Urban Underground Commercial Spaces - Approaches and Planning

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ABSTRACT

Humanity is facing enormous challenges as it moves into the Anthropocene – the era where human intervention is influencing the Earth's natural systems. Human Beings are a part of a transition that requires seeking a new balance between nature and humanity. The transition aims for new paradigms that question the past and show new ways toward a sustainable future. Earth has so much to offer, before leaving this planet in search of other worlds, we believe we should see what underground space has to offer. Urbanization has led to various challenges like pollution, rapid sprawl, environmental degradation, etc that mainly impact two different dimensions ie. Land and Economy. The trend of increasing urbanization results in dense urban spaces creating economic and environmental sectors. Land scarcity has become a major issue due to increasing population and urban sprawl resulting in enormous challenges in urban areas. Decreasing land availability and increasing urbanization has compelled the use of Urban Underground Spaces (UUS). The concept of "0-land use" is an idealistic approach to urban growth and development using just underground space. The use of underground facilities can positively impact the extent to which human occupancy of a land area affects the surface environment. It contributes to the sustainability of the environment in many ways: saving natural resources, including land, water, and biodiversity; reducing air pollution and enhancing the overall landscape and environmental quality. The bold insight of imagining the urban fabric in three dimensions has increased the focus on underground urbanism specifically for commercial spaces considering the footprint and scale. The research paper aims to investigate approaches and planning of Urban Underground Commercial Spaces by analyzing the usage pattern of existing underground spaces and analyzing the usage pattern of existing underground commercial spaces using case study methods. The paper culminates with the identification and enlisting of feasible parameters of the design and construction of urban underground commercial spaces.

Keywords – Underground spaces, Urban Underground spaces, underground commercial spaces, planning of urban underground commercial spaces, land scarcity

INTRODUCTION TO URBAN UNDERGROUND SPACES

"*Underground space can be literally defined as a geospace situated beneath the ground level, which is also referred to as subsurface space, subterranean space, or simply the underground and the subsurface in related studies.*" (Peng, Yong , Sabri, & Atazadeh, 2021) Considering a wider perspective, underground space includes all the elements, either biotic or abiotic, that exist between the ground surface and Earth's core. The significance of the use of underground space in urban areas has been frequently highlighted as a means of addressing the problems caused by rapid urbanization. Therefore, the term "UUS" has been widely accepted with typical UUS characteristics. However, UUS is often confused with the manmade space beneath cities, such as utility pipelines, tunnels, building basements, metros, and garages. These facilities are some of the major concerns of decision-makers and planning practitioners, who generally refer to UUS use to accommodate various urban functions such as storage, industry, transport, utilities and communications, public service, and civil defense. This strategy is considered to effectively extend the limited urban space for meeting the demands of the ever-increasing population. Specifically, such manmade space should be named UUI (Urban Underground Infrastructure), which can be defined as the artificially excavated physical space beneath the ground level of a city surrounded by a rock or soil mass. The underground resources are valuable subsets of UUS, while UUI, which one can consider to be equivalent to physical space, is one of the sub-categories of underground resources. Underground space is a worthwhile societal asset and with our understanding of it, the possibilities of use are rapidly increasing. As Douard Utudjian (1952) so poignantly phrased it nearly 100 years ago: "*It is necessary that the urban planner thinks deep and that underground development of cities is done not through random necessities, but according to a definite commitment, legislate, on and a predetermined plan*." (Admiraal & Cornaro, 2018) A new urban paradigm is required for the cities to overlook the use of underground space. Many challenges lie when considering underground space. It is not just about the ever-growing population on this planet or the mass immigration from rural areas to urban areas, it goes beyond that.

The key questions are:

1. **Incorporating underground spaces will overcome land scarcity?**
2. **Are underground spaces feasible for all the building typologies in the Urban area?**
3. **How will underground space contribute towards the sustainable development of the city?**

This is what an urban underground future is about: enabling cities to develop sustainably and be resilient, liveable, and inclusive. Diverting the vision in this context can there be a place for underground space within urban development. It does, however, entail us to demonstrate that underground space can only come about if it is shown to be part of a sustainable exploration of the subsurface.

NEED FOR URBAN UNDERGROUND SPACES

Underground development is an important tool in developing and reshaping urban areas to meet the challenges of the future. The trend of increasing urbanization is creating problems worldwide, both vertical and horizontal growth of the urban environment needs to be re-evaluated the further sustainable development. The need for Urban Underground spaces arises due to the following reasons –

- To relieve the pressure on the increasingly overcrowded urban surface. These urban dynamics, which are Changning over time, extend not only horizontally and upward, but also downward.
- To meet the demand for "alternating migrations" towards the city center. There is a classic imbalance that is connected via transportation, it plays a very important role to maintain the urban design of the city. Underground spaces would be more sustainable in terms of cost and construction when it comes to transport infrastructure.
- To establish a relationship between underground and above-ground activities. The underground spaces could sustain the maximum risk during seismic activities. The underground space when put to use for useable facilities/ structures, the land above can be used for landscaping, open urban spaces, etc. This will enhance the liveability of the city and make it more habitable.
- To accommodate facilities like libraries, art galleries, museums, swimming pools, sports complexes, etc can be designed underground.
- To meet the increasing urbanization and growing legal framework to acquire land, it has become a difficult and costly affair to take over land acquisition.

