THE 50 TWINS SKY

THE COMMERCIAL TWIN TOWERS
EAST DELHI

A REPORT BY -
RISHABH SINGH

THESIS REPORT ON

“COMMERCIAL TWIN TOWER”

‘SANJAY LAKE, EAST DELHI’

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF:

BACHELOR OF ARCHITECTURE

BY

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THESIS GUIDE

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<u>CERTIFICATE</u>

I hereby recommend that the thesis entitled, "COMMERCIAL TWIN, DELHI" under the supervision, is the bonafide work of the students and can be accepted as partial fulfilment of the requirement for the degree of Bachelor's degree in architecture, school of Architecture and Planning, BBDU, Lucknow.

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CONTENTS

Aims

To understand the needs of the corporates, residents and to design a commercial building catering to the needs of all commercial purposes and the corporate set-ups.

Objectives

To promote good working environment in the area of East Delhi, the hub of all the notorious activities due to various reasons in the whole of Delhi. To provide adequate, controlled and ideal environment for the residents and corporates. Addition to the employment, additionally helping generate revenue. The project covers the aspects of a commercial development in Delhi, one of the most crowded cities in India. With this I will learn not only about a commercial development but also it will help me to brush up my skills for designing in a populated place which is the need of the hour as per the increasing population and scarcity of land. At the same time providing a crown to the locality and the whole of Delhi, beautifying its skyline.

Client Details

The client for the project is the Delhi Development Authority, founded by the Government of India in 1957 under the provisions of the Delhi Development Act to "Promote and Secure the Development of Delhi". The client aims to develop a transit-oriented hub at the location, which would not even lead to a share in the vehicular load reduction but also create an iconic developed place for the locality.

Introduction

The project

It is a part of the redevelopment of the area of Sanjay Lake in East Delhi. Whole project has been termed as lake view complex by the DDA, which will have mixed land use development projects. Project is proposed by the Delhi Development Authority as a part of Transit Oriented Development (T.O.D.). TRANSIT ORIENTED DESIGN is a concept of design which is oriented towards better connectivity to the public transport system and the nearby amenities. The Twin Towers will be marking out the complex, with at least 50-60 storeys.

Skyscrapers

Tall buildings emerged in the late nineteenth century in the United States of America. They constituted a so-called “American Building Type,” meaning that most important tall buildings were built in the U.S.A. Today, however, they are a worldwide architectural phenomenon. Many tall buildings are built worldwide, especially in Asian countries, such as China, Korea, Japan, and Malaysia. Based on data published in the 1980s, about 49% of the world’s tall buildings were located in North America. The distribution of tall buildings has changed radically with Asia now having the largest share with 32%, and North America’s at 24%. This data demonstrates the rapid growth of tall building construction in Asian during this period while North American construction has slowed. In fact, eight of the top ten tall buildings are now in Asia and only two, **The Sears Tower** and **The Empire State Building**, are in North America. Traditionally the function of tall buildings has been as commercial office buildings. Other usages, such as residential, mixed-use, and hotel tower developments have since rapidly increased as Figure 1 shows. There has been some skepticism regarding construction of tall buildings since September 11, 2001, however, they will continue to be built due to their significant economic benefits in dense urban land use.

Brief History

In the late nineteenth century, early tall building developments were based on economic equations – increasing rentable area by stacking office spaces vertically and maximizing the rents of these offices by introducing as much natural light as possible. In order to serve this economic driver, new technologies were pursued that improved upon the conventional load-bearing masonry walls that had relatively small punched openings. The result was the iron/steel frame structure which minimized the depth and width of the structural members at building perimeters. Consequently, the larger openings were filled with transparent glasses, while the iron/steel structures were clad with other solid materials such as brick or terra cotta. Different from traditional load-bearing masonry walls, these claddings did not carry any loads from buildings except their own weights and the lateral wind pressure. A new cladding concept – curtain walls – was developed with the emergence of the new structural systems.

In terms of architectural expression of tall buildings at this time period, as can be observed from many eclectic style tall buildings, architects returned to the traditional architecture for representational quality, after a short pursuit of a new style for a new building type based on new technologies mostly by Chicago architects in the late nineteenth century. However, the rebirth of the early Chicago spirit and the application of European modern movements to tall buildings were only a matter of time.

The mid-twentieth century, after the war, was the era of mass production based on the International Style defined already before the war, and the technology developed earlier. The major driving force of tall building developments was economy. Even the once-prevalent height race did not occur after World War II until the construction of the World Trade Centre in New York and the Sears Tower in Chicago, completed in 1973 and 1974, respectively.

Structural systems for tall buildings have undergone dramatic changes since the demise of the conventional rigid frames in the 1960s as the predominant type of structural system for steel or concrete tall buildings. With the emergence of the tubular forms still conforming to the International Style, such changes in the structural form and organization of tall buildings were necessitated by the emerging architectural trends in design in conjunction with the economic demands and technological developments in the realms of rational structural analysis and design made possible by the advent of high-speed digital computers. Beginning in the 1980s, once-prevalent Miesian tall buildings were then largely replaced by the façade characteristics of postmodern, historical, diagrid and deconstructivist expressions. This was not undesirable because the new generation of tall buildings broke the monotony of the exterior tower form and gave rise to novel high-rise expressions. Innovative structural systems involving tubes, mega frames, core-and-outrigger systems, artificially damped structures, and mixed steel-concrete systems are some of the new developments since the 1960s.

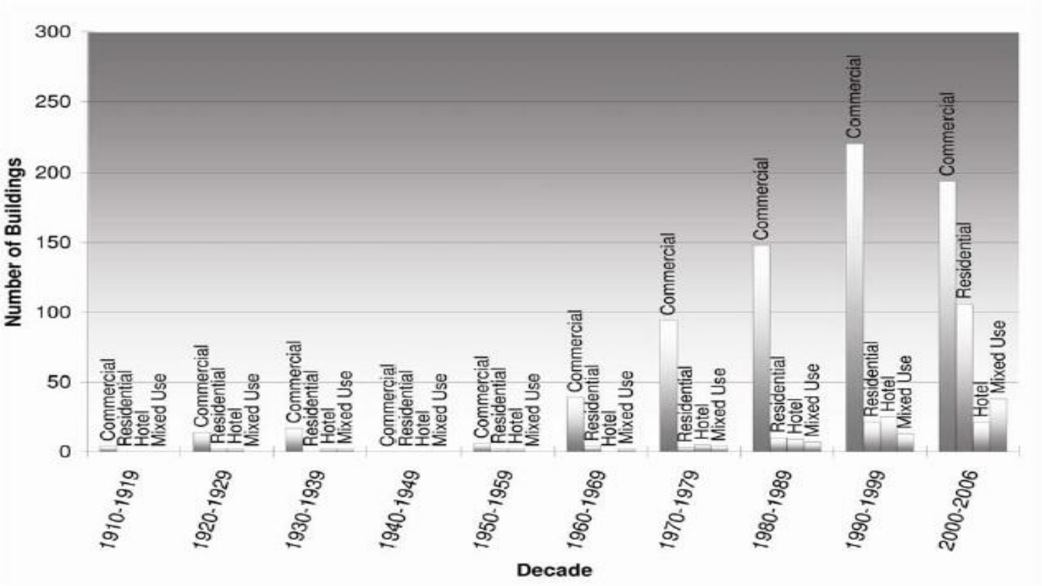


Fig.1 Building type distribution

Classification of Tall Building Structural Systems

In 1969 Fazlur Khan classified structural systems for tall buildings relating to their heights with considerations for efficiency in the form of "Heights for Structural Systems" diagrams. This marked the beginning of a new era of skyscraper revolution in terms of multiple structural systems. Later, he upgraded these diagrams by way of modifications. He developed these schemes for both steel and concrete as can be seen from *Figure 2*.

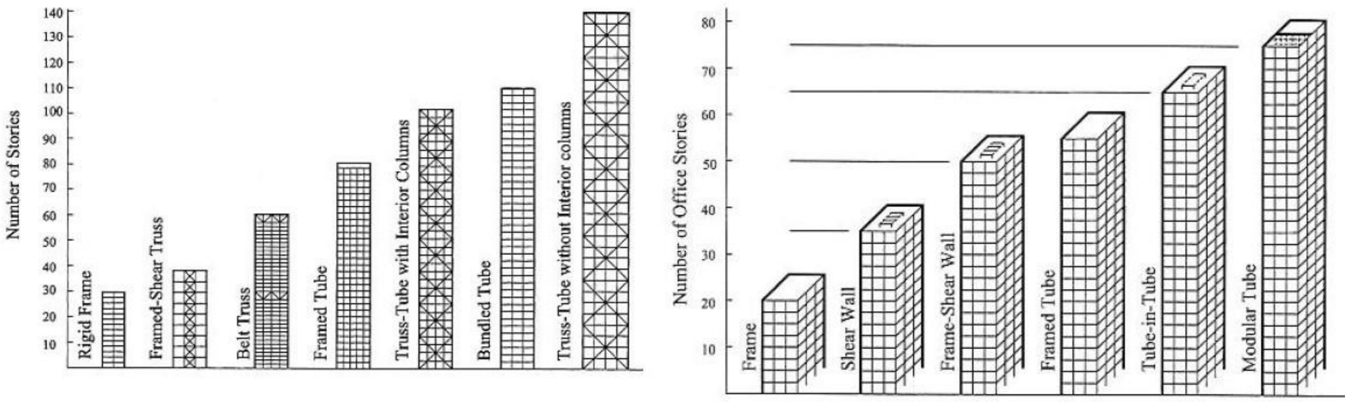


Fig.2 Classification of tall building structural systems by Fazlur Khan
(left: steel; right: concrete).

Khan argued that the rigid frame that had dominated tall building design and construction so long was not the only system fitting for tall buildings. Because of a better understanding of the mechanics of material and member behaviour, he reasoned that the structure could be treated in a holistic manner, that is, the building could be analysed in three dimensions, supported by computer simulations, rather than as a series of planar systems in each principal direction.

Feasible structural systems, according to him, are rigid frames, shear walls, interactive frame-shear wall combinations, belt trusses, and the various other tubular systems.

Structural systems of tall buildings can be divided into two broad categories: interior structures and exterior structures. This classification is based on the distribution of the components of the primary lateral load-resisting system over the building. A system is categorized as an interior structure when the major part of the lateral load resisting system is located within the interior of the building. Likewise, if the major part of the lateral load-resisting system is located at the building perimeter, a system is categorized as an exterior structure. It should be noted, however, that any interior structure is likely to have some minor components of the lateral load-resisting system at the building perimeter, and any exterior structure may have some minor components within the interior of the building.

Tables below summarize the details of the systems in each category. In addition, *Figure 3-1 and 3-2* show the concept of each system diagrammatically.

