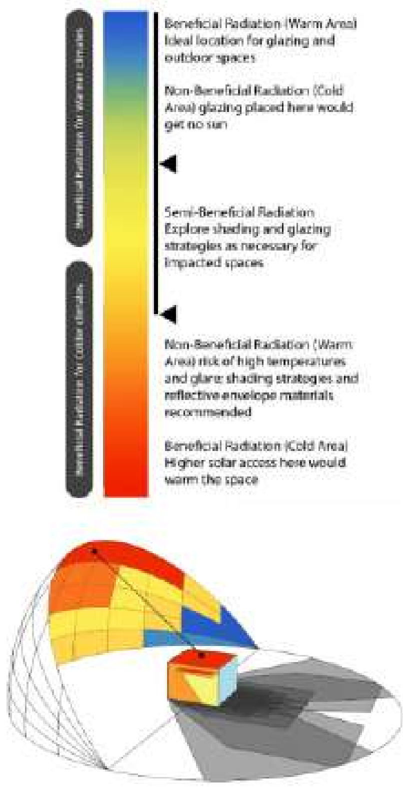


Figure 4: Radiation efffect diagram
Source: Center buildings redevelopment

Solar Radiation

Over time, solar energy is a big part of how houses stay warm. It has two effects on the temperature inside. First, direct radiation happens when sun energy hits the outside of the building. This causes the surface to absorb heat and get hotter. Then, this heat can move back inside through walls, roofs, and holes. Second, indirect radiation happens when, based on how the holes are made, sun energy comes in through them.

Transparent things take, reflect, and pass on radiation, but translucent things only receive and reflect it. Sunlight can be a good source of energy when it's cold outside. But in hot regions, too much sun radiation can make people feel uncomfortable. Because of this, it is very important to think about how sun radiation will affect building design, especially in hot areas.

The amount of sun energy, the local climate, and the conditions in the air are all things that can't change. But room use and the exterior facade can be reviewed and changed to make the best use of solar radiation. By carefully planning the layout and choosing the right materials, the effects of sun radiation can be controlled. This helps buildings be more comfortable and use less energy.

Daylight

Daylight is a key part of figuring out how natural the lighting is in a place because it affects both the lighting inside and outside. It can be looked at in terms of how much direct and indirect (reflected) sunshine gets into a house.

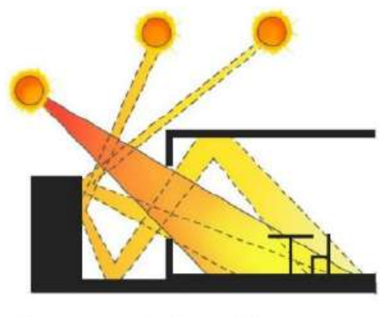


Figure 5: Daylight Factor
Source: Center buildings redevelopment

It is important to include lighting studies in the architectural design in order to make the building and its private spaces look and feel right. (Biket, 2006) To use sunshine to its fullest potential, many design factors must be taken into account.

Daylight optimisation is a way to plan buildings so that they use natural light as much as possible. When people live in places with natural light, they feel better, are more aware of their surroundings, and use less artificial lighting. This helps save energy. Screens, skylights, windows, and other building features can be placed in a way that lets the most light in.

How hot a house gets is directly tied to how much sunlight gets in. By putting holes in the right places, design can be made to work well. Combining natural light with artificial lighting can cut energy use by a lot, reducing the amount of heat that needs to be cooled by the air conditioner. To make the best use of energy in a building, architects and early designers must think carefully about how sunshine will be used.

Illuminance

The amount of light in a room, which is measured in Lux, shows how well it is lit. How far a colour goes in a place depends a lot on how bright it is and how much light it gets. Depending on how and where a building is built, it can take advantage of the way the sun moves during the day and seasons.

- Taller buildings with narrower surfaces can maximize daylight through side windows.
- Tall buildings can increase daylight and illuminance in more spaces by incorporating central courtyards, atria, or specific cut-outs in the building's geometry.
- Daylight and illuminance design strategies aim to maximize daylight availability, improve uniformity of light distribution, mitigate glare, and control solar gain.
- Several design strategies can be utilized to enable and regulate daylight and illuminance factors within a building, as shown in (Fig 3.4).

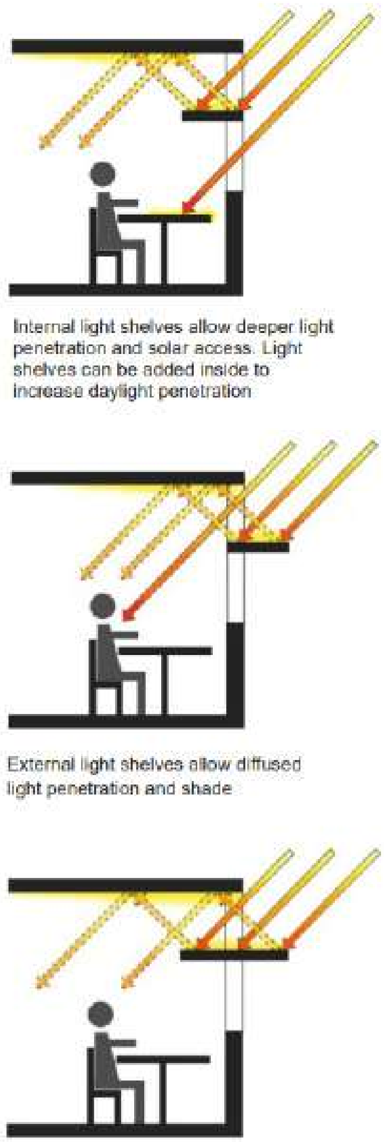


Figure 6: Side lightning
Source: Center buildings redevelopment

3.3 Wind and pressures

In building planning, you plan for a high-pressure area to form in the direction of the wind. By adding corridors between buildings, the amount of this pressure can be raised or reduced. Ventilation is important in hot and muggy places, while shade is important in hot and dry places. In some places, the angle of the sun affects how buildings are oriented, while in other places, the direction of the wind changes throughout the year. Different temperature zones have different needs for wind. In low latitudes, wind needs are important all year, but in high latitudes, defence is needed. When making planning decisions, like how tall a building should be or how far apart buildings should be, the wind factor of the area should be taken into account.

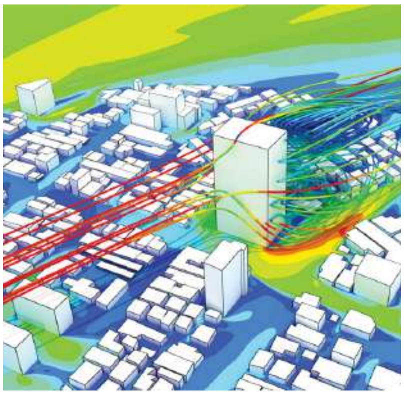


Figure 7: Wind flow simulation
Source: Center buildings redevelopment

CHAPTER 4: EVOLUTIONARY ALGORITHM

4.1 Generative design

The design process is complicated and involves a lot of moving parts. You have to deal with non-linear tasks and balance different design goals. But because of time limits, it is not possible for a human creator to try out and evaluate all of the possible designs. Instead, designers should focus on analysing and making a small number of designs before coming up with a final answer.

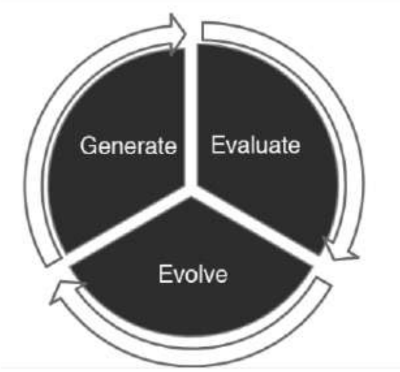


Figure 8: Process of generative design
Source: Simscale

Programming that is like evolution uses the ideas of evolution to try design solutions in a series of steps. It uses the three operators—selection, crossing, and mutation—to find answers and tests them against the design goals that were given. A genetic algorithm (GA) is a type of evolutionary algorithm (EA) that is used in generative design studies. (Rohrmann, 2019)

Generative algorithms are based on the following principles (Fig. 4.1):

- Generate: A set of the population with different design solutions
- Evaluate: The fitness of the individual solutions is determined
- Evolve: The best performing solutions are crossed-over to generate a new population.

This process is performed for a set number of generations or until a stop requirement is met, so that the algorithm can improve the fitness of a population over time and find the best answer.

Genetic Algorithms

(See Fig. 4.2.) Genetic algorithms (GA) are used to solve problems with multiobjective optimisation (MOO). Genetic algorithms cut down on the time it takes to get the best results and make it easier to compare them. So, the answer that was found is good. The fitness factors help to measure and analyse the designs that are made, which makes it easier to come up with results that have real resonance.

Since Holland made the first example of a genetic algorithm (GA) or an evolutionary algorithm (EA), different ideas have been put forward. Most of the ways they rank and choose options for new parents are different.(Rohrmann, 2019)

Multi-Objective Optimization

Most of the time, the planning process is unclear because there are many standards that must be met that contradict each other. Multi-objective optimisation (MOO) is the process of finding the best choices when two or more goals are in disagreement. There is no single answer to a multiobjective optimisation problem that optimises each objective at the same time. In a trade-off situation, the value of none of the goals can go up without the value of at least one of the other goals going down.

So, there can't be a single solution that meets everyone's needs. However, there are many Pareto optimal or non-dominated solutions where none of the main values can be changed without lowering other values. Because of this, there is no answer that is good for all the goals.
(Rohrmann, 2019)

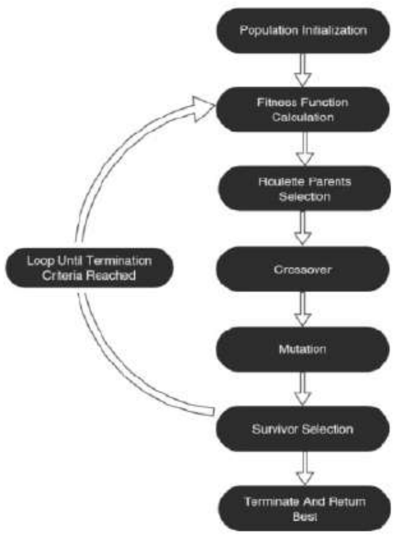


Figure 9: Process of generation step by step
Source: Simscale

4.2 Simulation workflow

Grasshopper is used to create the full simulation-based work flow for the study. The method created is used to compare different design strategies. Building shape optimisation from basic planning is part of the work-flow. So, it would be good to try out the whole method.

For the early stages of planning, like the size of the building, the shape of the face, and the size of the window spaces, the work-flow is split into four main categories. Each category has several steps that need to be taken into account for the final running of optimisation.

The first group focuses on finding the spot and giving the programme the context-specific geometries it needs. So, the input is the structure of the site and the main area of shape.

Once the shape is made, each iteration must be looked at to see how well it works in the world. The study of the surroundings is done by simulating plug-ins in the grasshopper script. Each study is written down for two different health standards.