Research Gap

Many research studies have been conducted on Urban underground spaces, their typologies and their classification. However, studies related to following aspects needs special attention -

- Urban underground spaces are unexplored in Indian context.
- There is a lack of relevant literature on Urban Underground commercial spaces

UNDERGROUND SPACE AND URBAN SUSTAINABILITY

Urban Underground Sustainability

In 1987, the United Nations Brundtland Commission defined sustainability as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*." The concept itself is much older and stems from the premise that our natural resources are limited. As the Brundtland Commission has stated: "In its broadest sense, the strategy for sustainable development aims to promote harmony among human beings and between humanity and nature" (World Commission on Environment and Development, 1987). There are many ways in which the subsurface can be characterised. The simplest would be to see the subsurface as the foundation of life. We use the subsurface to build our cities. We use the subsurface to sow our crops and to harvest them. We extract materials from the subsurface to fuel our industries and to build our cities. We are exploiting the subsurface for our needs. The subsurface provides us with resources and with services. These resources are non-renewable – they can be depleted. The ecosystem's services are renewable – they can regenerate. This regeneration is, however, limited in the sense that, when the natural processes are disturbed, the ecosystem services lose their capacity to regenerate and will disappear. (Admiraal & Cornaro, 2018)

Sustainable Development Goals

All the United Nations Member States adopted the 2020 Agenda for Sustainable Development based on 17 Sustainable Development Goals (SDGs) that were introduced in 2015 and 169 targets were set that are integrated within the three-fold sustainable development of social, economic and environmental cycles. They are mainly focusing on human rights realization, gender equality, women and girl's empowerment. The figure illustrates the 17 SDGs that must be achieved by 2030, focusing on people, planet, prosperity, peace and partnership. The main vision is "a world free of poverty, hunger, disease and want, where all life can thrive; a world free of fear and violence; A world with universal literacy; A world with equitable and universal access to quality education at all levels, to health care and social protection, where physical, mental and social well-being are assured; A world where we reaffirm our commitments regarding the human right to safe drinking water and sanitation and where there is improved hygiene; and where food is sufficient, safe, affordable and nutritious; A world where human habitats are safe, resilient and sustainable and where there is universal access to affordable, reliable and sustainable energy."

Figure 1 Sustainable Development Goals
(Source: https://sdgs.un.org/goals)

UNDERGROUND SPACE: TYPOLOGY AND CLASSIFICATION

There are a variety of uses for underground space. It is better to group underground space in various classes depending on different parameters, such as position, shape, geometry, and use. Such classification is useful for designers in understanding as to what group/class of underground space is being dealt with by them. Table 1 provides the major classification groupings chosen for underground space use—function, geometry, origin, site features, and project features. Under each category, major subcategories are listed. These subcategories further organize the way in which underground uses are described.

Function	Geometry	Origin	Site Feature	Project Feature
Residential	Type of space	Natural	Geography	Rationale
Nonresidential	Fenestration	Mined	Climate	Design
Infrastructure	Relationship to surface	End use	Land use	Construction
Military	Depth dimensions Scale of project		Ground conditions Building relationships	Age

Function

As mentioned in the book – *"Underground infrastructures – Planning, Design and Construction)"* (Singh, Zhao, & Goel, 2012) Major uses according to their functions are divided into residential, non-residential, infrastructure, and military uses. Uses are further separated into those for which user reactions are important and others for which reactions are either a very secondary consideration or else not applicable. This distinction is considered important as it is easier to develop underground facilities in which user acceptance is not a major issue. There are few examples of residential structures in rock apart from historical and archaeological uses. Non-residential underground structures are more common but are more usually built as cut-and-cover buildings in soil than as excavated or mined buildings in rock.

Geometry

Geometrical information is important in organizing underground space use. The nature of raw space utilized can be separated into uses involving underground caverns, uses developed by surface excavations, and aquifer storage involving the pore space in soil or rock.

Type

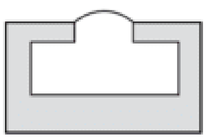
Under geometry, classification by type of space recognizes that most underground facilities are made up of relatively few basic geometric elements— pore space/fissures, boreholes/shafts, tunnels, caverns and trenches, or open pit excavations.

Depth

Classification by depth is always problematic for the wide number of uses and professional backgrounds involved in underground construction. The specific dimensions of excavations may also be used to allow the grouping of similar sizes of cavities for comparison of design and performance. The final category—scale of project—allows a differentiation of projects by overall project scale, complexity, and size of investment.

Relationship of structure with the ground

The element that characterizes underground structures is the relationship between the structure and the ground surface. Based on this criterion, the uses of underground space may be subdivided into four categories.

Description of Type of Under-Ground Structure	Relationship between Structure and Ground Surface	Main Users	Effects on Aboveground Environment
Located totally underground	Structure is totally below the surface	Shelters, storage, urban traffic facilities, supply management facilities	Preserves open space
Buildings having some floors above-ground and some floors underground	Structure uses both aboveground and belowground space	Offices, pedestrian walkways, parking, warehouses, industry substations	Aboveground buildings can receive more sunlight; deals with height limitations
Atrium-type structures 	Structure incorpo-rates atrium(s), sky-light(s), to connect the surface with the underground	Pedestrian walkways, residences, sports facilities	Very effective way to preserve scenery and open space aboveground
Underground structures that incorporate shafts	Depends on type of shaft; structures are mainly suited to an inclined plane	Storage facilities, residences	Preserves natural scenery

Fenestration and Ground Relationship

The differentiation by fenestration and relationship to surface is typically unimportant for rock structures as compared to earth-sheltered buildings. The major elements of the classification scheme were presented by Labs (1976) and it is mostly used for small near-surface buildings. The large-scale uses often involve several or all of the individual fenestration/ ground relationships within the overall scheme.