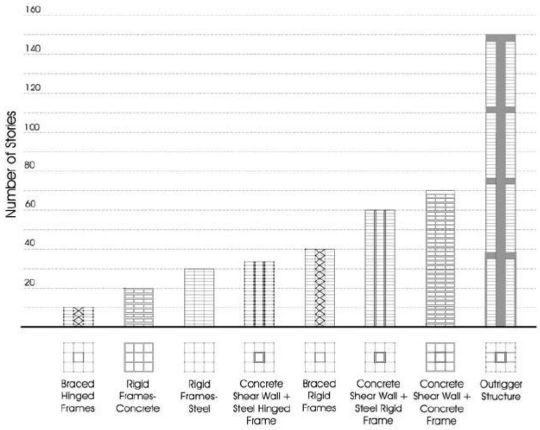


Fig.3-1 Interior Structure

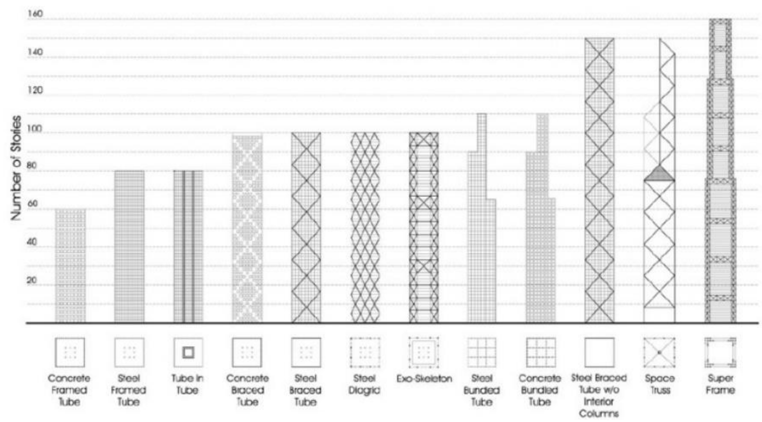


fig.3-2 Exterior Structure

This classification of structural systems is presented more as a guideline and should be treated as such. It is imperative that each system has a wide range of height applications depending upon other design and service criteria related to building shape, aspect ratio, architectural functions, load conditions, building stability and site constraints. For each condition, however, there is always an optimum structural system, although it may not necessarily match one of those in the system's tables due to the predominant influence of other factors on the building form. On occasions, an exterior structure may be combined with an interior one, such as when a tubular frame is also braced or provided with core-supported outriggers and belt trusses, to enhance the building's stiffness.

Category	Sub-Category	Material / Configuration	Efficient Height Limit	Advantages	Disadvantages	Building Examples
Rigid Frames	–	Steel	30	Provide flexibility in floor planning. Fast construction.	Expensive moment connections. Expensive fire proofing.	860 & 880 Lake Shore Drive Apartments (Chicago, USA, 26 stories, 82 m), Business Men's Assurance Tower (Kansas City, USA, 19 stories), Seagram Building, 30th to the top floor (New York, USA, 38 stories, 157 m)
		Concrete	20	Provide flexibility in floor planning. Easily moldable.	Expensive formwork. Slow construction.	Ingalls Building (Cincinnati, USA, 16 stories, 65 m)
Braced Hinged Frames	–	Steel Shear Trusses + Steel Hinged Frames	10	Efficiently resist lateral loads by axial forces in the shear truss members. Allows shallower beams compared with the rigid frames without diagonals.	Interior planning limitations due to diagonals in the shear trusses. Expensive diagonal connections.	Low-rise buildings
Shear Wall / Hinged Frames	–	Concrete Shear Wall + Steel Hinged Frame	35	Effectively resists lateral shear by concrete shear walls.	Interior planning limitations due to shear walls.	77 West Wacker Drive (Chicago, USA, 50 stories, 203.6 m), Casselden Place (Melbourne, Australia, 43 stories, 160 m)
Shear Wall (or Shear Truss) - Frame Interaction System	Braced Rigid Frames	Steel Shear Trusses + Steel Rigid Frames	40	Effectively resists lateral loads by producing shear truss - frame interacting system.	Interior planning limitations due to shear trusses.	Empire State Building (New York, USA, 102 stories, 381 m), Seagram Building, 17th to 29th floor (New York, USA, 38 stories, 157 m)
	Shear Wall / Rigid Frames	Concrete Shear Wall + Steel Rigid Frame	60	Effectively resists lateral loads by producing shear wall - frame interacting system.	Interior planning limitations due to shear walls.	Seagram Building, up to the 17th floor (New York, USA, 38 stories, 157 m)
		Concrete Shear Wall + Concrete Frame	70	-	-	311 South Wacker Drive (Chicago, USA, 75 stories, 284 m), Cook County Administration Building, former Brunswick Building (Chicago, USA, 38 stories, 145 m)
Outrigger Structures	–	Shear Cores (Steel Trusses or Concrete Shear Walls) + Outriggers (Steel Trusses or Concrete Walls) + (Belt Trusses) + Steel or Concrete Composite (Super) Columns	150	Effectively resists bending by exterior columns connected to outriggers extended from the core.	Outrigger structure does not add shear resistance.	Taipei 101 (Taipei, Taiwan, 101 stories, 509 m), Jin Mao Building (Shanghai, China, 88 stories, 421 m)

Category	Sub Category	Material / Configuration	Efficient Height Limit	Advantages	Disadvantages	Building Examples
Tube	Framed Tube	Steel	80	Efficiently resists lateral loads by locating lateral systems at the building perimeter.	Shear lag hinders true tubular behavior. Narrow column spacing obstructs the view.	Aon Center (Chicago, USA, 83 stories, 346 m)
		Concrete	60	-	-	Water Tower Place (Chicago, USA, 74 stories, 262 m)
	Braced Tube	Steel	100 (With Interior Columns) – 150 (Without Interior Columns)	Efficiently resists lateral shear by axial forces in the diagonal members. Wider column spacing possible compared with framed tubes. Reduced shear lag.	Bracings obstruct the view.	John Hancock Center (Chicago, USA, 100 stories 344 m)
		Concrete	100	-	-	Onterie Center (Chicago, 58 stories, 174 m), 780 Third Avenue (New York, USA, 50 stories, 174 m)
	Bundled Tube	Steel	110	Reduced shear lag.	Interior planning limitations due to the bundled tube configuration.	Sears Tower (Chicago, USA, 108 stories, 442 m)
		Concrete	110	-	-	Carnegie Hall Tower (New York, USA, 62 stories, 230.7 m)
	Tube in Tube	Ext. Framed Tube (Steel or Concrete) + Int. Core Tube (Steel or Concrete)	80	Effectively resists lateral loads by producing interior shear core - exterior framed tube interacting system.	Interior planning limitations due to shear core.	181 West Madison Street (Chicago, USA, 50 stories, 207 m)
Diagrid	–	Steel	100	Efficiently resists lateral shear by axial forces in the diagonal members.	Complicated joints.	Hearst Building (New York, USA, 42 stories, 182 m), 30 St Mary Axe, also known as Swiss Re Building (London, UK, 41 stories, 181 m)
		Concrete	60	-	Expensive formwork. Slow construction.	O-14 Building (Dubai)
Space Truss Structures	–	Steel	150	Efficiently resists lateral shear by axial forces in the space truss members.	Obstruct the view. May obstruct the view.	Bank of China (Hong Kong, China, 72 stories, 367 m)
Superframes	–	Steel	160	Could produce supertall buildings.	Building form depends to a great degree on the structural system.	Chicago World Trade Center (Chicago, USA, 168 stories, Unbuilt)
		Concrete	100	-	-	Parque Central Tower (Caracas, Venezuela, 56 stories, 221 m)
Exo-skeleton	–	Steel	100	Interior floor is never obstructed by perimeter columns.	Thermal expansion / contraction. Systemic thermal bridges.	Hotel de las Artes (Barcelona, Spain, 43 stories, 137 m)

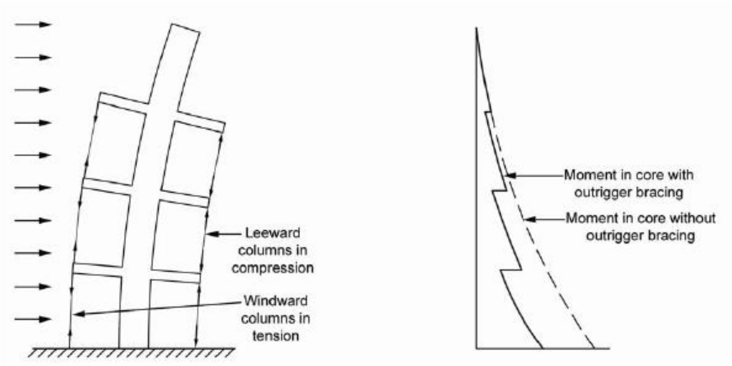
Interior Structures

The two basic types of lateral load-resisting systems in the category of interior structures are the moment-resisting frames and shear trusses/shear walls. These systems are usually arranged as planar assemblies in two principal orthogonal directions and may be employed together as a combined system in which they interact. Another very important system in this category is the core-supported outrigger structure, which is very widely used for supertall buildings at this writing.

The moment-resisting frame (MRF) consists of horizontal (girder) and vertical (column) members rigidly connected together in a planar grid form. Such frames resist load primarily through the flexural stiffness of the members. The size of the columns is mainly controlled by the gravity loads that accumulate towards the base of the building giving rise to progressively larger column sizes towards the base from the roof. The size of the girders, on the other hand, is controlled by stiffness of the frame in order to ensure acceptable lateral sway of the building. Although gravity load is more or less the same in all typical floors of a tall building, the girder sizes need to be increased to increase the frame stiffness. Likewise, columns already sized for gravity loads need to be slightly increased to increase the frame stiffness as well. MRFs can be located in or around the core, on the exterior, and throughout the interior of the building along grid lines.

Reinforced concrete planar solid or coupled shear walls have been one of the most popular systems used for high-rise construction to resist lateral forces caused by wind and earthquakes. They are treated as vertical cantilevers fixed at the base. When two or more shear walls in the same plane are interconnected by beams or slabs, as is the case with shear walls with door or window openings, the total stiffness of the system exceeds the sum of the individual wall stiffnesses. This is so because the connecting beam forces the walls to act as a single unit by restraining their individual cantilever actions. These are known as coupled shear walls. Shear walls used in tall office buildings are generally located around service and elevator cores, and stairwells. In fact, in many tall buildings, the vertical solid core walls that enclose the building services can be used to stabilize and stiffen the building against lateral loads. Many possibilities exist with single or multiple cores in a tall building with regard to their location, shape, number, and arrangement. The core walls are essentially shear walls that can be analysed as planar elements in each principal direction or as three-dimensional elements using computer programs.

Outrigger systems have been historically used by sailing ships to help resist the wind forces in their sails, making the tall and slender masts stable and strong. The core in a tall building is analogous to the mast of the ship, with outriggers acting as the spreaders and the exterior columns like the stays. As for the sailing ships, outriggers serve to reduce the overturning moment in the core that would otherwise act as pure cantilever, and to transfer the reduced moment to the outer columns through the outriggers connecting the core to these columns. The core may be centrally located with outriggers extending on both sides or in some cases it may be located on one side of the building with outriggers extending to the building columns on the other side.