The critical method is when different criteria that are at odds with each other and different tactics are used together to come up with an individual answer that is best based on all the evaluation criteria.
The created work flow optimises this multi-constraint shape by using a grasshopper plug-in called “Wallacie,” which uses the genetic algorithm to find the best solution.

This whole plan shows how different input design solutions can be used to come up with possible optimal solutions that can then be built on. This method showed a computer-driven optimisation approach that figures out the most likely values for the design parameters and does the work for the creators.

Figure 4.3 shows the four main steps of how modelling work-flow happens.

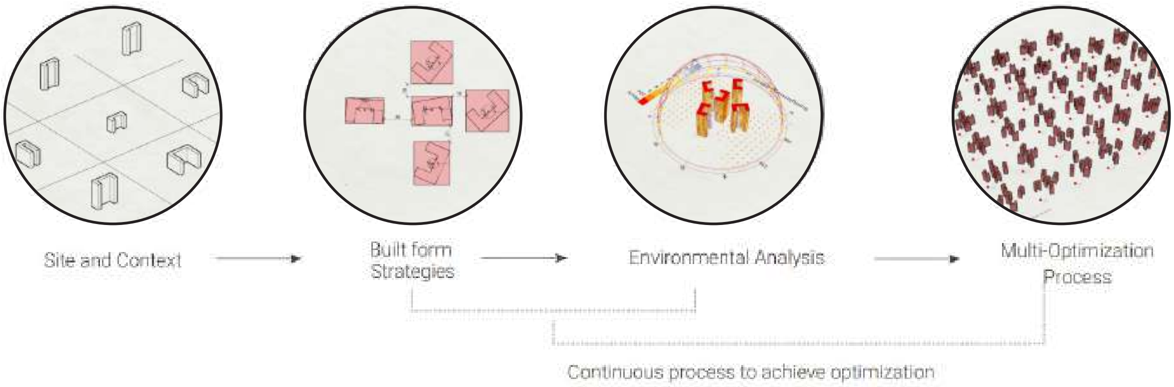


Figure 10: Steps of modelling simulation
Source: Author

Step 1: Site and Context

This step tells us how to enter the temperature data for each place.

The Energy Plus Weather (EPW) data file is used to import all of the weather data for each place into the plug-ins that are being used. For the exercise, you need information like the sun's path, hourly temperature ranges, sun directions, wind flow rates, and so on. All of these numbers are taken from the file about the weather.

In addition to the weather file, the surrounding building model and the site's topography were also used to get the correct results.

Step 2: Geometry formulation

This process focuses on making a framework for figuring out the built-morphology of a highrise apartment, which can then be analysed and simulated to optimise the genetic built-form based on how well it works with the surroundings.

In this simulation process, different design strategies are tested to get different kinds of geometric outputs. The algorithm then looks at how these geometric outputs work in the environment and rates them based on their performance values and fitness factors.

Design strategies are developed on various stages of the process to establish a structured workflow for the simulation. For the optimization process, the range of the variations in the design strategies is predefined before running the simulation.

Built Form Geometry

Length | Width | Height | Distance between building | Orientation

Length & width

As a final approach, the first time through the geometry is done by changing the orientation and the aspect ratio. The ratio between the shape's length and depth tells us what its aspect ratio is. This change in aspect ratio is done in different ways depending on how the geometry is set up. This is done so that the scaling, splitting, and stretching concepts of changing 2d-geometries can be used. (Tutorialspoint, 2020)

Height

Height is an important part of building design because it affects how much light gets in, how the wind moves, and how the space feels generally. (Gou et al., 2017) say that taller buildings can let more sunshine into the upper floors. Height also affects wind patterns, natural airflow, and how things look in an urban setting. To get the most out of daylighting, air, and fitting in with the environment, height must be carefully thought out.

3. Orientation

The next step in this approach is to set the orientation of the resulting shape. Orientation is one of the most important passive design techniques for lowering energy use and making a building better for the environment. It changes how much sun hits surfaces, how much light gets through, and which way the winds blow. (NZEB, 2020)

4.Distance between building

that the best distance between buildings affects how much light gets in, how much fresh air comes in, and how private the view is. A good distance between things lets in more natural light and lowers the need for artificial lighting, while more space between things improves movement and the quality of the air inside. By balancing how well land is used with how much room there is, a built environment is made that is both healthy and peaceful. (He et al. 2018) and (Li et al. 2019)

Step 3: Environmental analysis

Built-morphology's environmental performance is evaluated based on how the design strategy is affecting the environmental performance aspects of the geometry

Criteria 1: Sun hour

For this study, the Ladybird plug-in for grasshopper is used to analyse a part of the sun energy. In the optimisation process, the total amount of direct sun received by the shape is taken into account.
Ladybug
The collection of Ladybug Tools is used by many organisations for creating and teaching about the environment. The tool does a thorough look at climate data to make customised, live visualisations for designing with the environment in mind.

When weather research is done, standard EnergyPlus Weather files (.EPW) are used as inputs. The amount of Sun hour received by the surface is directly related to the amount of total direct light in hour h. This is how the monthly sun houris measured.

Criteria 2: Wind velocity

Grasshopper's butterfly plugin is a useful tool that lets you measure the speed of the wind by using weather files. By putting weather information into the programme, it is possible to simulate and analyse wind patterns and speeds around a built area. This knowledge can help you figure out how the wind affects the performance of a building, including natural airflow, thermal comfort, and general design tactics that are based on the wind.it is measure in m/s

Criteria 3: Daylight and illuminance

The Honeybee part of the Ladybird tools plug-in looks at the amount of daylight and light. For the optimisation process, the amount of the annual study as a whole is looked at.

Honeybee does a full study of daylight and thermodynamics by connecting different simulation engines and script conclusions from grasshopper. To get a correct analysis, the plug-in uses the given building geometry and the defined reflectance value. You can only figure out the sunshine and illuminance for a certain day and time. Honeybee takes measurements of daylight, illuminance, luminance, and radiation for the annual analysis. This gives the total value of the different analyses, which is measured as (lux) and is directly related to the defined analysis methods.so it is mesured as usefull daylight(UDI) the lux between 50-500lux

Step 4: Generative algorithm

The study is based on how well you understand the relationships between the three main areas of focus. Context and place of the shape are thought to be the most important factors, which brings out the needs of the project. The second is built morphology, which looks at the shapes and sizes of buildings. The third factor is how well the shape of the building protects the surroundings.

The goal of this study is to mix these three areas and use multi-objective optimisation to come up with an optimised design solution that works well. This multi-objective optimisation is based on the genetic method given by wallacie, a grasshopper plug-in for multi-objective optimisation.

Wallacie

wallacie is a plug-in for grasshopper that lets you do dynamic design.

The way this plug-in works is based on Dawkins's groundbreaking work. Biomorpher lets you use an interactive genetic algorithm (IGA) to repeat over customizable scripts made in Grasshopper. The dynamic genetic algorithm lets artists take part in the way things change over time.

The first settings
The plug-in needs to know the size of the population at the start and how fast it changes. During evolution, the plug-in lets you change the rate at which mutations happen, but you can't change the size of the population. Plug-in shows different iterations in real time and takes into account their fitness numbers for maximum and minimum fitness standards. The plug-in keeps track of the results of the models as well as the data needed to evaluate them.

CHAPTER 5: DESIGN EXPERIMENTATION

Experiment set-up

1.Site

Figure 11: Sun Path Diagram
Source: Author

2.Geometry

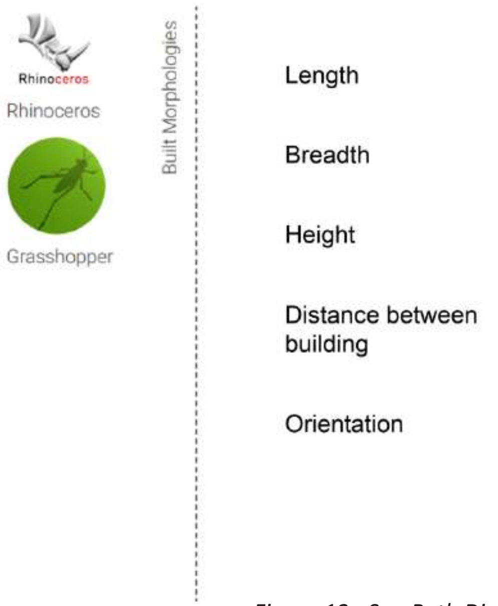


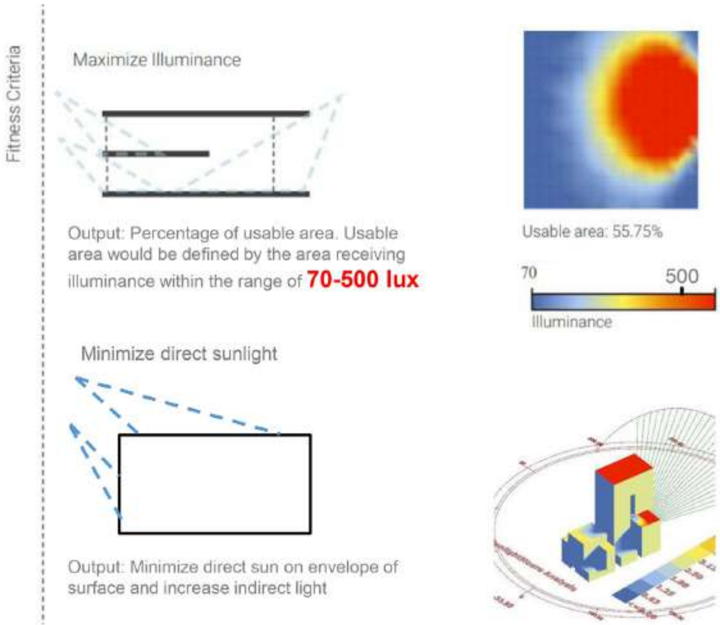
Figure 12: Sun Path Diagram
Source: Author

3. Enviorment annalysis

Reflectance value	Surfaces
0.5 Reflectance	Wall
0.8 Reflectance	Ceiling
0.2 Reflectance	Floor
0.76Reflectance	Single pane window

Table 3: Reflectance value of the surfaces considered for the analysis. These are the standard value set for generic surfaces

(Source: J. Alstan Jakubiec,2011)