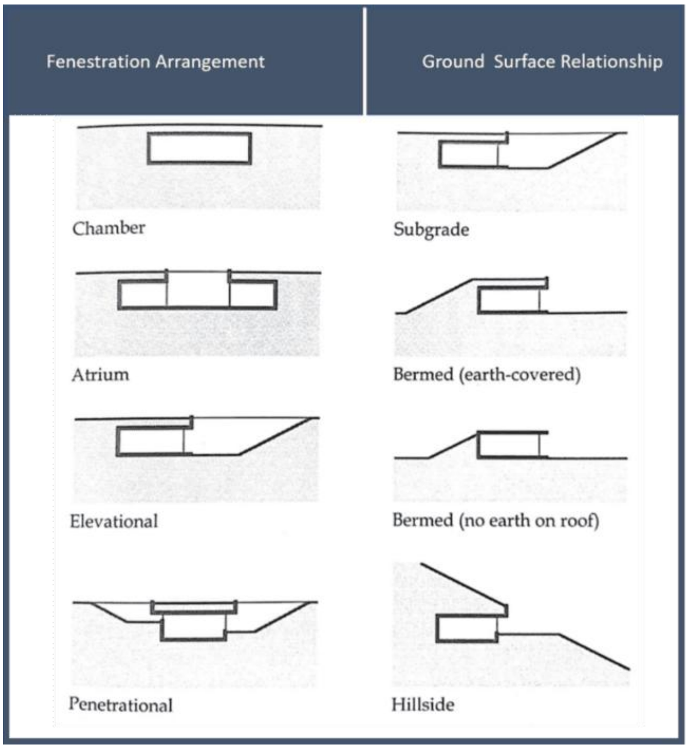


Table 3 Classification of underground space use by fenestration and ground surface relationship (Labs 1976)
(Source: Underground Infrastructure – planning, design and construction)

Size

Size depends on two principal aspects –

1. The size of individual spaces in the terms of access and clear span. It includes widths, heights, clear spans, and diameters.
2. The other important is overall size and complexity. Investments, social impacts, administrative problems etc.

URBAN UNDERGROUND SPACES - IMPORTANT DESIGN CONSIDERATION

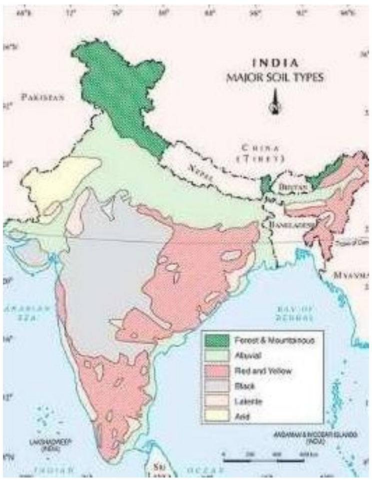
There is a major difference in construction as it depends on various other factors like the Geological factor, the formation of rock, hydrogeological factors, and the type of soil on which the construction is going to take place. The method of construction, cost of construction, time span required for construction, cost of land etc depends on the stability and workability of ground. While designing and constructing underground structures few very important aspects are considered in terms of geology, climate, psychology, engineering, cost and technology used for development.

Design Considerations

The design of underground structures is commonly for shear waves propagated vertically from the bedrock. The vertical propagation of the shear wave causes the horizontal movement of soil. While designing the underground structure, the following aspects are considered.

Geological Considerations

In accordance with the climate, geology controls the flow and action of surficial water, the extent and location of groundwater resources, and the design for the foundation of other buildings. The city sites are classified indicating both morphology and the rock or soil materials. Technically, the cities lying directly on bedrock provide better foundations together with better opportunities for the use of underground space. Map 1 shows the different types of soil found in India. Many cities do not fit into one general classification. Apart from the subsoil conditions and morphology, local geological features are of utmost importance which includes location, orientation, and design of underground works. The geological factors controlling underground construction in rock is the self-nature of rock. Basically, the rock system of India is divided into 4 major divisions based on this complex and varied geological



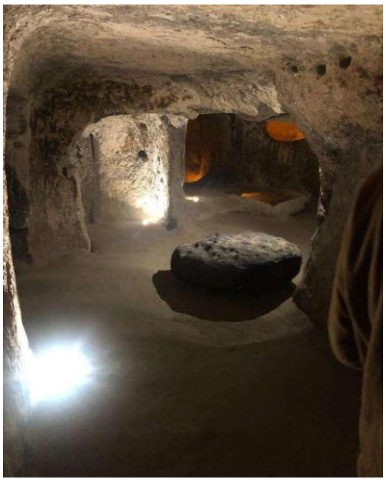
history – The Archean system, The Purana rock system, The Dravidian rock system and The Aryan Rock system.

Climatic Considerations

As per ECBC, India is classified into five climatic zones namely Hot and dry, Warm and Humid, Composite, Temperate, and Cold. The response of subsurface or underground surfaces varies in various climatic zones. The design principles depend on variable climatic factors along with geographical location and geographical context. The factors are

- Temperature
- Humidity
- Precipitation and groundwater condition
- Ventilation or wind flow

In underground space, the ground weather occurs below the earth's ground surface as the temperature of air has an influence on the underground temperature but it gradually decreases as the distance increases below ground. The air at the surface and the earth's ground surface due to differences in temperature heat exchange takes place. Warm air will warm the ground and vice versa for cold air. Cappadocia is the deepest underground city and has a 55m ventilation shaft. The city is a masterpiece in engineering because of its innovative ways of construction. They have holes at different levels to allow wind to pass through.