Core Outrigger Structure

The outriggers are generally in the form of trusses in steel structures, or walls in concrete structures, that effectively act as stiff headers inducing a tensioncompression couple in the outer columns. Belt trusses are often provided to distribute these tensile and compressive forces to a large number of exterior frame columns. The belt trusses also help in minimizing differential elongation and shortening of columns. Outriggers can also be supported on megacolumns in the perimeter of the building. Although this structure is primarily an interior system, the belt trusses or megacolumns offer a wider perimeter, thus resisting the lateral push of the building's 'feet' spread.

Likewise, in steel cores, excessive welded or bolted tensile splices could greatly reduce the ease of erection and fabrication. The core-outrigger system alleviates this problem.

Some other advantages of the core-and-outrigger system are that the exterior column spacing can easily meet aesthetic and functional requirements, and the building's perimeter framing system may consist of simple beam-column framing without the need for rigid-frame-type connections. For supertall buildings, connecting the outriggers with exterior megacolumns opens up the façade system for flexible aesthetic and architectural articulation thereby overcoming a principal drawback of closed-form tubular systems. In addition, outrigger systems have a great height potential up to 150 stories and possibly more.

The principal disadvantages are that the outriggers interfere with the occupiable or rentable space and the lack of repetitive nature of the structural framing results in a negative impact on the erection process. However, these drawbacks can be overcome by careful architectural and structural planning such as placing outriggers in mechanical floors and development of clear erection guidelines.

The outrigger systems may be formed in any combination of steel, concrete and composite construction. Because of the many functional benefits of outrigger systems and the advantages outlined above, this system has lately been very popular for supertall buildings all over the world. A very early example of outrigger structure can be found in the Place Victoria Office Tower of 1965 in Montreal designed by Nervi and Moretti. It was also used by Fazlur Khan in the 42-story First Wisconsin Center of 1973 in Milwaukee, Wisconsin. However, major application of this structural system can be seen on contemporary skyscrapers such as the Jin Mao Building in Shanghai and the Taipei 101 Tower in Taipei.

Exterior Structures

The nature of building perimeters has more structural significance in tall buildings than in any other building type due to their very tallness, which means greater vulnerability to lateral forces, especially wind loads. Thus, it is quite desirable to concentrate as much lateral load-resisting system components as

possible on the perimeter of tall buildings to increase their structural depth, and, in turn, their resistance to lateral loads.
One of the most typical exterior structures is the tube, which can be defined as a three-dimensional structural system utilizing the entire building perimeter to resist lateral loads.
In a framed tube system, which is the basic tubular form, the building has closely spaced columns and deep spandrel beams rigidly connected together throughout the exterior frames. Depending upon the structural geometry and proportions, exterior column spacing should be from 5 to 15ft (1.5 to 4.5m) on centers. Practical spandrel beam depths should vary from 24 to 48in (600 to 1200mm). The resulting structural organization not only provides a structural expression of the facade, thereby defining the architectural fenestration, but also can cut cost by eliminating the need for mullions of the curtain wall fully or partly. A framed tube subjected to lateral loads, the axial forces in the corner columns are the greatest and the distribution is non-linear for both the web frame (i.e., frame parallel to wind), and the flange frame (i.e., frame perpendicular to wind). This is because the axial forces in the columns toward the middle of the flange frames lag behind those near the corner due to the nature of a framed tube which is different from a solid-wall tube. This phenomenon is known as shear lag. The purpose of optimal design of a framed tube is to limit the shear lag effect and aim for more cantilever-type behaviour of the structure within reasonable and practical limits (i.e., by achieving a cantilever deflection of 50 to 80 percent of the total lateral sway of the building).
A braced tube is a variation of the framed tube and was first applied on the 100-story John Hancock Center of 1970 in Chicago. The columns in it can be more widely spaced and the sizes of spandrels and columns can be smaller than those needed for framed tubes, allowing for larger window openings than in the framed tubes.
A bundled tube is a cluster of individual tubes connected together to act as a single unit. For very tall structures, a single framed tube is not adequate, since the width of the building at its base should be large to maintain a reasonable slenderness (i.e., height-to-width) ratio such that the building is not excessively flexible and does not sway too much. The system efficiency is considerably diminished in a single framed tube of enormous height due to shear lag effect. For such a structure, the three-dimensional response of the structure could be improved for strength and stiffness by providing cross walls or cross frames in the building.
The inner tube in a tube-in-tube structure can act as a second line of defense against a malevolent attack with airplanes or missiles. For example, a solid concrete core in the World Trade Center in New York could probably have saved many lives of those who were trapped in fire above the levels of airplane impact.

Thus, tall buildings that employ outrigger systems still require cores having significant shear rigidity. The diagrid structure provides both bending and shear rigidity. Thus, unlike outrigger structures, diagrid structures do not need high shear rigidity cores because shear can be carried by the diagrids located on the perimeter, even though supertall buildings with a diagrid system can be further strengthened and stiffened by engaging the core, generating a system similar to a tube-in-tube.

Other types of lateral load-resisting systems in the category of exterior structures include space trusses, super frames and exoskeleton. These have been occasionally used for tall buildings. Space truss structures are modified braced tubes with diagonals connecting the exterior to interior. In a typical braced tube structure, all the diagonals, which connect the chord members – vertical corner columns in general, are located on the plane parallel to the facades. However, in space trusses, some diagonals penetrate the interior of the building. Examples include the Bank of China Tower of 1990 by I. M. Pei in Hong Kong.
A superframe is composed of megacolumns comprising braced frames of large dimensions at building corners, linked by multi-storey trusses at about every 15 to 20 stories. The concept of superframe can be used in various ways for tall buildings, such as the 56-story tall Parque Central Complex Towers of 1979 in Caracas, Venezuela and the 168-story tall Chicago World Trade Center proposed by Fazlur Khan in 1982.

Recent Developments in the Form of Tall Buildings

The direction of evolution of the tall building's structural systems has been toward efficiently increasing the lateral stiffness against lateral loads – primarily wind loads. In order to obtain the necessary lateral stiffness, introduced first were braced frames and MRFs followed by tubular structures, core-supported outrigger structures, and more recently diagrid structures. The interrelationship between this structural evolution and the accompanying architectural aesthetics is worth discussing. Several contemporary directions of design strategies in terms of generating new forms "outside the box," such as aerodynamic, twisted, and other forms are discussed in the following.

Structural Evolution and Architectural Expression

The inherent monumentality of skyscrapers resulting from their scale makes their architectural expression very significant in any urban context where they soar. Thus, constructing any tall building requires careful studies on aesthetic adequacy of the new structure within the existing urban context. Some structural systems for tall buildings have had major impacts on the building aesthetics, while others have had only minor impacts.

In the outrigger structures, a lateral load-resisting system is extended from the conventional core to the building perimeter columns through the outriggers that connect them. This basic configuration often requires perimeter super columns and/or belt trusses at the outrigger levels, and these elements of the outrigger system are sometimes incorporated with building aesthetics. For example, the First Wisconsin Center in Milwaukee clearly expresses the belt trusses on the façade at the outrigger levels as a building aesthetic element.
Tubular structures, including superframes and recent diagrid structures, locate their major lateral load-resisting components at the building perimeters where building facades are, creating structural domination in the expression of the buildings. This performance-induced juxtaposition naturally leads to an integrative design approach between the structural system and façade system. Therefore, in tall buildings that employ these types of structural systems, technological components and architectural components of building facades are inseparable, one complementing the other. These circumstances require very intimate cooperation between architects and engineers.

Regional Expression

As has been discussed earlier, the setting of most active tall building development has been shifting from North America to Asia over the last decade. The most significant trend of tall buildings constructed in various Asian countries is that they use their own regional architectural and cultural traditions as main design motives. This trend can be easily seen from notable recent tall buildings such as the Jin Mao Building in Shanghai, Petronas Towers in Kuala Lumpur, Landmark Tower in Yokohama, and Taipei 101 Tower in Taipei. Behind the traditional images are the products of the contemporary technology such as the tubular structures in the case of the Landmark Tower or the core supported outrigger structures in the cases of the Jin Mao Building and Taipei 101.

Aerodynamic Forms

Aerodynamic forms in general reduce the along-wind response as well as across-wind vibration of the buildings caused by vortex-shedding by “confusing” the wind (i.e., by interrupting vortex-shedding and the boundary layer around the façade and causing mild turbulence there). While irregular forms pose challenges to structural engineers for developing the structural framework, they can be advantageous in reducing wind load effects and building responses. In addition to today’s pluralistic architectural styles promoting diversity, this logic of rational aerodynamics has led to twisting, tapering, or other building forms with discontinuities and multi-planar facades that are emerging in urban skylines.

Emergence of Twisted Forms

An interesting approach in contemporary tall building design is twisted forms. Twisted forms employed for today's tall buildings can be understood as a reaction to boxed forms of modern architecture. In fact, this contemporary architectural phenomenon is not new in architecture. It is comparable to twisted forms of Mannerism architecture at the end of Renaissance architecture. For example, in Cortile della Cavallerizza at Palazzo Ducale in Mantua, Giulio Romano designed twisted columns. This twisted form can be found again in today's tall building designs such as the Turning Torso, apartment and office tower, in Malmo, Sweden and the proposed Chicago Spire Project in Chicago designed by Santiago Calatrava.

In general, twisted forms are effective in reducing vortex-shedding-induced dynamic response of tall buildings by disturbing vortex shedding. In terms of static response, twisted forms are not beneficial. If solid sections are considered, the moment of inertia of a square plan is the same regardless of its twisted angle. Thus, the displacements due to bending are the same as well. However, if the building type frames are considered, the lateral stiffness of the twisted forms is not as large as that of straight forms.