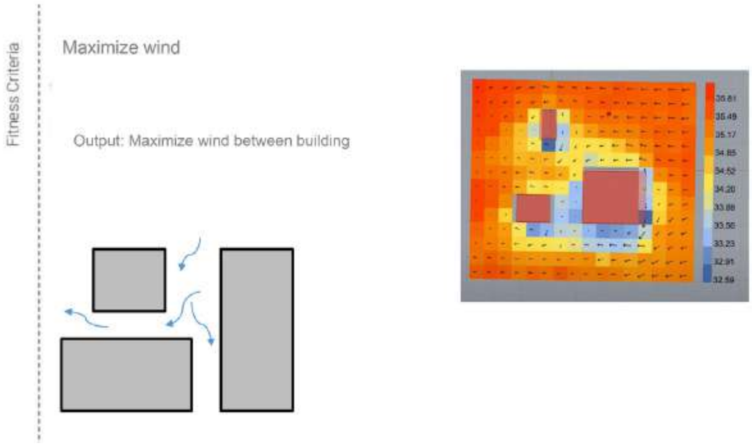


Figure 13: Environmental Analysis
Source: Author

4.Optimization

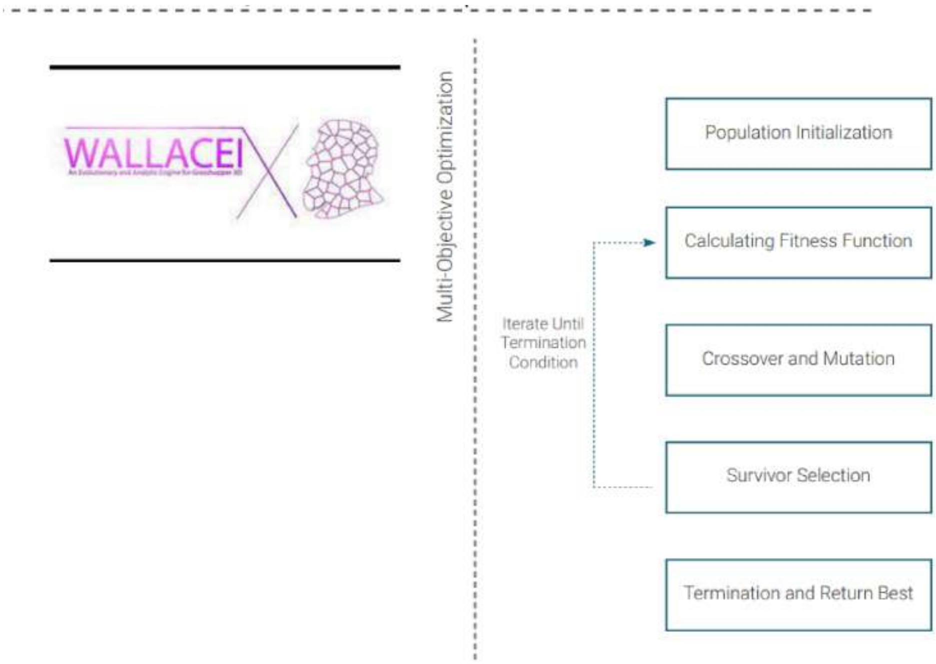
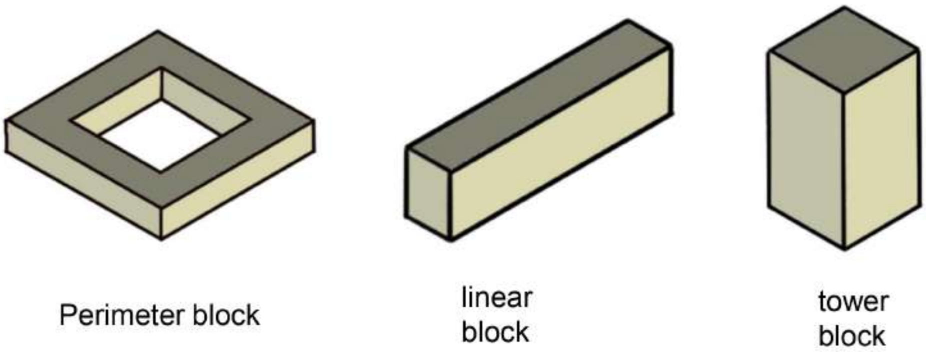


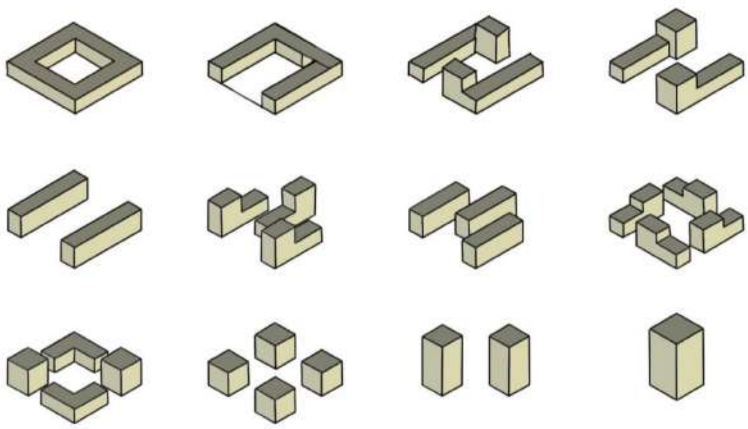
Figure 14: Plugin chart
Source: Author

Step 1 – Typologies Extraction

The three main typology :

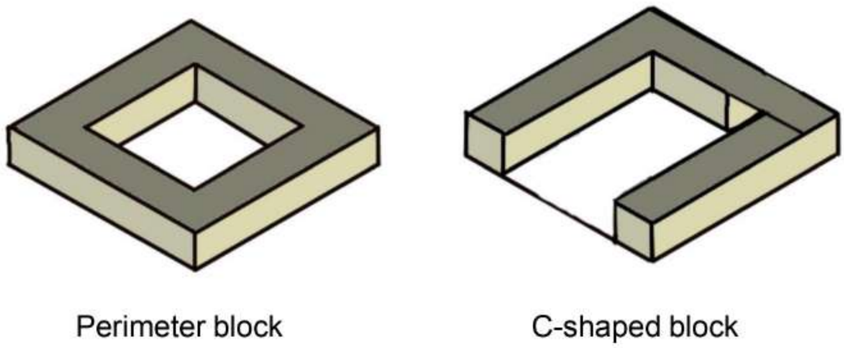


However, it is possible to create additional typologies by combining elements of these basic typologies. These combinations can offer unique design solutions and cater to specific site conditions or project requirements



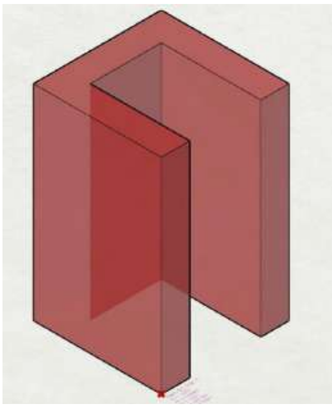
tower and linear block configurations can present difficulties in optimizing direct sunrays due to their vertical or elongated forms.

the focus is on maximizing daylight and minimizing direct sunrays, perimeter block and C-shaped block typologies may offer more favorable conditions since they provide a more enclosed space with controlled sunlight penetration.



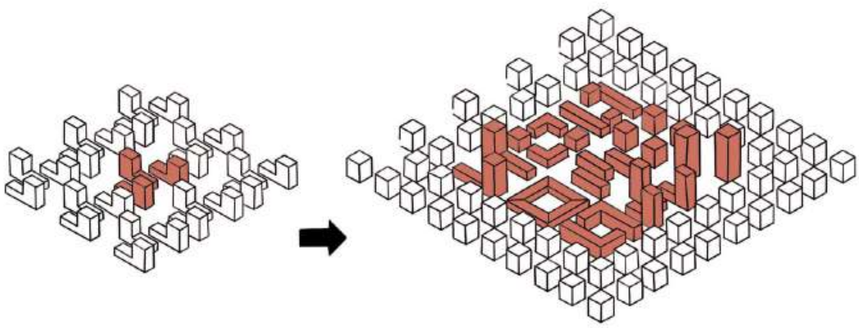
So these two typology are taken further into simulation

Step 2 – optimizing typology

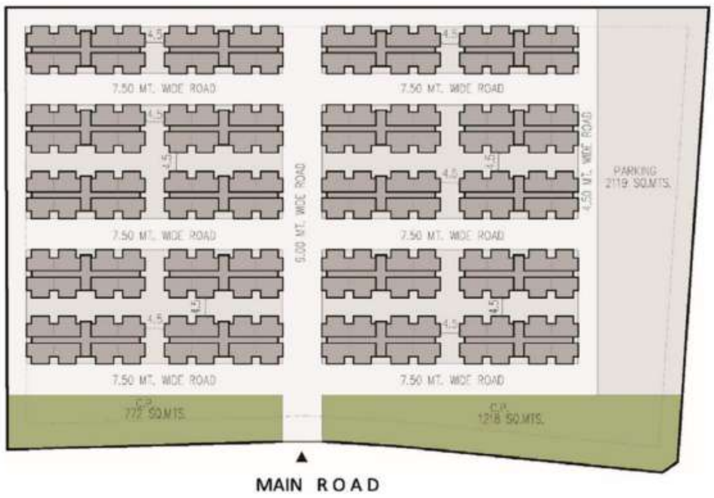


In the first step of the optimization process, each typology is individually optimized to ensure that its design and performance meet specific criteria and objectives. This approach allows for a detailed examination of the strengths, weaknesses, and potential enhancements of each typology on its own

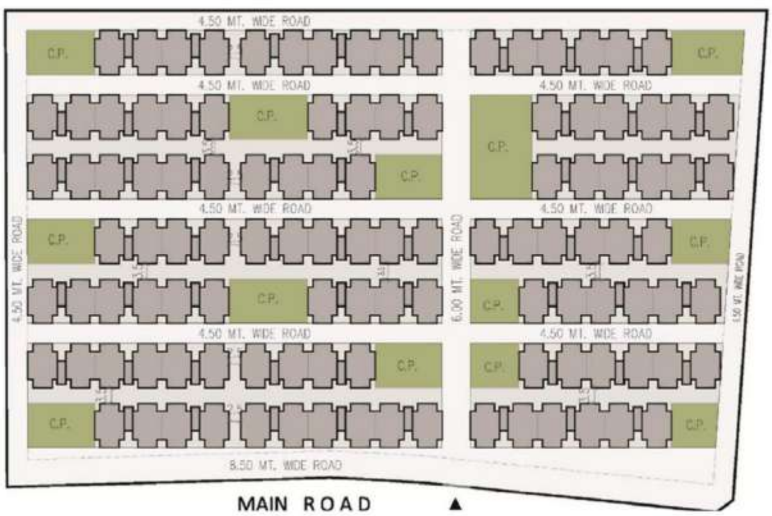
Step 3 – Urban Form Generation Using optimized typologies