Psychological and Physiological Considerations

Underground structures have the advantage of various benefits but it is important to recognize the negative association with underground spaces including darkness combined with humid, stale air and lack of sunlight. Among the most powerful associations are those related to those of burial or fear of being entrapped and the fear of being lost or disoriented. The main reason for disorientation is one cannot find a normal reference point such as sun, sky, ground or any adjacent objects and spaces. Due to loss of connection between natural world and the variety of changing weather conditions and sunlight. Underground spaces display a wide spectrum of physical characteristics and functional uses. The

continues concern of overcrowding people in the underground reflects few historic images of dark, damp environments that linger our mind.

Although lack of sunlight and view, inadequate lighting and ventilation, and fear of structural collapse were seen as drawbacks for some workers, many positive advantages were cited as well. These included constant temperature, protection from weather extremes, a unique work environment, a quite space with few distractions and a safe environment protected from disasters.

Considerations for Construction

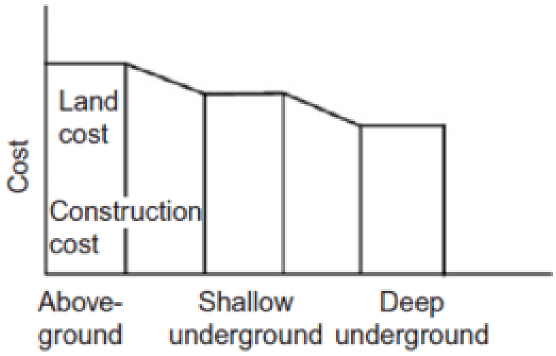
The underground structures are generally built with concrete as it is the strongest and most durable building material. Steel is often used in conjunction with concrete to add stability to the structure. Apart from material usage, there are other aspects to be decided as a part of construction like engineering, cost and technology used.

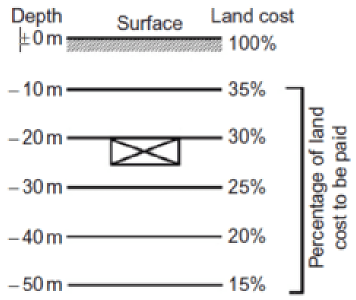
Engineering:

Underground engineering can provide a means to reduce energy use, increase green space preservation and sustainably help to conserve and store water and waste and enhance the quality of life. The ground is self-supporting up to a certain span limit.

Cost:

The cost of construction of underground structures is more expensive than surface construction. Some combinations of the geologist environment, the scale and the type of facility may provide direct savings in construction costs. On the other hand, the initial cost of land purchase is saved. Land or lease cost for an underground project can range from site purchase for the project that usurps the surface use to a very small percentage of land/property value if no impact on the existing surface use will occur the owner has little opportunity in developing use at the proposed depth. According to the book *"Underground Infrastructures*: *Planning, Design, and Construction"*, the cost of land decreases with depth as shown in the Fig 5. Underground space has become an important resource for optimizing urban spatial structure, increasing urban capacity, improving urban efficiency, enhancing disaster prevention and mitigation, alleviating traffic congestion, and improving public services and infrastructure. Considering environmental factors and social benefits in the whole life cycle of the project, underground facilities can become the number one priority for infrastructure development." (Sulaiman & Devi, 2020)





<u>Legal and Administrative:</u>

After considering all the merits of the use of underground spaces, the biggest pause point is – who owns the land? Legal and administrative decisions may act as a restriction in the development and use of underground space. In India, there are no rules or bye–laws for the construction of underground spaces. There are several issues that need to be focused while designing the underground structure. Humankind has started digging the earth for their daily needs and thereby interfering with the ecosystem. Contribution and participation in this study should be considered urgent. There are many prospects under legal and administrative consideration which need special attention while designing urban underground spaces.

URBAN UNDERGROUND COMMERCIAL SPACES

Commercial space is used by businesses for trading their products with consumers. *"Commercial property is real estate that is used for business activities"* (Chen, 2021). Commercial buildings are further classified into five categories, which includes:

- Office
- Retail – Retail stores, Shopping centres, shops
- Industrial – Warehouse, Factories
- Leisure – Hotels, pubs, restaurants, cafes, sports activities
- Healthcare – Medical centres, Hospitals, Nursing homes

The urban commercial layer encourages the concentration of retail, office, and service businesses in locations that serve as hubs for neighbourhood and city-wide consumer activity. Urban commercial streets are pillars to a city's economic growth. They are vital to the liveability of any city because it emphasizes the lifestyle characteristics that are defined by the patterns of activity from social to cultural values of a population leveraged by shopping habits (Balasubramanian, Irulappan, & Kitchley, 2022). Underground streets in modern cities connect to various buildings or infrastructures. The form of its existence may be an independent entity or attached to some other buildings. The following aspects of function to improve the living environmental conditions:

1. Urban traffic function
2. Commercial supplementary performance
3. Comprehensive environmental improvement function

Location	Climatic data	Geography	Soil condition
City: Pune, Maharashtra Latitude: 18°52'°N	Moderate as per IMD Warm and Humid as per ECBC	Basaltic rock formation	Shallow well drained, clayey soil

The underground market is located near the Pune railway station, Agarkar Nagar. It was earlier used as a link from the Bus station to the railway station, which is now obstructed by a newly constructed parking unit. The daily footfall of the active market street is 800 people and during weekends it exceeds 1500 people.