The Turning Torso, Malmo, Sweden, by architect Santiago Calatrava

Free Forms

The number of free-form tall building projects has been rapidly increasing these days. In the past, only a few free-form tall building projects were proposed by some architects like Peter Eisenman and Frank Gehry, but they were never built. Within the context of tubular design, however, free-form structure is exemplified by the Sears Tower and One Magnificent Mile Building, both in Chicago, which employed a bundled tube system. Today, many free-form tall buildings are designed and actually constructed. It was quite a difficult task to perform the structural designs and analyses of irregular free-form tall buildings in the past. Relying on the powerful support of contemporary structural engineers, some architects find their design solutions in free forms feasible. These architects include Daniel Libeskind, Zaha Hadid and Thom Mayne of Morphosis. Even though the supporting structural systems behind the free forms vary depending on the project-specific situations, diagrids are often employed as primary structures for free-form tall buildings as can be observed from Daniel Libeskind's Fiera Milano Tower and Morphosis' Phare Tower in La Defense. Other contemporary free-form (poetic, cinematic and tilted) tall buildings include Hadid's Dancing Tower in Dubai and The Sail @ Marina Bay in Singapore

The Sail at Marina Bay, Singapore by NBJJ

Future Prospects

Development of new technology occurs based upon necessity, and the technology evolves towards enhanced efficiency. The development of braced frame structures to produce more rentable spaces in dense urban lands by constructing tall buildings in the past and their evolutionary paths up to the present towards even taller and more efficient structures to maximize land uses more economically are within this track. Tall buildings, which began from with 10-story office towers in the late nineteenth century, have evolved to megastructures like the Burj Dubai, which is over 150 stories and the tallest building in the world

There continues to be a need for building upward. Populations worldwide have grown rapidly, and migration of populations from rural areas to urban, has resulted in high-density mega cities. Denser cities with megastructures are more efficient in terms of energy consumption and land use. By making a city smaller and denser, the power grid becomes smaller, making the transfer of electrical energy more efficient. The need for automobile transportation declines as well as the need for personal transportation, which is a large contributor to the problems of efficient energy consumption and pollution. By creating denser cities with tall buildings, more natural green areas can be saved globally. In 1956, Frank Lloyd Wright proposed the Mile-High Illinois Tower in Chicago. It was composed of five vertical zones of 100 stories each.

The Visionary Mile-High Illinois Tower In Chicago, Illinois By Architect Frank Lloyd Wright In His 1957 Book, A Testament

The range of the heights of these recently proposed megastructures are from about 600m tall Holonic tower to 4000m tall X-Seed 4000. A building height of 500m is already reached by Taipei 101, and 700m by Burj Dubai. For the future megastructures in megacities, it is expected that the building height will be continuously increased in conjunction with the improvements in technology in structural systems, materials, elevators, fire protection, energy efficiency, and damping systems. Better strategies of integration are required to accomplish high-performance skyscrapers in the future. The future primary structural system may be speculated as an unprecedented newly developed system, or a variation of an existing system, or possibly a logical vertical combination of two or more existing systems to build higher.

Finally, it is expected that we Architects and Engineers have to explore the aesthetic potentials not only of the primary structural systems but also of the auxiliary damping systems.

The need to Rise-up Vertically

There are a number of interrelated reasons for the development of Skyscrapers. Some of the driving factors that have increased the need for tall buildings are:

Driver A: Land Prices and Return on Investment

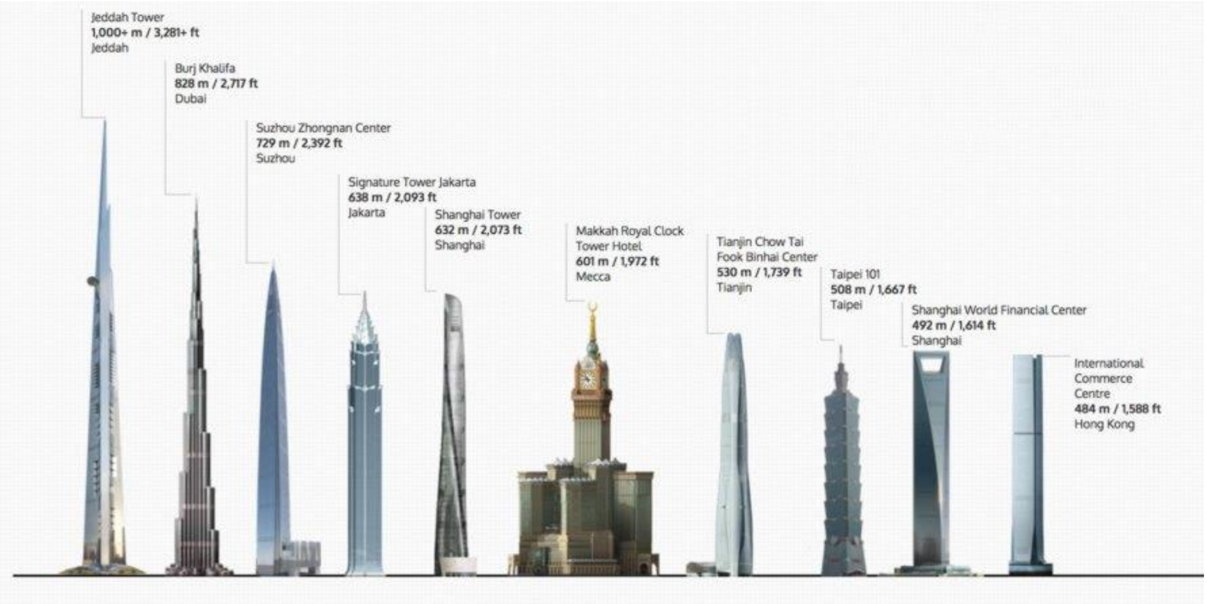
The higher cost of land typical of city centres-where the vast majority of support infrastructure located-has always been a driver for tall building. The higher land cost drives both the developer's need to offset that cost by creating more floor area for sale or rent, and the opportunity for a greater on investment by developing tall.

Driver B: Building as Corporate Branding and Skyline as Global Branding

Whereas tall buildings have been used throughout their history as marketing tools to portray the vitality of a corporation, now they are increasingly being used to portray the vitality of a city or country on a competitive world stage.

Driver C: Rapid Urbanization and Climate Change.

There are other, perhaps more compelling, reasons for the increase in tall buildings than just corporate or urban branding. It is believed that there are now almost 200,000 people urbanizing on this planet every day, requiring a new city of about one million inhabitants every week. And with this urban sprawl comes climatic changes.



Increasing with the timeline, there is no limit to the growth of either the human or the buildings. What's Permanent Is Just Growth!

Some Key Terminologies for Skyscraper Design

Leasing Depth

Leasing depth or lease span is the distance of the usable area between the exterior wall and the fixed interior element, such as the core or the multi-tenant corridor. Although it depends on the functional requirements and is closely related with the structural frame and the material, there are considerable varieties in different markets

	Name of Building	Leasing Depth (m)	Floor-to-floor height (m)	Floor-to-ceiling height (m)	Structural floor material
WORLD	Taipei 101 T.	13.9 – 9.8	4.20	2.80	Composite
	Shanghai WFC	12.5	4.20	2.75	Composite
	Petronas T. 1-2	13.0 – 8.3	4.00	2.65	Composite
	Sears Tower	22.9	3.92	2.70	Composite
	Jin Mao Tower	14.8 – 11.8	4.00	2.79	Composite
	Two International Finance Center	14.5	4.00	2.70	Composite
	CITIC Plaza	11.3	3.90	2.70	Composite
	Shun Hing Square	12.5 – 12.0	3.75	2.65	Composite
	Central Plaza	13.5 – 9.4	3.90	2.60	Reinforced concrete
	Bank of China	17.6	4.0	2.80	Composite
	Average	**12.1**	**3.98**	**2.7**	

Corner offices and the articulation of the façade significantly improve the ability to provide more space efficiency and quality than spaces with greater leasing depth. As floors become deeper, the marketability of the space significantly decreases.

Floor-to-floor / Floor-to-ceiling Height

The floor-to-floor height of an office building is typically the same for all occupied floors except for the lobby and floors for special functions. In high-rise office buildings, additional floor-to-floor height significantly entails greater cost on structural elements, cladding, mechanical risers, and vertical transportation.

As per the NBC Rules, a height of 4.2m is suggested.

Core Integrity

As heart can be coined as the core of a human body similar the heart of a skyscraper is a core, because when it comes to vertical circulation, there has to be a specific pint which will provide us with means to transport vertically, either through lifts, escalators, staircases etc.

During the life term of the use of a skyscraper, the core is the most travelled to and from destination, so as per the design aspect it becomes the most important aspect.

It comprises all of the vertical circulation elements, such as elevators, fire-stairs, mechanical shafts, toilets, and elevator lobbies. In early office buildings, these elements tended to be dispersed on the floor rather than concentrated, while today's contemporary buildings include all these elements in a specific zone, which is mainly the core. Many of the key structural elements, such as the shear walls that provide lateral stability, are integrated into the core in order to simplify the architectural design.

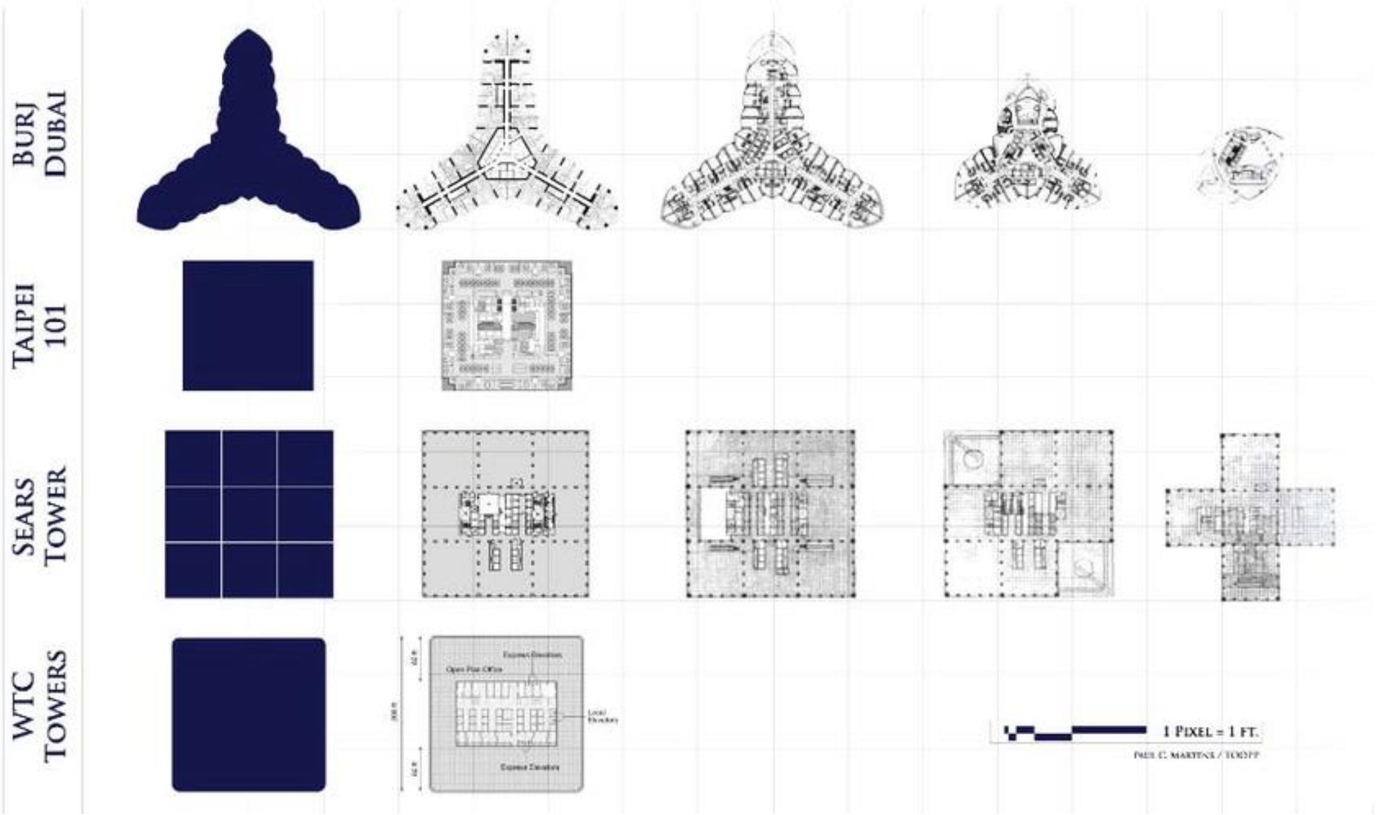
Layout of the core is critical to the development efficiency and operational effectiveness of a high-rise office building, while also playing a significant role in the way the structure copes with lateral loads.