Step 4 – Comparing with original scenario



Case-1



Case-2

Figure 15: Existing case diagrams
Source: Research paper

Structure of Methodology

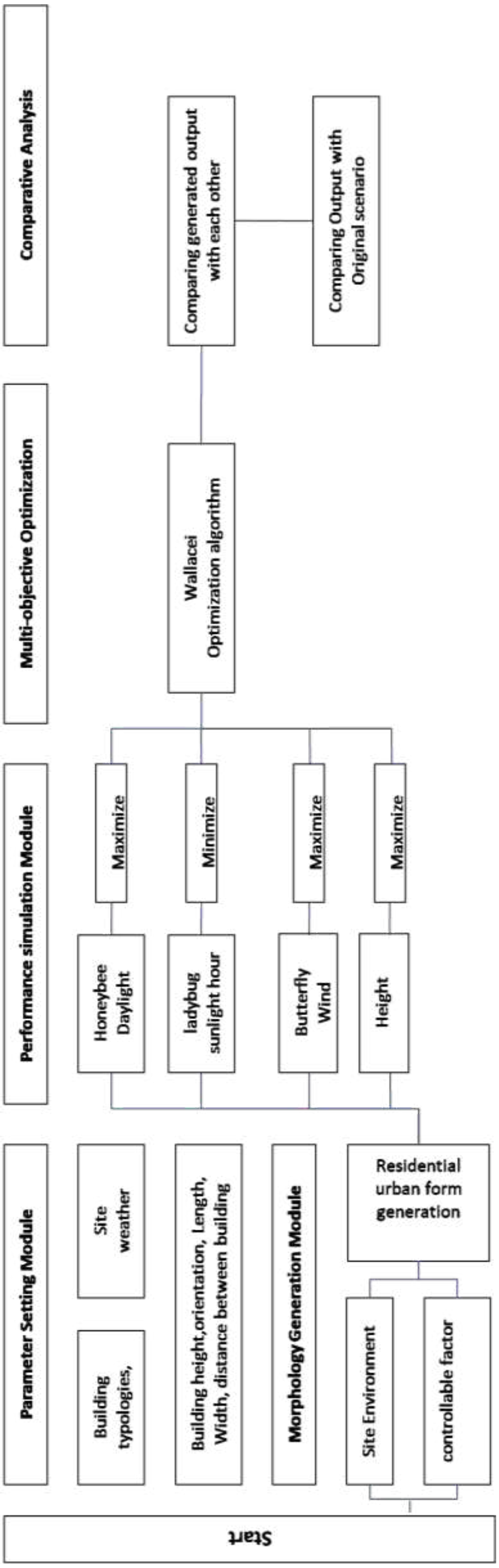
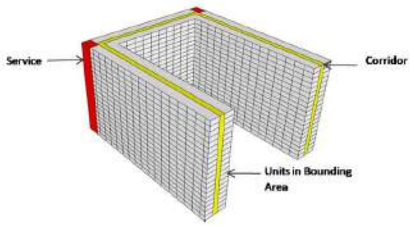
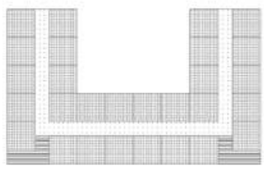


Figure 16: Methodology chart
Source: Author

Conceptual Layout

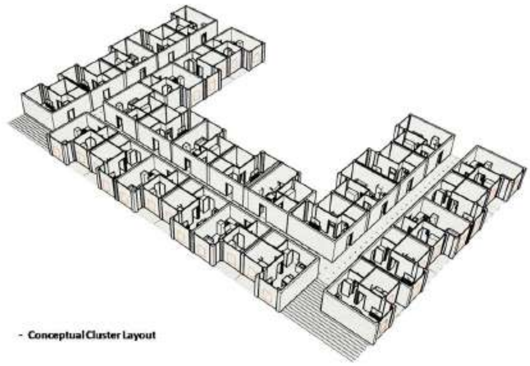




- Maximum Length and Breadth can be taken as 60 Meter

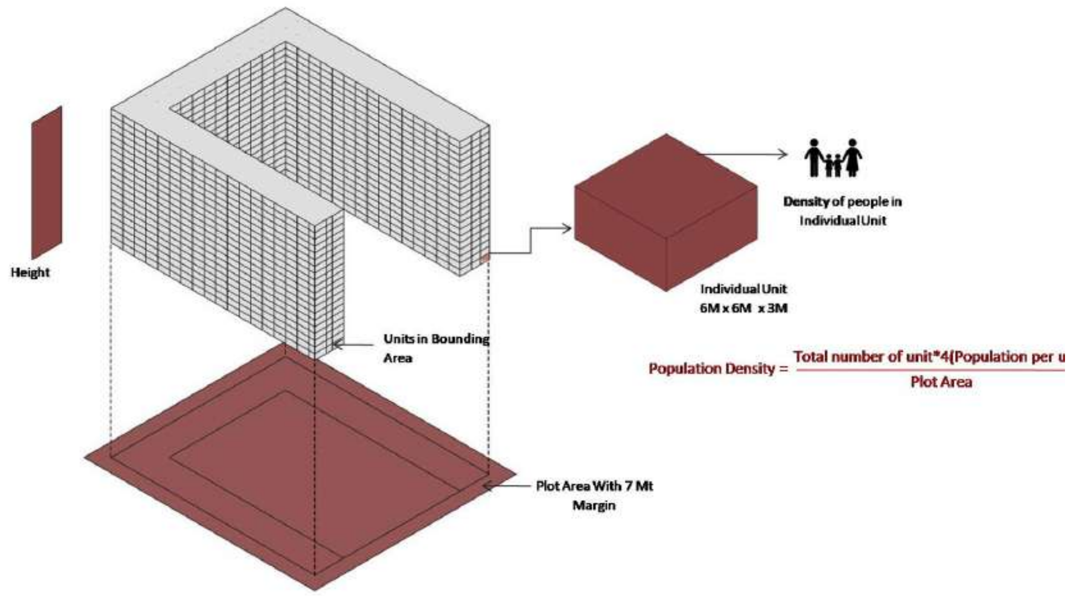
- Conceptual Unit Layout

For this 6 M by 6 M Unit size is taken



- Conceptual Cluster Layout

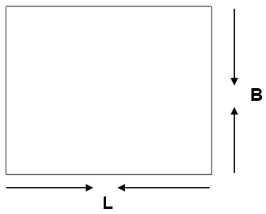
Density calculation



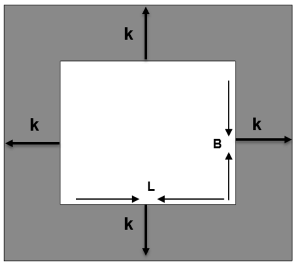
Design Experiment

Experiment 1

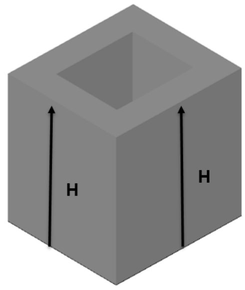
- Geometry 1



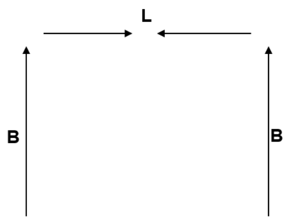
Courtyard having size L: 6m – 60m
B:6m-60m



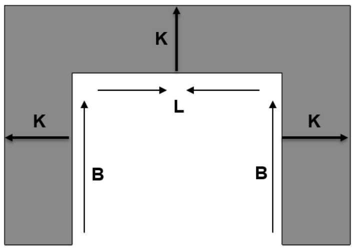
Offsetting K:15 for Built space



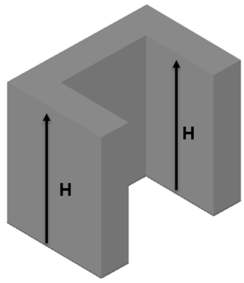
Extruding H:7-35 floor the built



Courtyard having size L: 6m – 60m
B:6m-60m

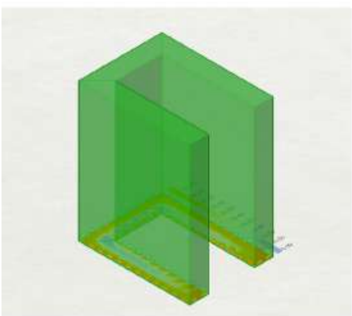


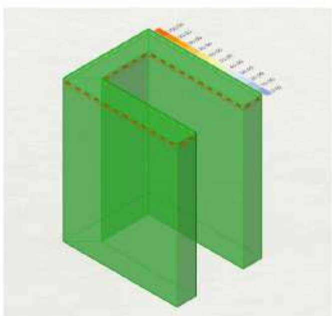
Offsetting K:15m for Built space

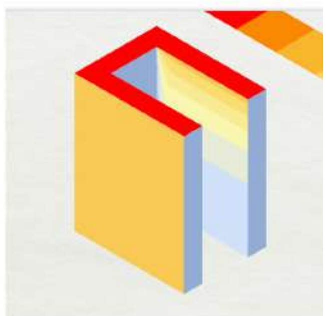


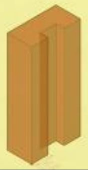
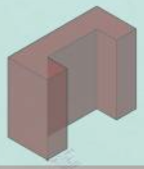
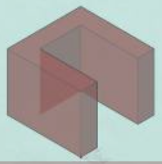
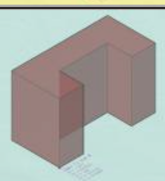
Extruding H:7-35 floor the built

Variable	Constant
Length(L) Breadth(B) Height(H)	width(K)

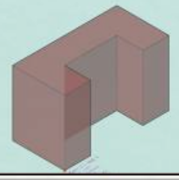
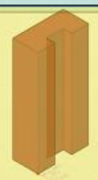
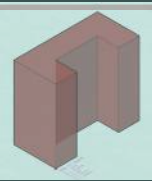




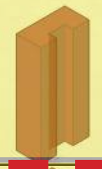
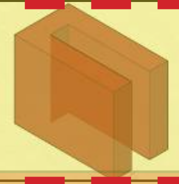
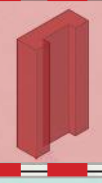
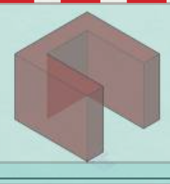
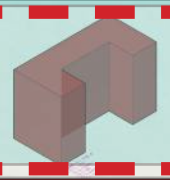
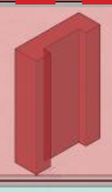
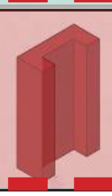


Genration 1	L	B	GROUND COVER-AGE(GC)	GC%	Plot area(m2)	FSI	Total unit(no)	densi-ty(pop/M2)	Height(m)	floor	total sun hour(hr)	courtyard area(m2)	UDI Ground Floor(percent)	UDI Top Floor(percent)
	36	18	576	36	1600.0	9	400	1	75	25	18504	72	46	29
	54	18	792.0	36.4	2176.0	10.19	616	1.13	84	28	25923	180	45	29
	48	24	864.0	36.67	2356.0	3.67	240	0.41	30	10	12617	288	50	33
	72	30	1296.0	34.25	3784.0	9.93	1044	1.1	87	29	40897	864	55	32
	54	54	1656	35.81	4624.0	10.39	1334	1.15	87	29	45291	1260	61	36
	36	66	1728.0	43.2	4000.0	7.34	816	0.82	51	17	30981	648	66	41
	54	24	936.0	36.22	2584.0	5.07	364	0.56	42	14	16630	360	50	33
	54	54	1656.0	35.81	4624	5.01	644	0.56	42	14	27198	1260	60	35
	66	36	1368.0	34.2	4000.0	8.55	950	0.95	75	25	37555	1008	56	33
	48	24	864.0	36.67	2356.0	3.67	240	0.41	30	10	12617	288	50	33