Water level	Surface activity	Usage pattern of UUS	Wind/ ventilation	Daylight	Artificial Daylight
The water level on site is 10-15 m below ground level	• Road • Pedestrian street	Market	Natural ventilation through the opening.	The daylight is entered via the dome-shaped opening along with those from the different gates	All the shops have individual lights along with main COBs in the passage

Categories	Description
Universally accepted	The 2 entry and exits are through the ramps thereby making it universally accepted.
Safety	There are 10 CCTV cameras in working conditions. The market is safe for women and children as it is crowded almost throughout the day and night.
Entry/ Exit	There are 3 entry exits connecting different streets through a single underpass
No. of shops	60
Waste management	The dustbins are provided which is maintained regularly.
Material used	Ceiling – RCC Flooring – Vitrified tiles Walls – Brick walls with paint
Structural system	RCC Structure
Height of structure	3.5 m
Psychological impact	the people are quite comfortable in summers and winters. Suffocation is not an issue

Location	Climatic data	Geography	Soil condition

City: Mumbai, Maharashtra Latitude: 19°07'°N	Moderate as per IMD Warm and Humid as per ECBC	Black Deccan basalt	Alluvial and loamy

The underground market is located in the VT railway station. It is connecting different parts of station. The market has wide variety of low-cost products like clothes, games, mobile accessories, toys etc.

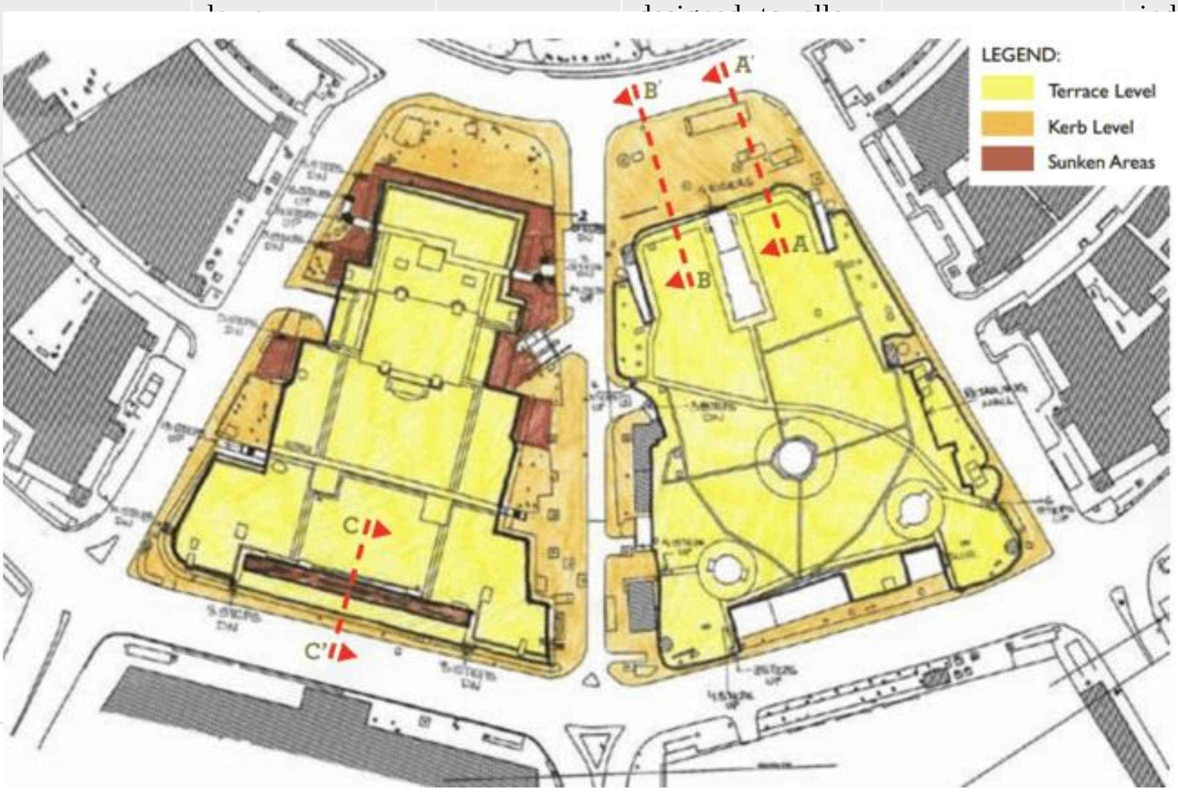
Water level	Surface activity	Usage pattern of UUS	Wind/ ventilation	Daylight	Artificial Daylight
The water level on site is 8.34 m below ground level	• Road • Pedestrian street	Market	No natural ventilation. VRF System is installed but it is not in working condition. there were exhaust fans installed in front of every shops	No natural daylight	All the shops have individual lights along with main COBs in the passage

Categories	Description
Universally accepted	The entry and exits are through the staircase which is not universally acceptable by all
Safety	There are 15 CCTV cameras in working condition. At night it is locked and closed so the sectary is not an issue
Entry/ Exit	There are 4 entry/exits leading to different parts of station
No. of shops	75
Waste management	The dustbins are provided which is maintained regularly.
Material used	Ceiling – Cement sheet Flooring – Vitrified tiles Walls – Brick walls with paint
Structural system	Load bearing
Height of structure	3.0 m
Psychological impact	People feel suffocated when it is overly crowded or during harsh summers.