	Name of Building	Number of cores	Location of core		Core integrity		Core Area (m^2)	Core/ GFA (%)
			Center	Outside	Yes	No		
WORLD	Taipei 101 Tower	Single	X			X	665	25
	Shanghai WFC	Single	X		X		750	30
	Petronas T. 1-2	Single	X			X	530	25
	Sears Tower	Single	X			X	1113	22
	Jin Mao Tower	Single	X			X	800	29
	Two International Finance Center	Single	X		X		740	26
	CITIC Plaza	Single	X			X	480	22
	Shun Hing Square	Single	X			X	570	26
	Central Plaza	Single	X		X		560	25
	Bank of China	Double	X			X	800	30

Comparison of the core's details of few buildings over the world

The design of the core significantly affects the overall space efficiency of the buildings, vertical circulation, and distribution of mechanical and electrical shafts. The lifting strategy drives the core size and has a major impact in terms of design on all high-rise office buildings. One of the drivers is the acceptable period of time for users to get from ground floor to their destination. The ideal solution balances a number of factors such as the number and the speed of lifts, group sizes, building zones and the core arrangement, considering the space usage as well as cost. In order to achieve the maximum space efficiency of a high-rise office building, the core must be reduced to an acceptable ratio of the gross floor area, while coping with the fire regulations and achieving an effective vertical transportation with the elevators.

In United States, steel is commonly used as the structural material and lightweight fire-rated drywall is used to form the walls in order to reduce its thickness and save the foundation cost and construction time. However, in Asian countries, the use of the structural steel with drywall forming is less common because their costs are higher than the conventional reinforced concrete construction. High-strength concrete is generally used to reduce the thickness of reinforced concrete core wall enabling more efficient spaces.



Core And Floor Plate Design Comparison Of Few Of The World's Skyscrapers

SITE ANALYSIS

Site Specifics

The site is located in East Delhi(a.k.a. Trans Yamuna), is an administrative district of the National Capital Territory of Delhi in India. It is bounded by the Yamuna River on the west, North East Delhi to the north, Ghaziabad District of Uttar Pradesh state to the east, and Gautam Buddha Nagar District of Uttar Pradesh to the south.

CO-ORDINATES OF SITE: 28°37’00.21” N 77°18’08.01” E 204m.

Map of Delhi

Google-Earth image of site

DEMOGRAPHICS		
DESCRIPTION	2011	2001
POPULATION	17.09 lacs	14.64 lacs
ACTUAL POPULATION	1,709,546	1,463,583
MALE	9,07,500	794,074
POPULATION GROWTH	16.79%	43.06%
AREA (km^2)	63	63
DENSITY/ km^2	27,132	29869
PROPORTIONAL TO DELHI	10.18%	10.19%
POPU.	884	843
SEX RARIO (/1K)	871	865
CHILDREN’S SEX RATIO	89.31	84.91

Demographic Study of the locality

CONNECTIVITY

Delhi has significant reliance on its transport infrastructure. The city seeks to develop a highly efficient public transport system with the introduction of the Delhi Metro, which is undergoing a rapid modernization & expansion as of 2006. There are 16.6 million registered vehicles in the city as of 30 June 2014, which is the highest in the world among all cities. Delhi has significant reliance on its transport infrastructure. The city seeks to develop a highly efficient public transport system with the introduction of the Delhi Metro, which is undergoing a rapid modernization & expansion as of 2006. There are 16.6 million registered vehicles in the city as of 30 June 2014, which is the highest in the world among all cities.

RAIL:

Connected to Indian Railways the nearest railway station being, Anand Vihar Terminal 6.2 km.
Other station to reach Delhi are:
1.New Delhi Railway Station,
2.Old Delhi Railway Station,
3.Hazrat Nizamuddin Railway Station,
4.Sarai Rohilla

Road:

Major Roads: NH-1, NH-2, NH-8, NH-10 and NH-24
BUS: Nearest BUS STATION is Inter State Bus Terminal (ISBT) Anand Vihar in Trans-Yamuna area 5.8km
Bus services: The other 2 inter-state terminals in city are:
ISBT Kashmere Gate in Northern Delhi
ISBT kaushambi, Ghaziabad
ISBT Sarai Kale Khan in South Delhi

Air:

Indira Gandhi International Airport (IGI); both domestic and international connections: 30km

METRO:

At Trilokpuri Sanjay Lake Metro Station (pink line) connected with Delhi metro’s major blue line at Karkar Duma & Anand Vihar Metro Station.

Trilokpuri metro will be connected with Mayur Vihar Pocket 1 metro to complete the pink line.

On site considerations

The site for the commercial towers

Topography

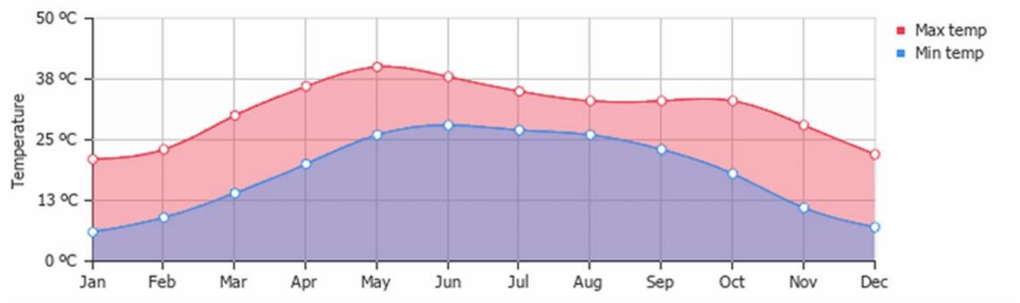
Mostly flat surface with gentle slope towards the west and south. Water flows in the south direction. Few undulations are of the scale that could be easily levelled, no such contour which could help as a landscaping feature, the site is 2m higher than the DDA park nearby.

Parkside entry

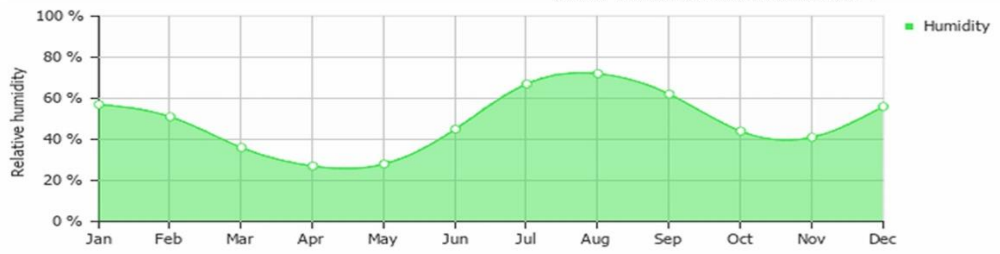
Climatic Study

Avg. Temperature:12º-32ºC
Avg. Max. Temperature:20º-39ºC
Avg. Min. Temperature:12º-32ºC
Avg. Rain: 0-8 cm