FSI 0-6,7-9,10-12   0-6   7-9   10-12

Genration 2	L	B	GROUND COVER-AGE(GC)	GC%	Plot area(m2)	FSI	Total unit(no)	densi-ty(pop/ M2)	Height(m)	floor	total sun hour(hr)	courtyard area(m2)	UDI Ground Floor(percent)	UDI Top Floor(percent)
	72	36	1440.0	33.49	4300.0	10.05	1200	1.12	90	30	46281	1152	57	33
	48	24	864.0	36.67	2356.0	3.67	240	0.41	30	10	12617	288	50	33
	48	30	1008	36.95	2728.0	11.82	896	1.31	96	32	33028	432	55	34
	54	18	792	36.4	2176.0	10.19	616	1.13	84	28	25923	180	45	29
	54	18	792	36.4	2176.0	10.56	638	1.17	87	29	26568	180	46	29
	36	66	1728.0	43.2	4000.0	7.34	816	0.82	51	17	30981	648	66	41
	48	24	864.0	36.67	2356.0	3.67	240	0.41	30	10	12617	288	50	33
	36	18	576.0	36	1600.0	9	400	1	75	25	18504	72	46	29
	54	54	1656.0	35.81	4624.0	5.01	644	0.56	42	14	27198	1260	60	35
	48	24	864.0	36.67	2356.0	5.13	336	0.57	42	14	15679	288	50	33

FSI 0-6,7-9,10-12   0-6   7-9   10-12

Genration 3	L	B	GROUND COVER-AGE(GC)	GC%	Plot area(m2)	FSI	Total unit(no)	densi-ty(pop/ M2)	Height(m)	floor	total sun hour(hr)	courtyard area(m2)	UDI Ground Floor(percent)	UDI Top Floor(percent)
	36	18	576.0	36	1600.0	9	400	1	75	25	18504	72	46	29
	36	66	1728	43.2	4000.0	7.34	816	0.82	51	17	30981	648	66	41
	48	18	720.0	36.29	1984.0		580	1.17	87	29	24138	144	47	29
	54	54	1656.0	35.81	4624.0	5.01	644	0.56	42	14	27198	1260	60	35
	48	24	864.0	36.67	2356.0	3.67	240	0.41	30	10	12617	288	50	33
	72	36	1440.0	33.49	4300.0		1200	1.12	90	30	46281	1152	57	33
	48	30	1008.0	36.95	2728.0		896	1.31	96	32	33028	432	55	34
	54	18	792.0	36.4	2176.0		616	1.13	84	28	25923	180	45	29
	36	24	720.0	37.89	1900.0	4.55	240	0.51	36	12	12710	144	52	36
	54	24	936.0	36.22	2584.0		780	1.21	90	30	29644	360	50	33

FSI 0-6,7-9,10-12   0-6   7-9   10-12

Infrences

FSI Range	Plot Area Range(m)	Length Range(m)	Breadth Range	Ground Coverage Range	Courtyard Area Range
0-6	<2500	36-72	18-66	576-1296 sq.m	72-864 sq.m
7-9	2500.0-4000.0	36-54	18-54	1368-1728 sq.m	288-1008 sq.m
10-12	>4000	48-72	24-66	1656-1984 sq.m	1152-1260 sq.m

FSI Range	Height Range	Built-Up Area Range	Light on Ground Floor Range	Light on Top Floor Range
0-6	<50	<8640.52	45-55	29-41
7-9	30-75	12528.0-34208.16	46-66	29-41
10-12	70-96	>48295.04	50-56	32-36

Height greater than 75meter have breadth(B) smaller than le
B ≤ L/2

Height between 30m-75m have breadth(B) greater than leng
B ≥L/2

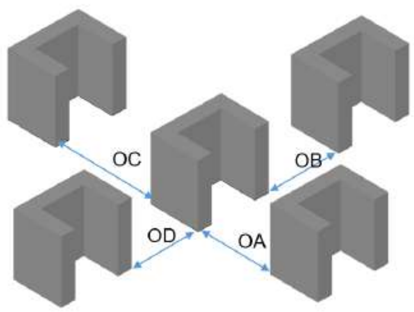
So as height increses the breadth become smaller than le

Experiment 2

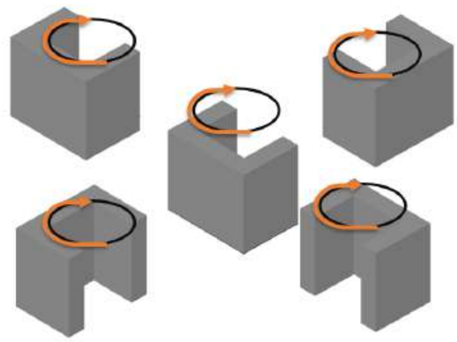
To create an optimized urban form, it is crucial to consider how different typologies come together as a cohesive whole. The combination of typologies can influence the overall spatial configuration, functional organization, and visual character of the urban environment. By conducting Experiment 2, we aim to explore the effects of various typology groupings on the urban form and assess their potential for optimization.

By studying the interaction between typologies, we can identify synergies, explore design possibilities, and optimize the urban form to meet specific objectives. This experiment enables us to evaluate how the grouping of typologies influences factors such as sunlight exposure, shading effects, pedestrian connectivity, social interaction, and overall visual aesthetics.

- **Geometry**

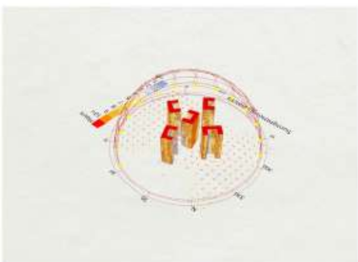


Changing distance from center building
OA,OB,OC,OD 0-100M

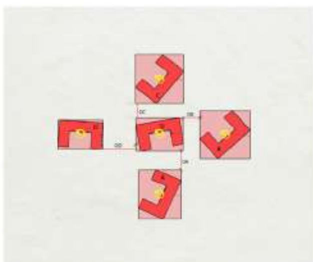


Rotating building 0-360 degree

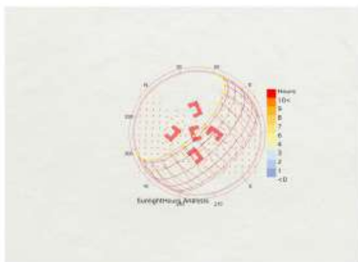
Variable	Constant
Distance Between Building(OA,OB,OC,OD)	Block(l,b,h)
Rotation of block (RA,RB,RC,RD	



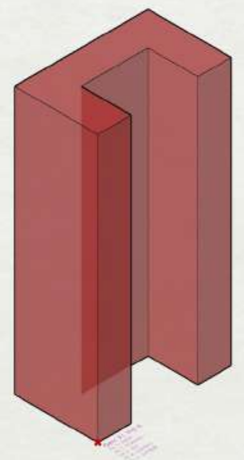
Maximize wind flow between block



Maximize usefull daylight on ground floor



Manimize direct sun light on evelope

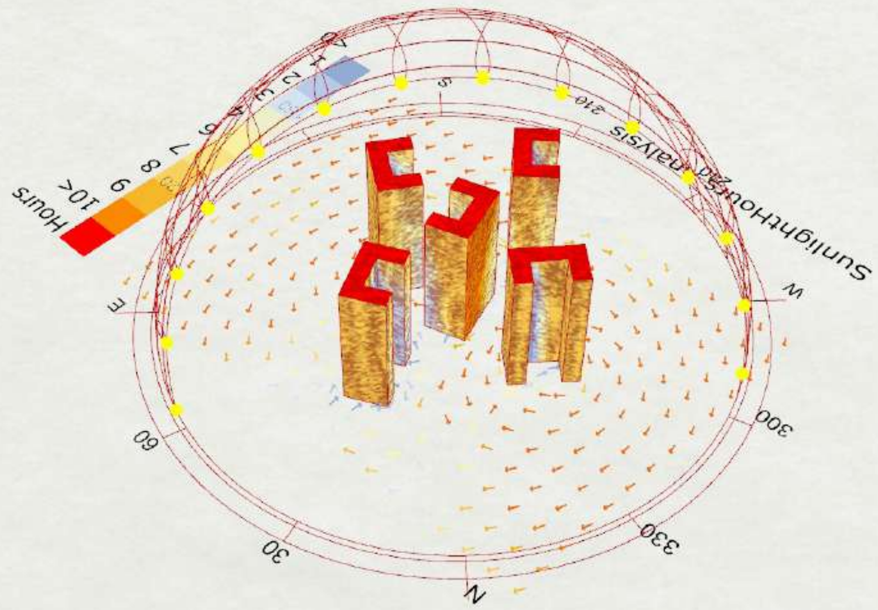


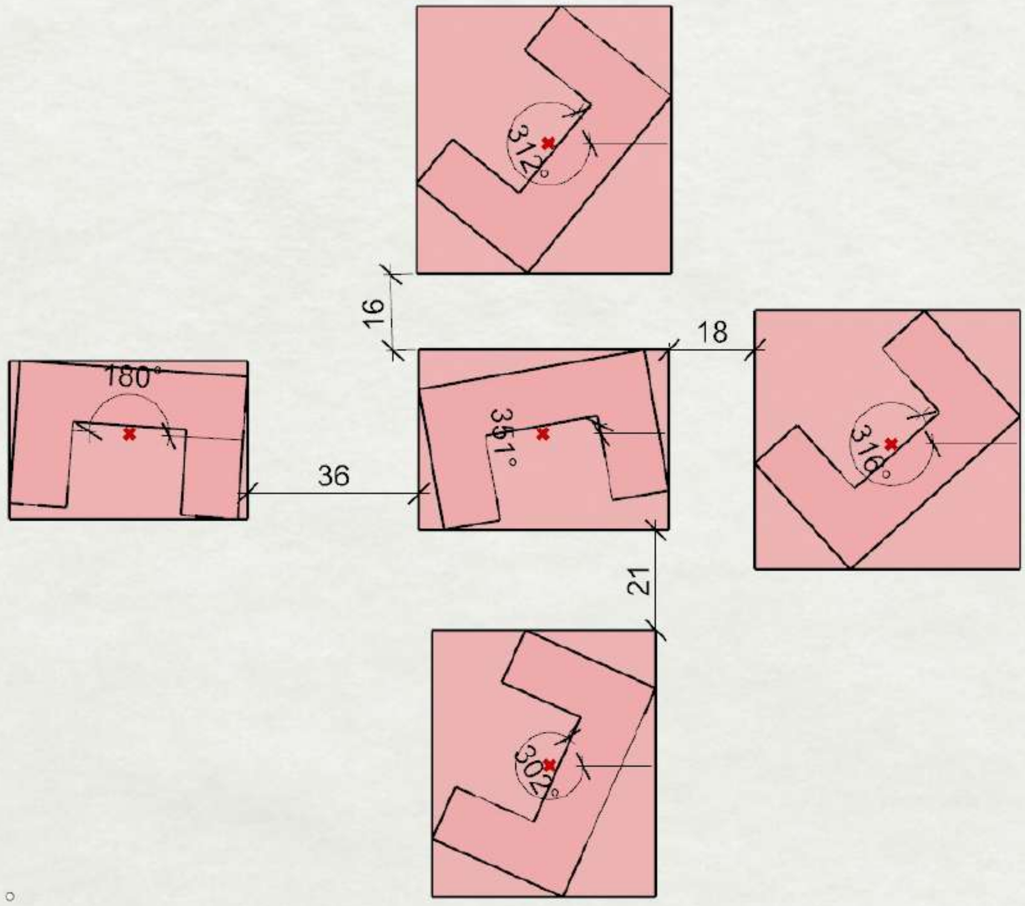
Plot area(m2): 1440.0
Total unit(no): 896
density(pop/unit): 2.49
Height(m): 96
total sun hour(hr): 33028
courtyard area(m2): 432
UDI Ground Floor(percent):55
UDI Top Floor(percent):34