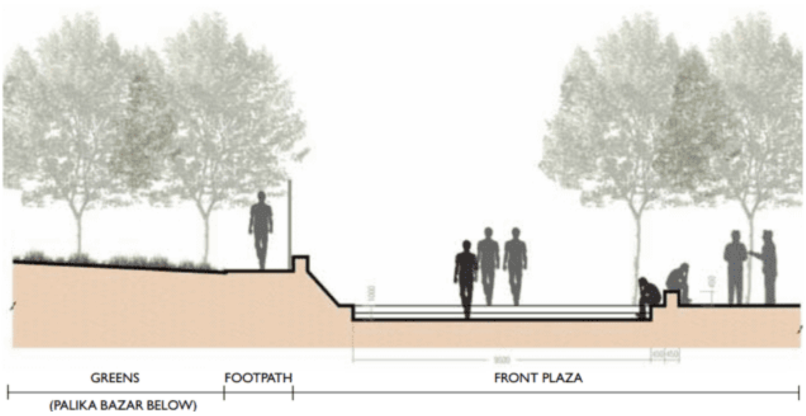
There are two underground activities taking place, first is the underground Market and other is Parking. Both the activities are used on regular bases and is successful in terms of operation.

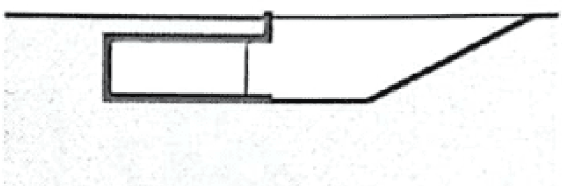
Location	Climatic data	Geography	Soil condition
City: Delhi Latitude: 28°04'°N	Moderate as per IMD Composite as per ECBC	Older alluvial plain	Alluvial and loamy

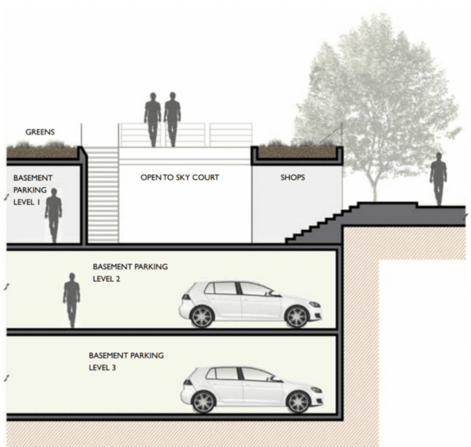
Water level	Surface activity	Usage pattern of UUS	Wind/ ventilation	Daylight	Artificial Daylight
The water level on site is 15-20 m below ground level	The open space Above parking is used as Charkha museum, Weaver's enclosure and ticket counter also some part is used as open l...	Underground market and parking	Palika bazaar is a fully air-conditioned market but there are outlets provided to allow the air exchange. The ventilators are beautifully ...	The ceiling is dome shaped with aquamarine glass that filters sunlight and gives a vintage look to the entire complex.	Majorly the market and parking depend on artificial source of light. COBs are installed in the passage and i..ividual ...p owners ...e separate ...ts in their ...p as per ...uirement.



Surface activities above	Activities	Services
Parking	Charkha musuem - Weaver's enclosure and ticket counter - open lawn	Fire control room, Transformer, D/G Room, NDMC Dhalao, Toilets, Regal sump, AC Plant room, cooling water tank, sump, electric sub station, fire hydrant sump
Underground market	Open Lawn, walkway	