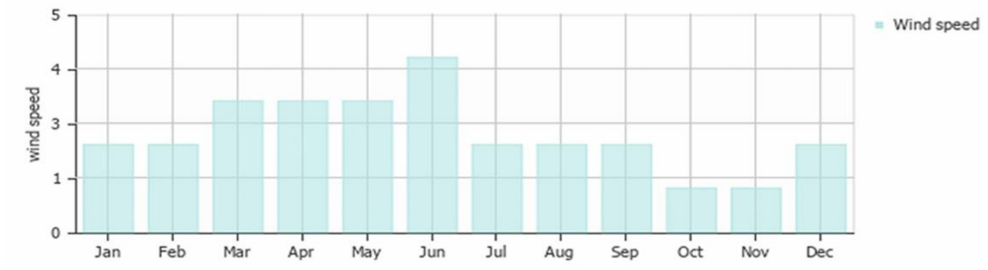
GRAPH SHOWING MAX. TEMP & MIN. TEMP



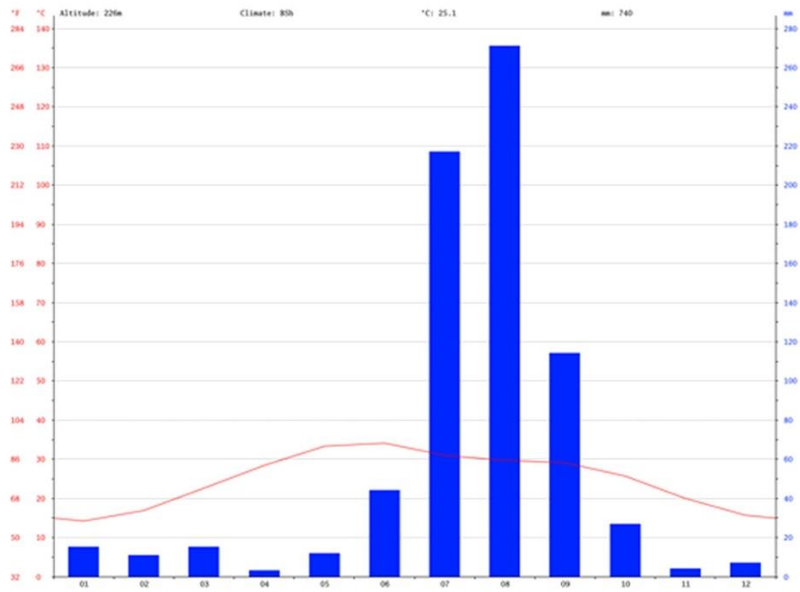
GRAPH SHOWING HUMIDITY



GRAPH SHOWING WIND SPEED



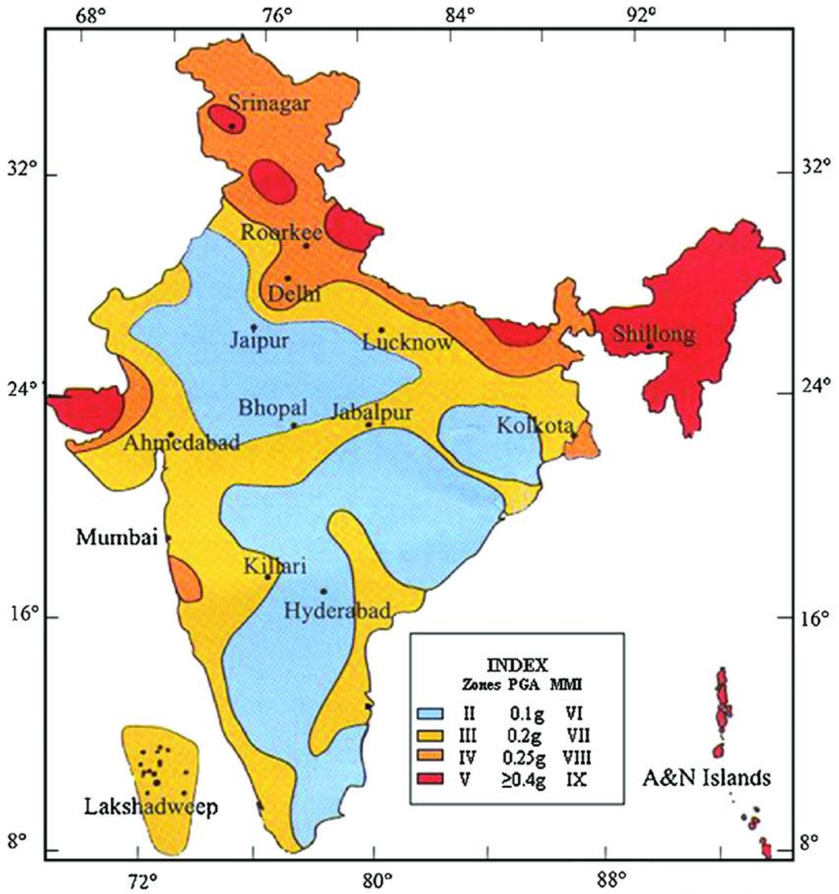
GRAPH SHOWING RAIN



Seismic Study

When it comes to the designing of a high rise or ultra-high-rise building, Seismic Study and soil study become a key factor. Its very well known that India is divided into four seismic zones. Zone 2,3,4 & 5.
And Delhi lies in the seismic zone 4, speaking of Delhi, the region is vulnerable to earthquakes in particular mainly because of its location. Delhi is situated on the top of few seismic fault lines which include Mahendragarh fault line, the Moradabad fault line, Delhi-Haridwar ridge zone, and the Sohna fault line. In addition to all this, Delhi's high density population is another concern.

We studied the Seismic conditions for our site, falling in seismic zone 4, which experiences earthquakes of intensity 6 & higher on Richter Scale and VIII on the Modified Mercalli Scale.



Source: IS 1893-2002

Soil Profile

Soil Profile is another driving factor in high-rise design, or rather for any project, one of a large scale or a smaller, it's always the first concern, the type of soil, strength etc. The soil on the site is of mixed type & there is no distinct boundary between any two type of soil, the soil type of the site is silty clay and has a **Bearing Capacity of 95.69 kN/m2.**

Wind Study

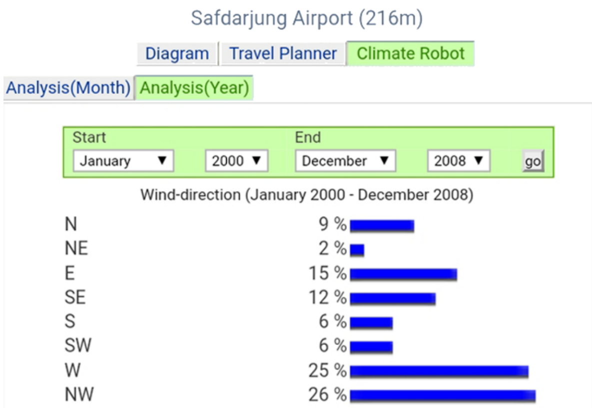
It is so far the most important factor for any high-rise building's construction, design, or habitability. the maximum wind velocity at our site through over the year is 12.6 kmph in the month of May, studied at an height of 10 metres from the ground level, while the calmest experienced velocity went down to around 5.6 kmph in the month of November, with North-West & West as the direction of prevailing winds.

Jan	Feb	Mar	Apr	May	Jun	
8.0	**9.1**	**10.0**	**10.5**	**12.6**	**11.0**	[km/h]
88	88	88	88	88	88	Data availability[%]

Jul	Aug	Sep	Oct	Nov	Dec	
10.7	**9.9**	**8.6**	**6.4**	**5.6**	**6.1**	[km/h]
88	88	82	75	77	77	Data availability[%]

Averaged Value (January 2000 - December 2008) : **9.0 km/h**

Wind velocity study



Wind direction study

The Study of The Velocity of Wind becomes a major factor while designing the skyscrapers. The speed of wind at the site ranges from 5.6km/h in the month of November to 12.6 km/h in the month of May.

While this speed stated is at a height of 10m from the ground. To calculate the speed at any height we use the formula:

$$\mathbf{V_z = V_b k_1 k_2 k_3}$$

where, V_z-Design wind speed at any ht. z in m/s

k_1-Probability factor (risk coefficient)

k_2- Terrain, ht. & structure size factor

k_3- Topography factor

Wind Loads

Design Wind Pressure is given by the formula,

$$\mathbf{Pd=0.6\ V_z^2}$$

Where, Pd -Design wind pressure in N/m2 at height d.

Vz -Wind velocity at height z mt

While the wind load on individual members is given by:

$$\mathbf{F=(C_{pe}-C_{pi}).A.p_d}$$

Where, C_{pe}= external pressure coefficient,

C_{pi}= internal pressure coefficient,

A=surface area of structural element or cladding unit,

p_d=design wind pressure

RELEVANT BUILDING CODE & BYE-LAWS

SETBACK OR OPEN SPACES

Sufficient open space (setbacks) around residential buildings, as indicated alongside, is essential to facilitate free movement & operation of fire Service vehicles.

If the setback area/open spaces are more than 12 meters, the provision of car parking. Can be done in the setback or open spaces at the periphery of the courtyard leaving the 6-meter motor able road.

CAR PARKING

Car parking shall have to be done at the basement with provision for minimum 2 ramps one remote to other.

ENTRANCE WIDTH & HEIGHT CLEARANCE

High-rise building should have at least 2 means of access, one remote to the other, of minimum width 4.5m with height clearance of 5m. This minimum width is essential to facilitate free movement of fire units.

STAIRCASE

a) Every high-rise building has minimum 2 number of Staircases.

b) Width of staircases varies from 1m-2m.

c) For residential building width of staircases should be 1 meter.

d) Out of 2 staircases, 1 can be used as a fire escape staircase.

e) Width of fire escape should be minimum 0.75 meter.

f) Number of staircases shall be given as per the travel distances

g) Staircase shall not be extended to basement to prevent smoke, heat & gases. From the basement smoke, heat 7 gases can be travel to upper floors.

h) Access to the basement from the ground should be through a separate staircase, which is not connected to main staircase (i.e. it should be remote to each other.)

i) Staircase shall be of enclosed type to prevent entry of smoke & fire to the staircase & vice versa.

j) Spiral staircase shall be provided up to 9-meter height.

k) External staircase normally shall not be allowed.

LIFTS

a) Minimum 1 lift capable of carrying minimum 8 persons weighing 545 kg shall be provided for every high-rise building.

b) Landing doors of lifts shall open to ventilated lobby & shall have a fire resistance of 1 hour.

c) 1 lift shall be designed as a “fire lift”

d) “Fireman Switch” shall be provided for each lift.

e) Lifts shall not be used as means of evacuation.

f) Collapsible gates shall not be provided for the lift.

g) if more than 1 lifts are installed the partition wall should be of minimum 2 hours fire resistance.

THE REFUGE AREA

The refuge area shall be provided on the periphery of the floor & open to air at least on one side protected with suitable railing.

a) For floors above 24m & up to 39m one refuge area on the floor immediately above 24m.

b) For floors above 39m one refuge area on the floor immediately above 39m & so on after 15m refuge area shall be provided.

SERVICE DUCTS

All the services ducts, if provided, should have to be enclosed by walls of at least 2-hour fire resistance & should have to be sealed at every alternate floor with non-combustible materials having at least 2-hour fire resistance. The sealing at floor level is to prevent travel of smoke & fire to the upper floors through the ducts.

BUILT IN FIRE FIGHTING SYSTEM

Wet riser: It is a vertical pipeline (dia. Depends on the floor area of the building) connected to a bottom tank (underground water tank).

Down comer: It is a vertical pipeline (dia. depends on the floor area of the building) connected to an overhead tank.

Dry riser: It is a vertical pipe which is always kept dry to avoid the freezing of water.

Hydrant: It is a horizontal pipe line with outlet of 63mm. dia connected to underground water tank.

- Wet riser cum down comer or only down comer system shall be provided for residential building.
- For commercial building only wet-riser system shall be provided.
- For hotels wet-riser cum down comer both the systems shall be provided.
- Diameter of riser will be 150mm for all the buildings.
- For each $1000m^2$ floor area or its part one riser shall be provided.
- At every landing twin outlet each of 63mm dia. Shall be provided (one should be connected to hose reel & another should be to hose & branch).
- Length of hose should be shall that it should reach at the last point of floor area.
- Minimum two courtyard hydrants shall be provided (courtyard hydrant will be an extension to riser).
- Hose reel hose of 12mm dia. Shall be provided from landing valve to wet-riser at each floor.
- A separate fire service inlet shall be provided at the ground floor.
- Location of wet-riser shall be preferable as near to staircase.

Fire Alarm System

1) Manually operated electrical fire alarm system. (M.O.E.F.A.)

2) Automatic Fire Alarm System (A.F.A.)

Fire Detection System

Sprinkler System

- Sprinkler system is a must for basement parking & other risk areas where large quantities of combustible materials are stored.
- Each sprinkler should cover 6.96m2 area.

Water Tank

1. Under Ground Water Storage Tank

2. Terrace Level Tank

3. Mid-level storage tanks

Alternate Power Supply

A stand by generator should be installed to supply power for staircase lighting, corridor lighting, fire pump, pressurization fan & blowers, in the event of disconnection of failure of main supply.

Portable Fire Extinguishers

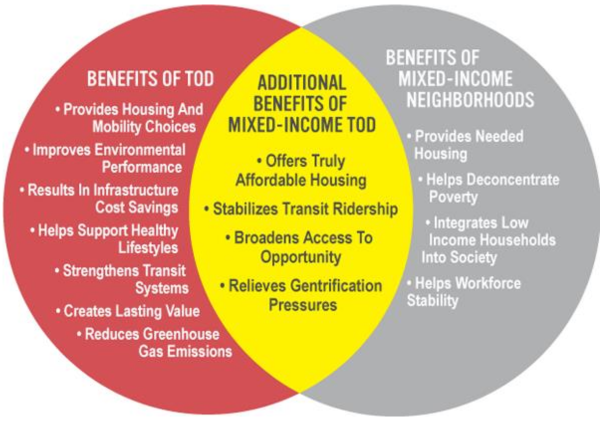
First aid firefighting appliances shall be provided & installed in accordance with latest IS 2190.