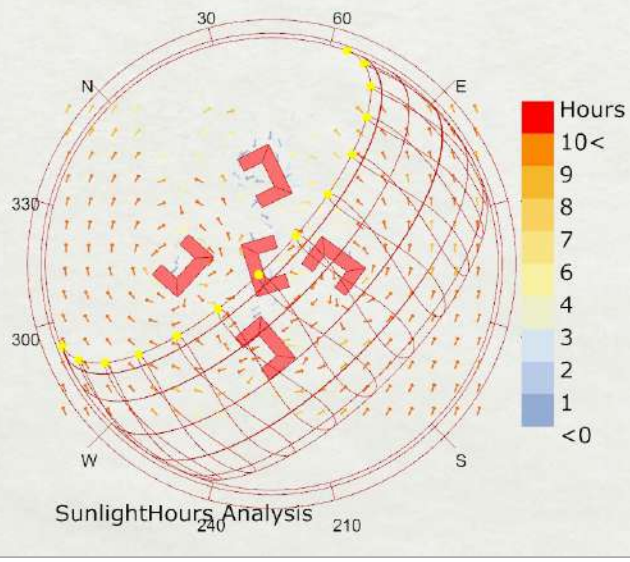
Maximize wind

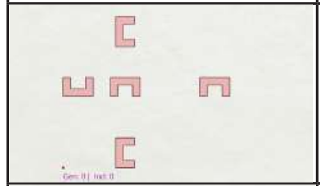
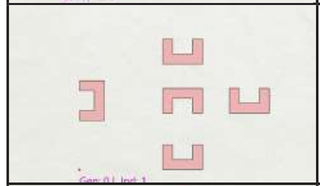
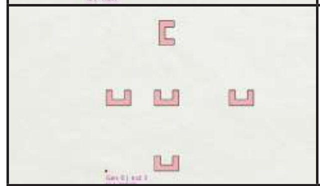
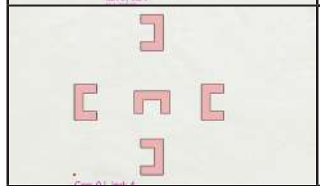
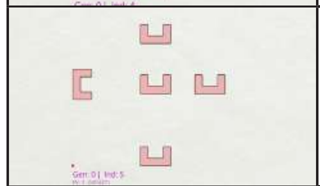
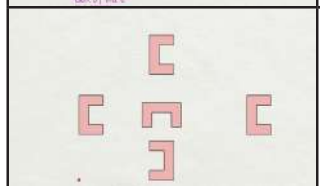
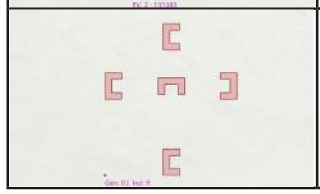
maximize daylight

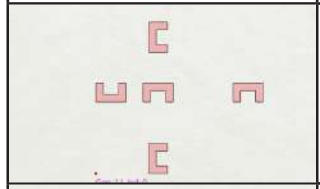
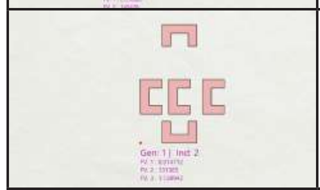
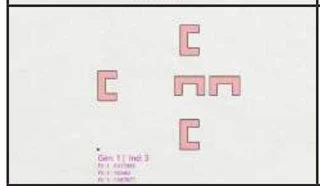
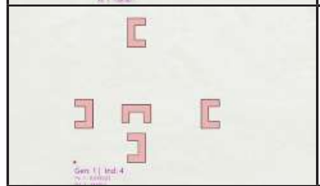
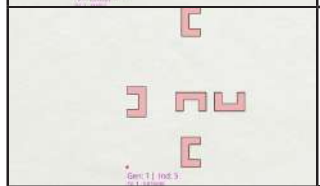
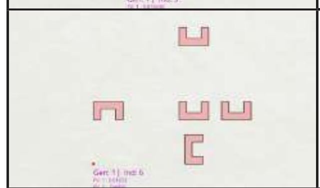
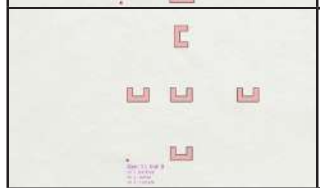
Minimize direct sun light

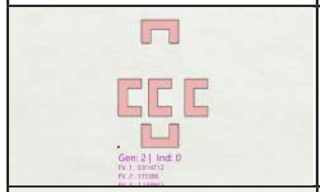
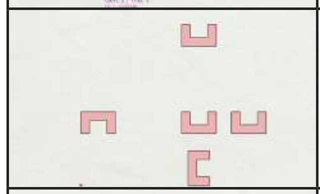
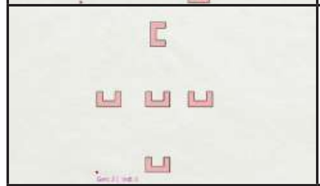
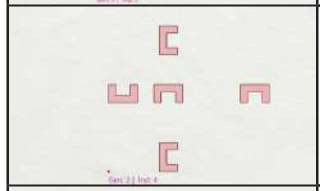
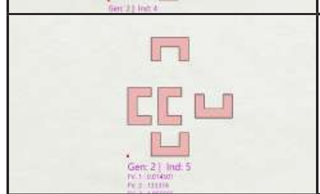
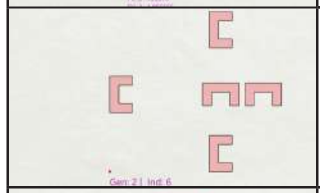
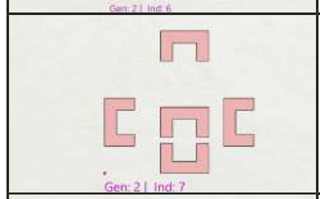
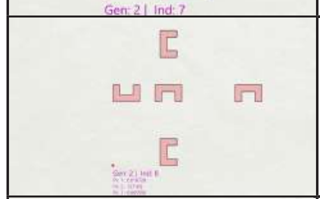


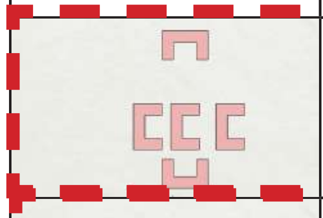
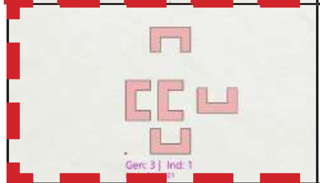
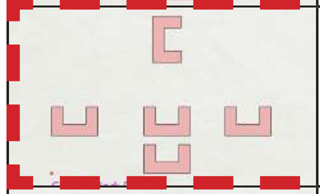
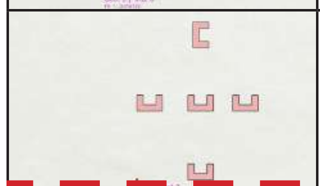

312°
16
18
180°
351°
36
316°
21
302°

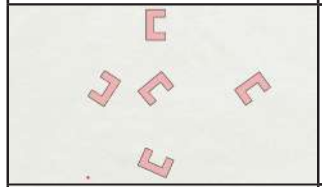
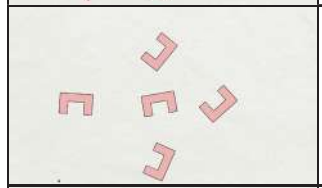
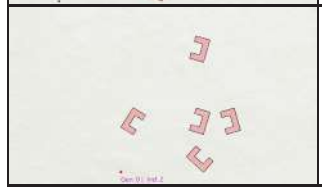
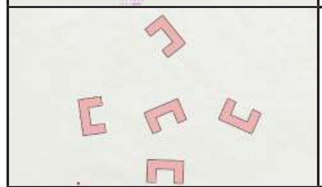
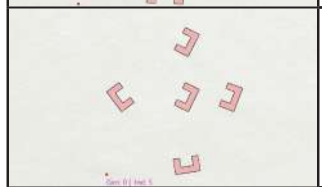
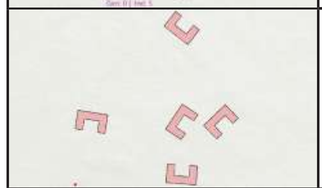
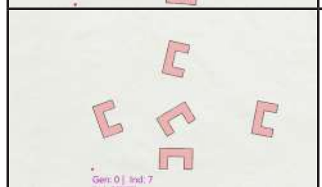
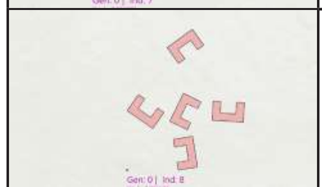
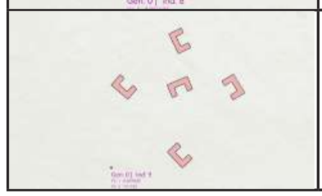

30
60
N
E
330
300
W
S
240
210
Hours
10<
9
8
7
6
4
3
2
1
<0
SunlightHours Analysis

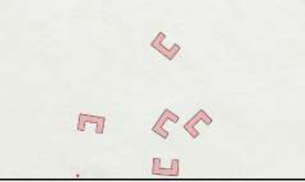
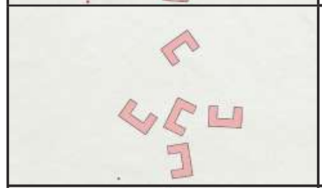
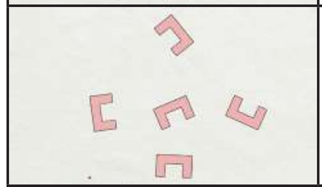
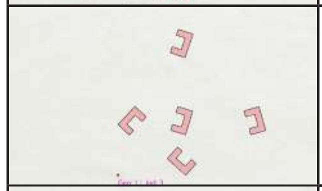
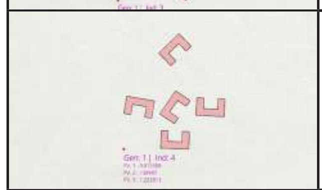
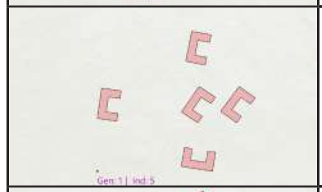
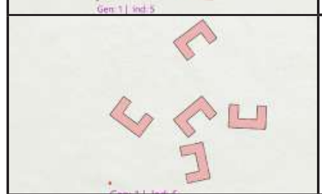
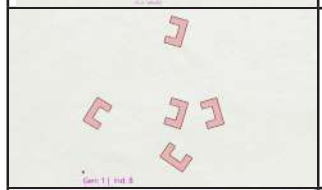
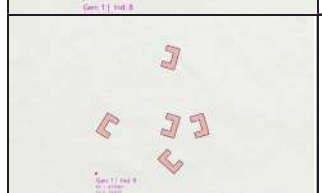
Genration 0	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-66	95	49	-27	90	0	90	180	0	157169	1.036	59.8
	-38	32	29	-70	180	180	180	270	0	147344	0.828	63.6
	-24	21	95	-91	90	180	180	0	180	155072	0.848	61.5
	-99	99	89	-47	180	180	90	180	180	164764	0.892	59.8
	-34	42	54	-50	270	90	270	90	0	144103	0.812	61.5
	-84	38	50	-77	180	180	180	90	180	159793	0.859	61.5
	-39	9	95	-92	90	0	90	270	0	149434	0.751	60.6
	-17	81	35	-48	270	90	90	90	0	145478	0.887	62.2
	-10	17	46	-9	180	90	0	90	90	131385	0.878	68
	-99	64	50	-66	90	270	90	90	0	155226	0.77	59.1