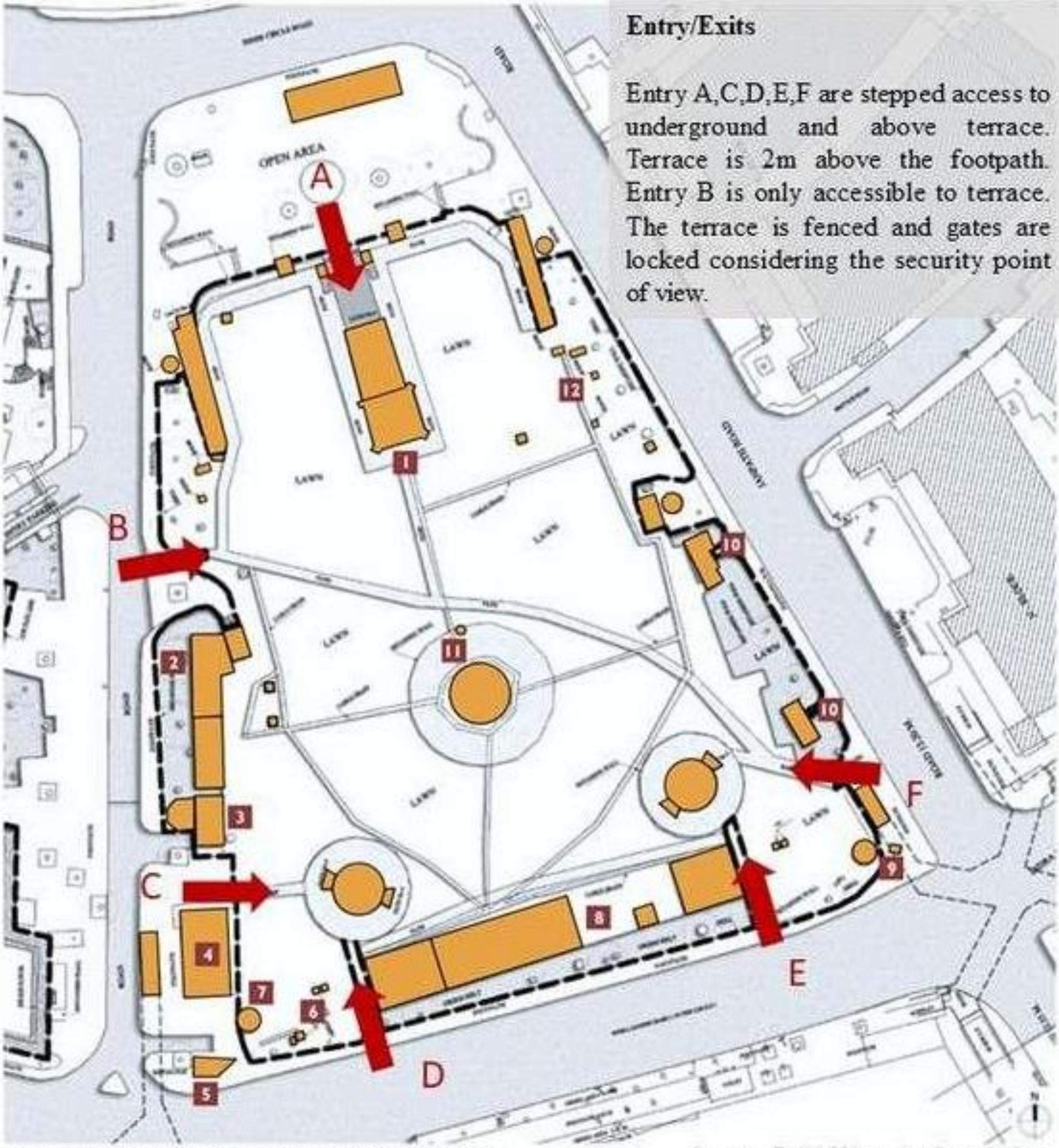


Categories	Description
Universally accepted	As per Economic times dated on Apr 25, 2011, it states that ramps have been designed to make it disable friendly
Safety	As per Economic times dated on Apr 25, 2011,there are 49 CCTV installed. The terrace is fenced and gates are locked
Entry/ Exit	There are 4 entry/exits to Palika Parking and 6 entry exits to Palika Bazar
No. of shops	380
Waste management	The dustbins are placed at regular intervals to maintain cleanliness
Material used	Ceiling – RCC Flooring – Vitrified tiles Walls – Brick walls with paint
Structural system	Load bearing
Height of structure	7m

Services above Palika Bazar:

Entry/Exits

Entry A,C,D,E,F are stepped access to underground and above terrace. Terrace is 2m above the footpath. Entry B is only accessible to terrace. The terrace is fenced and gates are locked considering the security point of view.

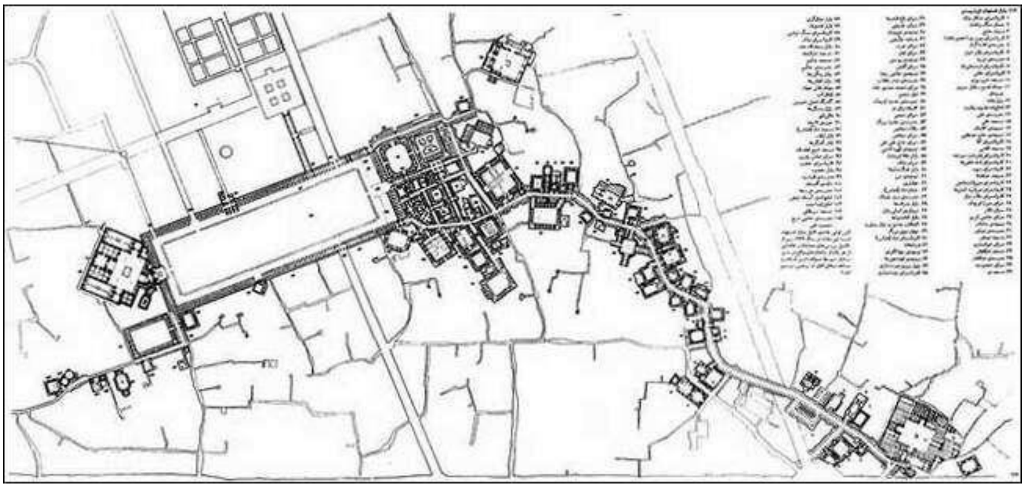


Map showing services and entry/ exits above Palika bazar

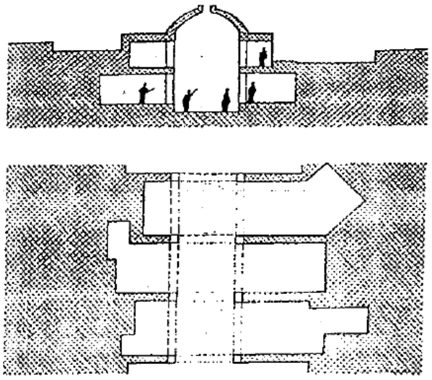
Source : Delhi Urban Art Commission

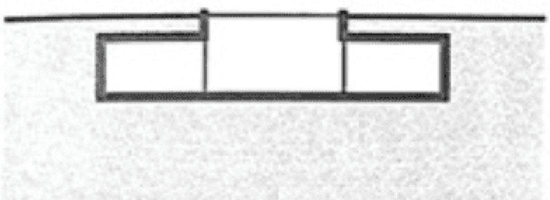
1. Skylight to render diffuse light
2. Fire control room
3. Transformer
4. D/G Room
5. NDMC Dhalo
6. Toilets (below) ventilation (above)
7. Regal sump
8. Air controlling plants and cooling water tank
9. Janpath sump
10. Electric sub station
11. Dome shaped structure with skylight and exhaust fans
12. Fire hydrant system

Location	Climatic data	Geography	Soil condition
City: Iran Latitude: 32°42'°N	Moderate as per IMD Hot and dry as per ECBC	Igneous rock	Fertile soil



The market is not entirely underground, it is designed such that half of the street activities are underground and remaining are above ground. The street has shops on either side





\ ifies the air and allow it to flow in the bazaar. As per thermodynamics principle is the hot air rises and cold air settles down. In order to cool the bazaar, the air is allowed to pass through a small hole thus moving from high pressure to low pressure making it cool and giving it the ability to absorb heat.