Provision of helipad

For High rise Buildings above 200m in height provision for a Helipad should be made.

Transit Oriented Development

In urban planning, a transit-oriented development is a type of urban development that maximizes the amount of residential, business and leisure space within walking distance of public transport. It promotes a symbiotic relationship between dense, compact urban form and public transport use.



Since our site falls under an influence zone, T.O.D. will determine the building by- laws for it.

Road width

In case road width less than 18m at the front, road widening space is left by the plot owner, to accommodate it to 18m for future use.

Setbacks

Plot size >**3,000 sq.m**. **up to 10,000 sq. m.**

Minimum setback for all edges- **6m**

Plot size > **10,000 sq.m.**

Minimum setback for all edges- **12m**

Setbacks to be handled to the local body as public roads- at least 20% of plot/ scheme area.

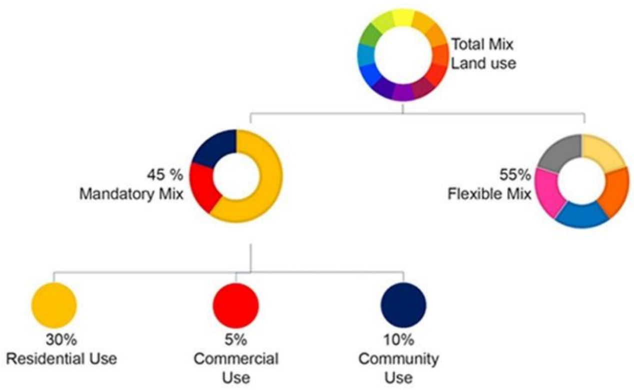
Front Setback- **0m (in case of no road widening)**

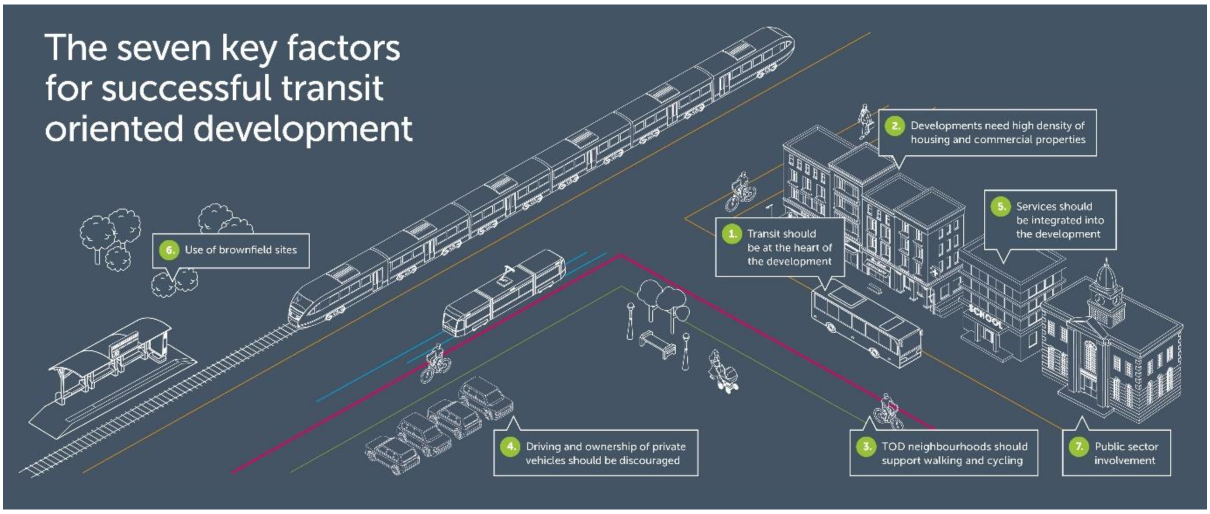
If due to the setbacks we are unable to achieve the PGC, setbacks can be reduced.

F.A.R.

The Floor Area Ratio (FAR) is 4, while restriction is that at least an FAR of 2 should be achieved in any condition.

Land Use





Parking

An ECS of 1.33 per 100 sq. m. of built up area is required as a parking space

Literature Study

Petronas Towers, Kuala Lumpur, Malaysia

Head Architect: Cesar Pelli & Associates

Local Architect: Adamson Associates International

RSP Architects Engineers & Planners Ltd.

Completion Year: 1998

Project Advisors: Knight Frank, London

Client: KLCC Property Holdings Berhad

Introduction

Petronas Tower usually termed "Twin Towers" were the world's tallest building, before being surpassed by Taipei 101. However, the towers are still the tallest twin tower and office building in the world and are still an architectural marvel for Malaysia and an example to the whole world set by Sir Cesar Pelli.

Typology

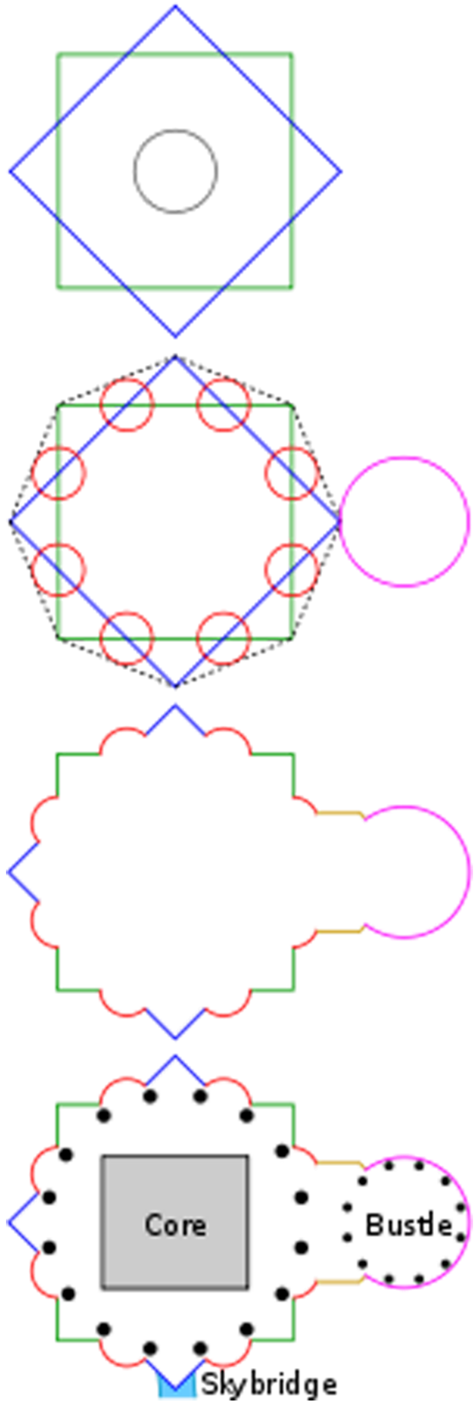
Offices: Twin Towers, total gross area: 1,366,714 m2
Retail: A multi-level retail centre, total gross area: 699,654 m2
Hotel: A 1,800 room convention hotel and conference centre.
Total Gross Area: 491,289 m2
Parking: integrated parking for 6,650 cars.

Design Development

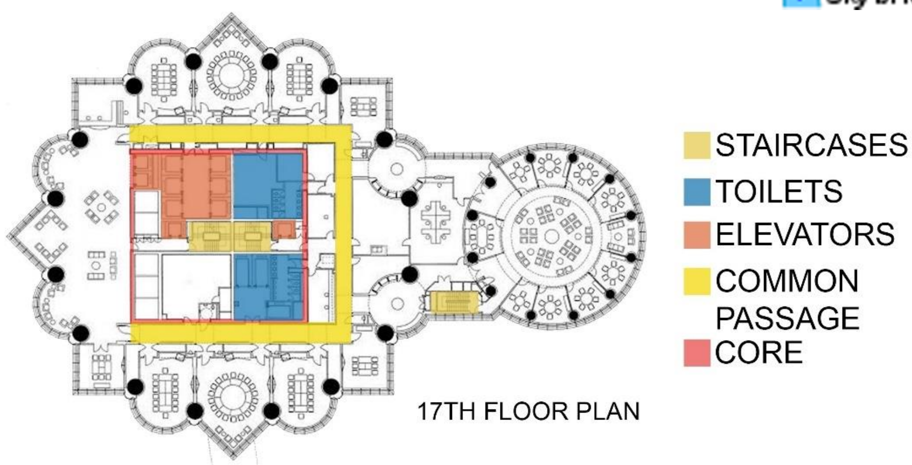
The design of the tower responds to its climate and to formal characteristics of the dominant Islamic culture. The towers are figurative and symmetrical and create figurative space between them.
Towers are tapered and set back five times in its ascent. The 88 floor towers are constructed largely to resemble motifs found in Islamic art.
Columns are inserted to enable a continuous uninterrupted skin and enable clear view of the exterior from interior.

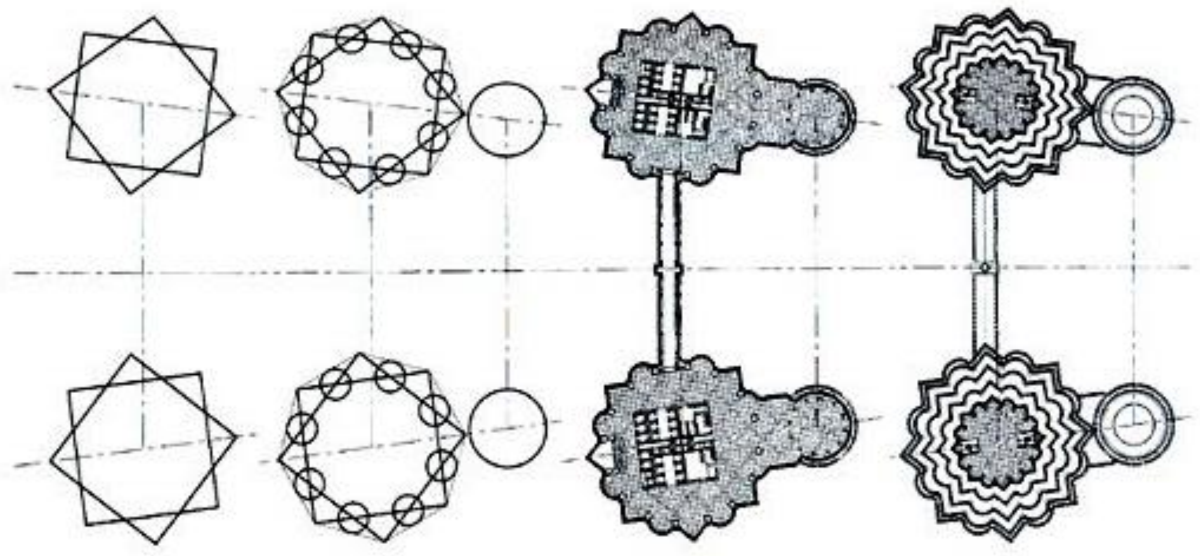
Floor Plate Design

Is based on simple geometric forms of two interlocking squares creating a shape of eight-pointed star.
Upon the eight-pointed stars, are eight superimposed semi circles softening the inner angles.
These semicircles are themselves anchored by the arcs of the main structural columns of the buildings.
The semicircles were superimposed in the inner angles of the interlocked squares to create more usable floor space.