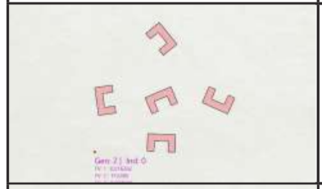
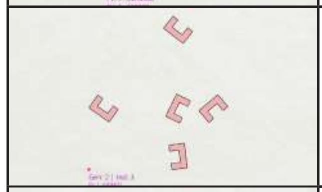
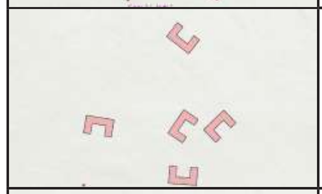
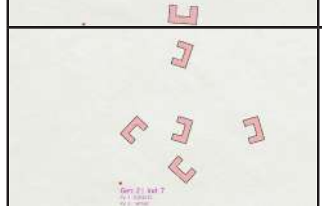
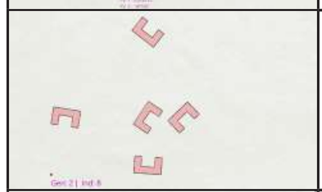
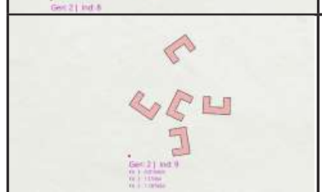
Genration 1	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-66	95	49	-27	90	0	90	180	0	157169	1.036	59.8
	-17	81	35	-48	270	90	90	90	0	145478	0.887	62.2
	-10	17	46	-9	180	90	0	90	90	131385	0.878	68
	-39	8	34	-92	90	0	90	90	0	150462	0.919	62.5
	-17	83	95	-48	270	90	90	270	0	144011	0.886	60.5
	-41	13	89	-47	90	180	90	270	0	148178	0.969	61.6
	-24	21	91	-91	90	180	180	0	180	154856	1.003	61.6
	-99	36	89	-48	180	180	90	180	180	161394	1.025	60.4
	-99	99	89	-47	180	180	90	180	180	164764	0.892	59.8
	-6	15	46	-26	180	90	0	90	0	139945	0.828	67.9

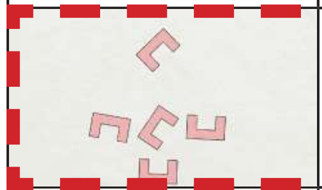
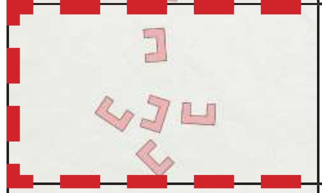
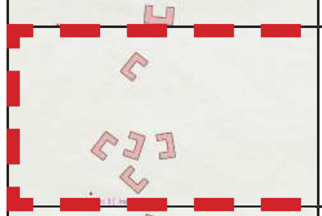
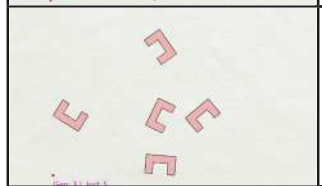
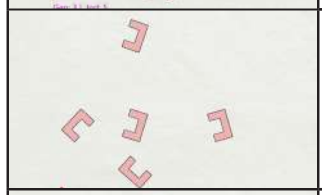
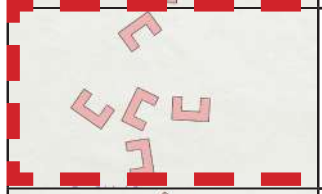
Genration 2	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-10	17	46	-9	180	90	0	90	90	131385	0.878	68
	-41	13	89	-47	90	180	90	270	0	148178	0.969	61.6
	-24	21	91	-91	90	180	180	0	180	154856	1.003	61.6
	-99	36	89	-48	180	180	90	180	180	161394	1.025	60.4
	-66	95	49	-27	90	0	90	180	0	157169	1.036	59.8
	-10	17	34	-9	180	180	0	90	90	133374	0.947	69
	-39	8	46	-92	90	0	90	90	0	151639	0.98	62
	-6	15	46	-26	180	90	0	90	0	139945	0.828	67.9
	-66	95	49	-27	90	0	90	180	0	157169	1.036	59.8
	-39	8	34	-92	90	0	90	90	0	150462	0.919	62.5

Genration 3	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-10	17	46	-9	180	90	0	90	90	131385	0.878	68
	-10	17	34	-9	180	180	0	90	90	133374	0.947	69
	-10	16	46	-9	180	90	0	90	90	130993	0.855	68
	-41	13	89	-47	180	180	90	270	0	147011	1.015	62.6
	-39	13	46	-92	180	90	90	90	0	149661	1.019	63.2
	-9	36	46	-48	180	180	90	180	180	151790	1.214	64.8
	-66	95	49	-27	90	0	90	180	0	157169	1.036	59.8
	-99	36	89	-48	180	180	90	180	180	161394	1.025	60.4
	-10	17	80	-9	180	90	0	90	90	135921	0.789	66.9
	-6	15	39	-26	180	90	0	90	0	139349	0.834	68.3

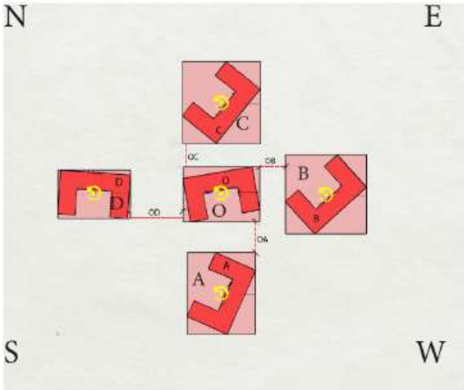
Genration 0	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-66	95	49	-27	156	36	90	237	40	153965	0.944	59.6
	-38	32	29	-70	246	222	231	356	10	152111	0.965	60.9
	-24	21	95	-91	138	286	254	58	253	143222	0.907	60.9
	-99	99	89	-47	252	290	111	258	296	148838	0.794	58.7
	-34	42	54	-50	358	156	309	98	23	153298	1.005	61.1
	-84	38	50	-77	189	249	243	127	244	153840	0.88	60.6
	-39	9	95	-92	176	44	142	351	56	150518	1.076	60.7
	-17	81	35	-48	359	79	77	110	31	145480	0.832	61.5
	-10	17	46	-9	279	177	36	145	64	137084	0.842	64.1
	-99	64	50	-66	133	301	116	139	23	151183	0.879	59

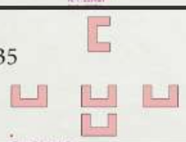
Genration 1	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-39	9	95	-92	176	44	142	351	56	150518	1.076	60.7
	-10	17	46	-9	279	177	36	145	64	137084	0.842	64.1
	-34	42	54	-50	358	156	309	98	23	153298	1.405	63.1
	-24	99	95	-47	138	286	251	47	253	147582	0.988	59.8
	-12	10	43	-9	178	177	44	350	56	139997	0.816	65.3
	-39	8	34	-92	171	54	79	82	56	144457	0.914	61.8
	-6	15	46	-26	282	177	37	143	40	139817	0.877	63.6
	-39	16	98	-92	277	40	142	145	64	145998	0.984	60.1
	-24	21	89	-91	145	286	254	58	253	143472	0.946	61.2
	-24	21	95	-91	138	286	254	58	253	143222	0.907	60.9

Genration 2	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-34	42	54	-50	358	156	309	98	23	153298	1.005	61.1
	-24	99	95	-47	138	286	251	47	253	147582	0.988	59.8
	-12	10	43	-9	178	177	44	350	56	139997	0.816	65.3
	-39	16	98	-92	277	40	142	145	64	145998	0.984	60.1
	-10	17	48	-9	135	177	274	146	252	135570	0.976	64.7
	-41	21	95	-91	138	279	254	58	253	143850	0.983	60.6
	-39	9	95	-92	176	44	142	351	56	150518	1.076	60.8
	-24	100	95	-47	138	286	251	47	253	147582	0.995	59.7
	-39	9	95	-92	176	44	142	351	56	150518	1.076	60.7
	-10	17	46	-9	279	177	36	145	64	137084	0.842	64.1

Genration 3	D-OA	D-OB	D-OC	D-OD	R-A	R-B	R-C	R-D	R-0	SUN HOUR	WIND SPEED	UDI GROUND FLOOR
	-12	10	43	-9	178	177	44	350	56	139997	0.816	65.3
	-10	17	48	-9	135	177	274	146	252	135570	0.976	64.7
	-39	9	95	-92	176	44	142	351	56	150518	1.076	60.8
	-11	21	98	-9	138	279	51	53	252	137125	1.008	63.8
	-24	99	95	-92	138	37	251	47	65	148673	1.016	58.6
	-34	16	54	-92	355	40	305	148	64	149996	1.04	60.7
	-24	100	95	-47	138	286	251	47	253	147582	0.995	59.7
	-34	42	54	-50	358	156	309	98	23	153298	1.005	61.1
	-10	17	46	-9	279	177	36	145	64	137084	0.842	64.1
	-39	9	95	-92	176	44	142	351	56	150518	1.076	60.7

Inferences

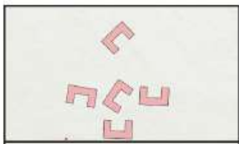
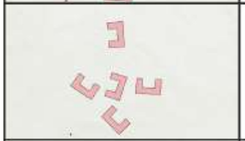


GENERATION	OA	OB	OC	OD	RA	RB	RC	RD	RO	SUN HOUR	WIND	UDI
G30 	-10	17	46	-9	180	90	0	90	90	131385	0.878	68
G31 	-10	17	34	-9	180	180	0	90	90	133374	0.947	69
G35 	-9	36	46	-48	180	180	90	180	180	151790	1.214	64.8
G38 	-10	17	80	-9	180	90	0	90	90	135921	0.789	66.9

•The block arrangement forms a continuous wall on the southern side, creating shadows within the courtyard and reducing sunlight on the southern-facing sides.