Water level	Surface activity	Usage pattern of UUS	Wind/ ventilation	Daylight	Artificial Daylight

the water table is depleting at a very alarming rate in Iran. As per 2013 data, the groundwater table has reduced more than 18m	Because of vaulted brick roofs no activity is possible on the top	Undergroun d market	the holes purify and allows the air to flow in the bazzar	large window on dome roof, holesin the ceiling	Additional artificial lights enhance the beauty of the space and are used during the night time or in the absence of daylight.

Categories	Description
Universally accepted	The markets were universally accepted and used by all
No. of shops	400
Material used	Original Floors – Marble Added floors – colored tiles and stone (Jonābādi, pp. 759-60) Walls – mosaic bricks, decorative tiles
Structural system	Arch / dome structures some with brick arches, some with poplar beams, over a hundred caravanserais and innumerable covered halls and connecting wings.
Height of structure	7 - 8m

Planning and Approaches for Urban Underground Commercial spaces:

There are several parameters that are the outcome of the case studies and the literature study that was carried out. The parameters are further classified into the pre-design stage, design stage and post-design stage.

Stage	Parameters
Pre-design	Soil/ rock strength, Subsoil type, rock type, Rock Quality Designation, Location of site, Geology of ground, Geological context – surface and subsurface, Morphology of ground, Depth of construction, Typology of construction, Groundwater level, Measurement of groundwater pressure, Future expansion consideration, Aperture size, and arrangements Physical investigations, Design technology involved in predicting the groundwater behavior, Landuse zoning – law should be provided, Survey technology, Technology for underground planning, Construction technology – vertical and horizontal shaft, Construction method for foundation and bedrock, Method of underground construction of structure, Earthquake probabilities, Land ownership, Drainage pipeline corridor Water supply, Electrical lines, Existing natural and mineral reserves below earth's surface, Existing flora, and fauna
Design	Ventilation/ wind flow, Humidity, Underground temperature, surface temperature, fenestration design, size of opening, material selection, type of UUS, radiation, size of structure, quality of interior space, entrance design, Sense of space, Connection with the outer world (visually or physically), Natural light, Mechanical system technique, Sewage removal technique, Noise and vibration consideration, Means of egress, Initial cost, Land use efficiency, Transportation network, Telecommunication network, Electrical lines, Span limit, Right of way, Fire alarm, detection and suppression system, Emergency preparedness, Fire department provision, No. of entry and exit, Electrical room, Drainage water channel, Substation, Transformer/DG set location, Sewage treatment plant, Waste water treatment , Precipitation, Consideration of rise in water level during rainfall, Building recognition and image, Interior design elements, Universally accessible, Grade of concrete to retain soil, Land/ site margin
Post – design	Ratio of cost factor with depth, Construction cost, Land cost saving, Cost of ventilation and lighting, Energy cost, Technology for maintenance of ground structure, Maintenance cost, Insurance, Repair cost, Artificial daylighting, Issue regarding further expansion after design, Leakage in structure, Security cameras, Physiological effects, Indoor air pollution. Indoor air pollution, Occupancy patterns, Environmental impacts on the ground

Conclusion

The bold insight of imagining cities in three dimensions has tenfold multiplied the thinkers to focus upon underground urbanism specifically for commercial spaces. Vital spaces can be freed for better use by placing uses below the surface that are not required at the surface. Commercial spaces have valid reasons for their placement in the subsurface which indirectly gives rise to incidental underground development. The integration of surface into subsurface development by creating a new tissue is an immense step however creating a new urban tissue from a spatial design perspective at first seems simple. The opportunities demonstrated by the subsurface help to create awareness. It is explained the contribution of at least 7 SDGs set by the UN that could be targeted by 2030. Here lies the caveat to this, a balance between the surface and subsurface needs to be planned. It is at this point we need to start appreciating the urban complexities.

The underground commercial spaces need to be designed in such a way that they become spaces for people, adding to the livelihood and inclusive to the city. They will provide and promote the psychological and physical well-being of underground spaces that adds to the city fabric. The architectural density can be increased by going underground as well, the architecture disappears and there is room for green areas and public spaces. Daylight is the key orchestrating design tool that is required to create a comfortable space. This might not be possible for all the situations either due to design or the absence of sunlight (dark condition). Lighting, therefore, needs to be addressed both regarding daylighting and artificial lighting. The design for commercial spaces should be such that it negates any thought of being underground. The planning is dependent on geology and soil composition. A remarkable reduction in carbon footprint can be achieved by the efficient utilization of underground spaces. There is a need to find a glimpse into all the possibilities that our future holds. The research enlists the parameters required for design and planning. Will India become an urban underground age for commercial spaces in the 21st century? Let’s tap into the yet unforeseen opportunities that will allow humankind to prosper and survive on this planet, by appreciating the world below our feet.

List of Abbreviations

UUS – Urban Underground Spaces

UUI – Urban Underground Infrastructure

PPP – Public Private Partnership

MPD – Master Plan Delhi

FSI – Floor Space Index

FAR – Floor Area Ratio

TOD – Transit Oriented Development

SDGs – Sustainable Development Goals

SMART - Stormwater Management and Road Tunnel

ECBC – Energy Conservation Building Code

IMD – Indian Metrological Department

COBs – Chip on Board

bgl – Below Ground Level

LCC – Life Cycle Cost

UN – United Nations

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