•The blocks are arranged in a way that all faces of the courtyard are oriented towards the east, receiving direct morning sunlight.

•The block is repositioned upwards, creating improved wind circulation within the courtyard, which faces the southwest direction to maximize wind exposure

	-12	10	43	-9	178	177	44	350	56	139997	0.816	65.3
	-10	17	48	-9	135	177	274	146	252	135570	0.976	64.7
	-11	21	98	-9	138	279	51	53	252	137125	1.008	63.8
	-24	100	95	-47	138	286	251	47	253	147582	0.995	59.7
	-10	17	46	-9	279	177	36	145	64	137084	0.842	64.1

•By allowing the blocks to rotate freely between 0-360 degrees, an increase in wind speed is observed. However, this rotation also leads to a decrease in useful daylight within the courtyard.

maximize-minimize	OA(m)	OB	OC	OD	RA	RB	RC	RD	RO
max-Average wind	9-11	21-36	46-48	9-48	140-180	180-280	50-90	146-180	180-250
max-daylight	10-12	10-17	43-48	9	180	90-180	0-60	90-150	50-90
man-sun hour	10	17	34-48	9	135-180	90-180	270-360	90-150	252-360 0-90

	-10	17	34	-9	180	180	0	90	90	133374	0.947	69

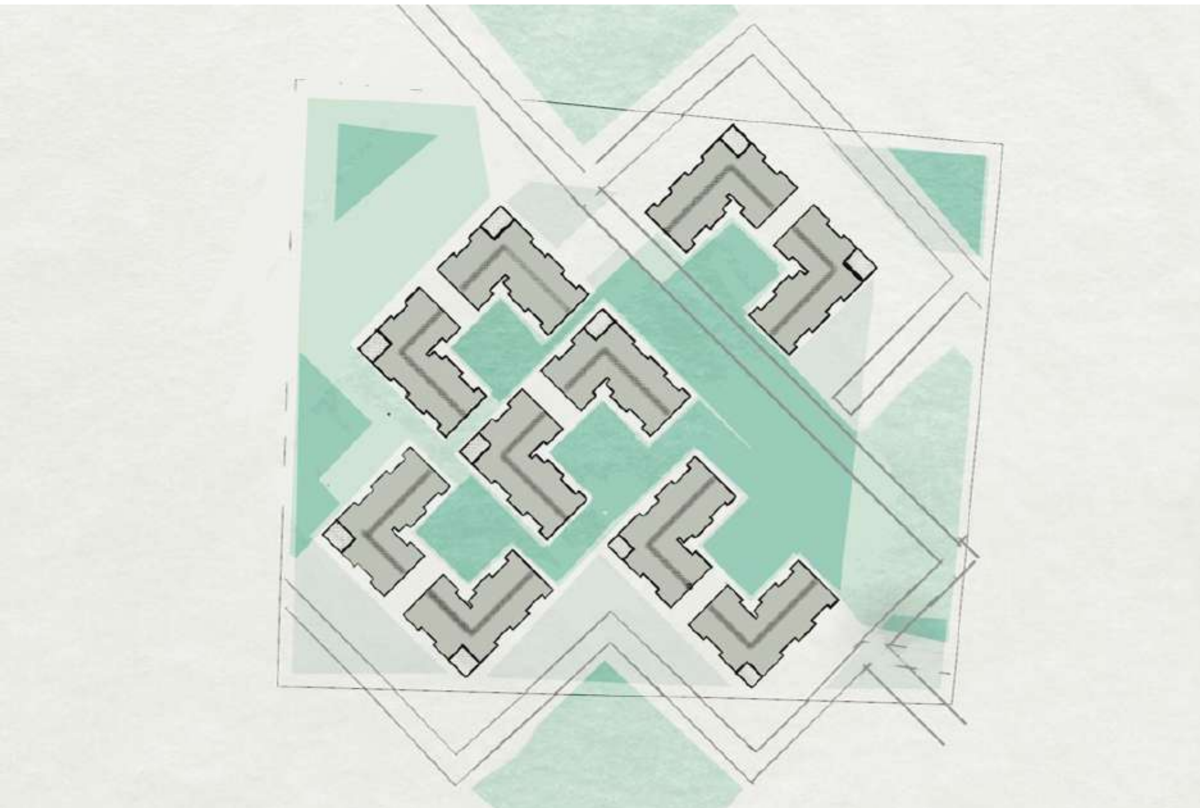
CHAPTER 6: CONCLUSION

Comparing with original scenario

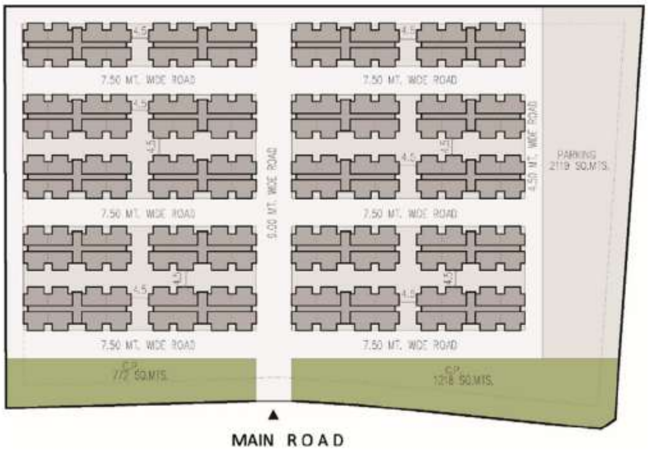
Further comparing the case 1 and case 2 with generated optimized case.

Comparing the cases on the basis of parameters like daylight, average wind speed, direct sunlight hour, green cover, population density.

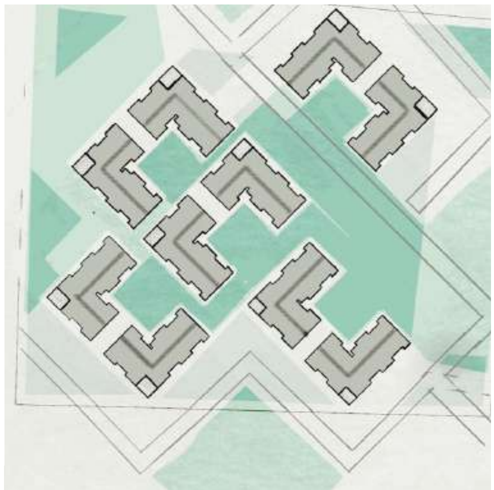
Generated case for comparison are:



Case 1



Generated Case

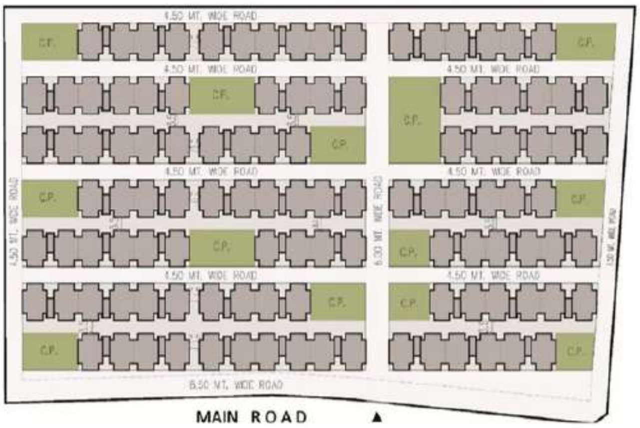


Case-1	If height=96m	If height=15m
UDI(useful daylight 70-500lux)	56%	63%
Average wind speed	0.3m/s	0.3m/s
Direct sun (hr)	193457hr	96547hr
Total unit\(160)	5120	800
Population density	1.04	0.16
Ground cover	6300sqm	6300sqm
floor	32	5
fsi	10.08	1.5
Green cover	3000	3000

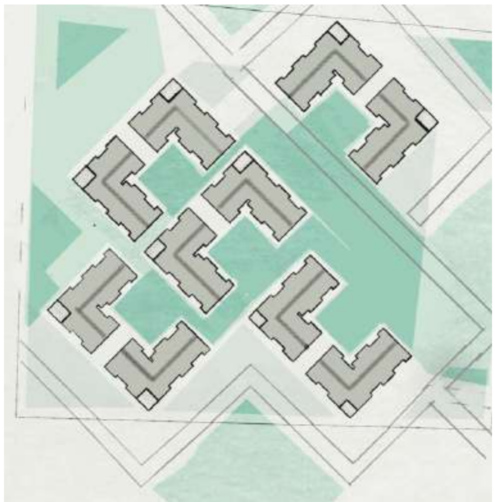
Generated case	height=96m
UDI(useful daylight 70-500lux)	69%
Average wind speed	0.9m/s
Direct sun (hr)	133347hr
Total unit (140)	4480
Population density	0.22
Ground cover	6400sqm
floor	32
fsi	10.24
Green cover	4100

- Plot size for both is 20000sqm
- Generated case has 13% more daylight compare to case-1(96m)
- Generated case has 6% more daylight compare to case-1(15m)
- Generated case has 0.6m/s more wind speed compare to case-1
- Generated case has 1100sqm more green area compare to case-1
- Total unit in case 1(96m) is 5120 and generated case is 4480 because in case-1 unit size is
- 27sqm and generated case it is 36sqm

Case 2



Generated Case



Case-2	If height=96 m	If height=15m
UDI(useful daylight 70-500lux)	55%	62%
Average wind speed	0.2m/s	0.2m/s
Direct sun (hr)	194236hr	96797hr
Total unit (216)	6912	1080
Population density	1.1	0.22
Ground cover	7330	
Green cover	1900	

Generated case	height=96m
UDI(useful daylight 70-500lux)	69%
Average wind speed	0.9m/s
Direct sun (hr)	133347hr
Total unit (140)	4480
Population density	0.22
Ground cover	6400sqm
Green cover	4100

- Generated case has 14% more daylight compare to case-2(96m)
- Generated case has 7% more daylight compare to case-1(15m)
- Generated case has 0.7m/s more wind speed compare to case-1
- Generated case has 2200sqm more green area compare to case-2
- Total unit in case 1(96m) is 6912 and generated case is 4480 because in case-1 unit size is
- 27sqm and generated case it is 36sqm

A Way forward

Moving forward, the optimization of high-rise apartment building typologies and the proposal of new regulations can be accomplished through a strategic approach that involves two key steps:

Optimization of typologies: This involves enhancing existing building typologies or creating new ones that are better suited for high-rise apartment buildings. By analyzing and improving upon factors such as layout efficiency, space utilization, energy efficiency, and comfort, developers and designers can optimize the typologies to meet the evolving needs of residents while adhering to regulatory standards.

Clustering typologies: To further optimize the utilization of space and resources, a strategic approach involves clustering a mixture of typologies within a single high-rise apartment building. By strategically grouping different typologies based on factors such as size, functionality, and target demographics, developers can create a diverse range of apartment units that cater to various needs and preferences. This clustering approach enables better utilization of common amenities and shared spaces, leading to increased efficiency and improved overall livability of the building.

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List of Figures:

Figure 15: Existing case diagrams
Source: Research paper

Figure 16: Methodology chart
Source: Author