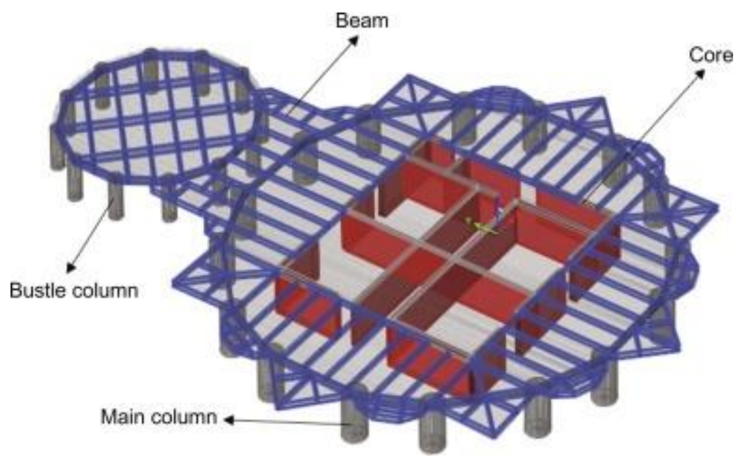
The form evolution on the right
& floor plan for 17th level representing
The various spaces below





The floorplate is derived from the simple geometry of interlocking squares

Structural Design Development



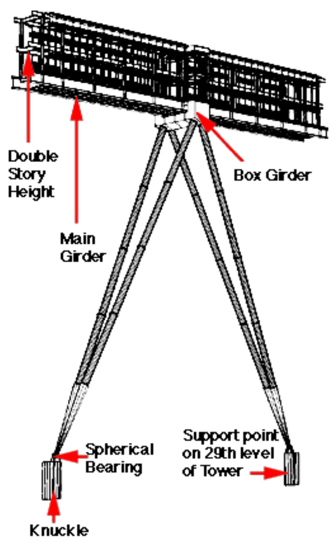
Early Structural concepts are studied for a concrete perimeter tube.
Openings happen over frame: corners. Under wind loads, the L-shaped corner columns would experience biaxial bending and reduce frame stiffness.
Columns occur mid face and windows wrap around corners. Biaxial column bending and loss of frame stiffness is avoided but columns would block views.
-Twelve concrete columns surround the bustle; 16 columns surround the tower.
-Steel beams support floor slabs, typically with 4.3-inch-deep concrete fil including 2-inch metal deck.
-Concrete beams link columns to form ring frames around the tower and bustle.
-Core is a box of concrete shear walls.

Skybridge

Another astonishing feature of the PETRONAS Tower is the 58.4m connecting skybridge at level 41,42; joining the sky lobbies situated in both the towers. The structural system selected utilises a 'two-hinge arch' springing from supports at level

29 and rising at 63 degrees to support a pair of parallel two-span continuous bridge girders at Level 41.

The structure of the two-level bridge is conventional framing constructed of structural steel with beams moment-connected to columns which bear on the level 41 continuous girders. The bridge is 58.4 m long and weighs about 750 tonnes. The two-hinge arch supporting the bridge has rotational pins (spherical bearings) at the end of each leg or 'spring point' and at the top or 'crown' of the arch (bearings). The main bridge girders have a rotational (centering) pin directly over the arch crown to permit the crown to rise and fall as the Towers move closer or further apart.



Petronas Tower Details	
Number of storeys	88
Height	452m above street level
Total Built-Up Area	341,760 sq. m. (3.7 million sq. feet)
Vertical Transportation	29 double deck high speed passenger lift in each tower
Number of Escalators	10 in each tower
Stainless Steel Cladding	65,000 sq. m.
Vision glass	77,000 sq. m
Steel	160,000 cubic metres in superstructure
Foundation	4.5m thick raft containing 13,200 cubic Metres of grad 60 RCC, weighing approx. 32,550 tonnes under each tower, supported by 104 barrette piles varying from 60 to 115 m high.

<u>**Shanghai Tower, Shanghai, China**</u>

Head Architect: Gensler
Associate Architect: Tongji University
Completion Year: 2015
Project Advisors: Thonton Tomasetti (Structural) Consentini (MEP); SWA(Landscape)
Client: The Shanghai Tower Construction & Development Company Limited

Introduction

Designed to embody Shanghai's rich culture, the 632-meter high mixed-use building has completed the city's Super-Highrise precinct. The new tower takes inspiration from Shanghai's tradition of parks and neighbourhoods. Its curved facade and spiralling form symbolize the dynamic emergence of modern China.
By incorporating sustainable best practices, Shanghai Tower is at the forefront of a new generation of super-high-rise towers, achieving the highest level of performance and offering unprecedented community areas.

Typology

Mixed Use: Offices, Hotel, Retail

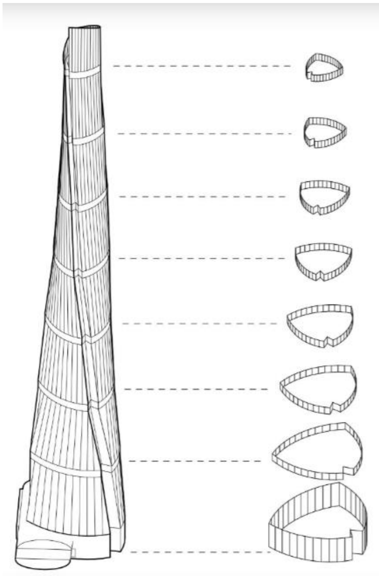
Architecture

Shanghai Tower is a city within a city, comprising of nine vertical zones, each 12 to 15 stories high. With its emphasis on public space and its shops, restaurants, and other urban amenities strategically located on floors with public atriums. Shanghai Tower envisions a new way of inhabiting supertall towers.
The upper floors will house hotels, cultural venues, and an observation deck with views of Shanghai's skyline.
A six-storey podium concentrates shopping and dining near the

base, and the Ground floor will serve as an urban market. Both gateway and connector, The Shanghai Tower retail podium will be a world- class destination for shoppers, office workers, and hotel guests. The podium clads in luminous cast glass tiles.

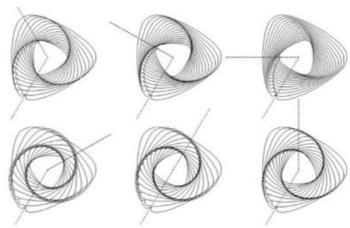
The design team has anticipated that three important design strategies- the asymmetry of the tower's form, its tapering profile, and its rounded corners- would allow the building to withstand typhoon wind forces common to Shanghai.

Using wind tunnel tests, the designers refined the tower's form, pinpointing a 120- degree rotation as the optimum for minimizing wind loads. Findings from the test produced a structure and shape that reduce wind loads by 24%, ultimately yielding savings of $58 million in construction costs.



Form

The from of shanghai tower can be observed to a spiral and taper upward. This is due to a one-degree shift on each floor. With the risk of frequent typhoons, the design of spiral aims to minimize the winds impact. Through a series of wind-tunnel tests, the tower is "expected to reduce wind loads by as much as 24 per-cent during the typhoons". The spiralling design also saves the construction costs by cutting down on the need for steel by 1/4. The floor plates are shaped like rounded triangles and the image on the right below illustrates the spiral in plan.



Structure

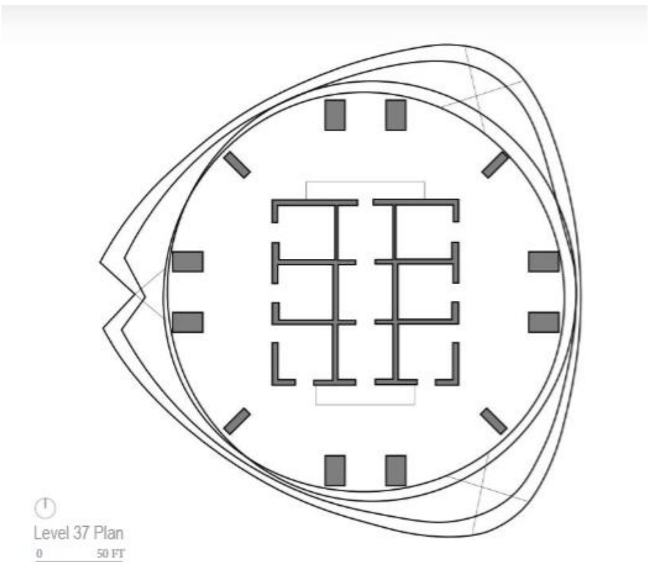
The tower's scale and complexity have created so many "firsts" for China's construction industry that more than 100expert panels have been established to analyse every aspect of the design. Yet the structural system is relatively straightforward, designed in response to a windy climate, an active earthquake zone, and clay-based soils. At the heart of the structure is a concrete core. This core acts in concert with an outrigger and super column system, with double belt trusses that support the base of each vertical zone.

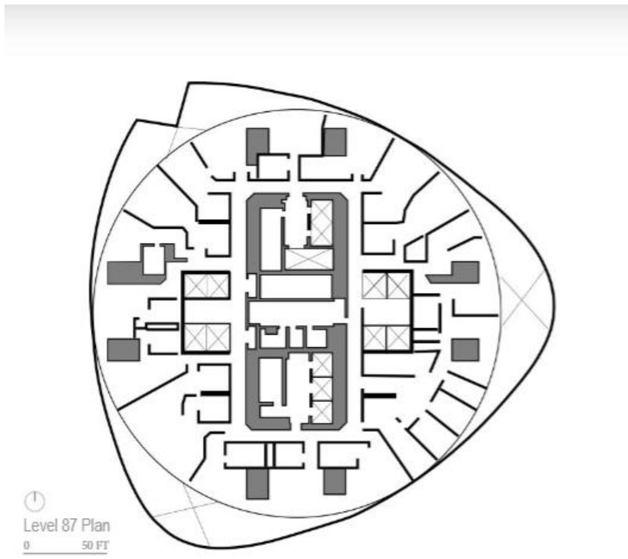
To carry the load of the transparent glass skin, Glenser designed

an innovative curtain wall suspended from mechanical floors above and stabilized by a system of hoop rings and struts. And the strategic division of the tower into distinct vertical zones will supply the lifeblood of the building's heating, cooling, and water throughout, using less energy and at lower cost.
An Innovative feature of design is the incorporation of two independent curtain walls-the outer cam shaped in plan, the inner one is circular. The space between them forms the atria that will house the landscaped sky gardens at regular intervals throughout the building.

Sustainability

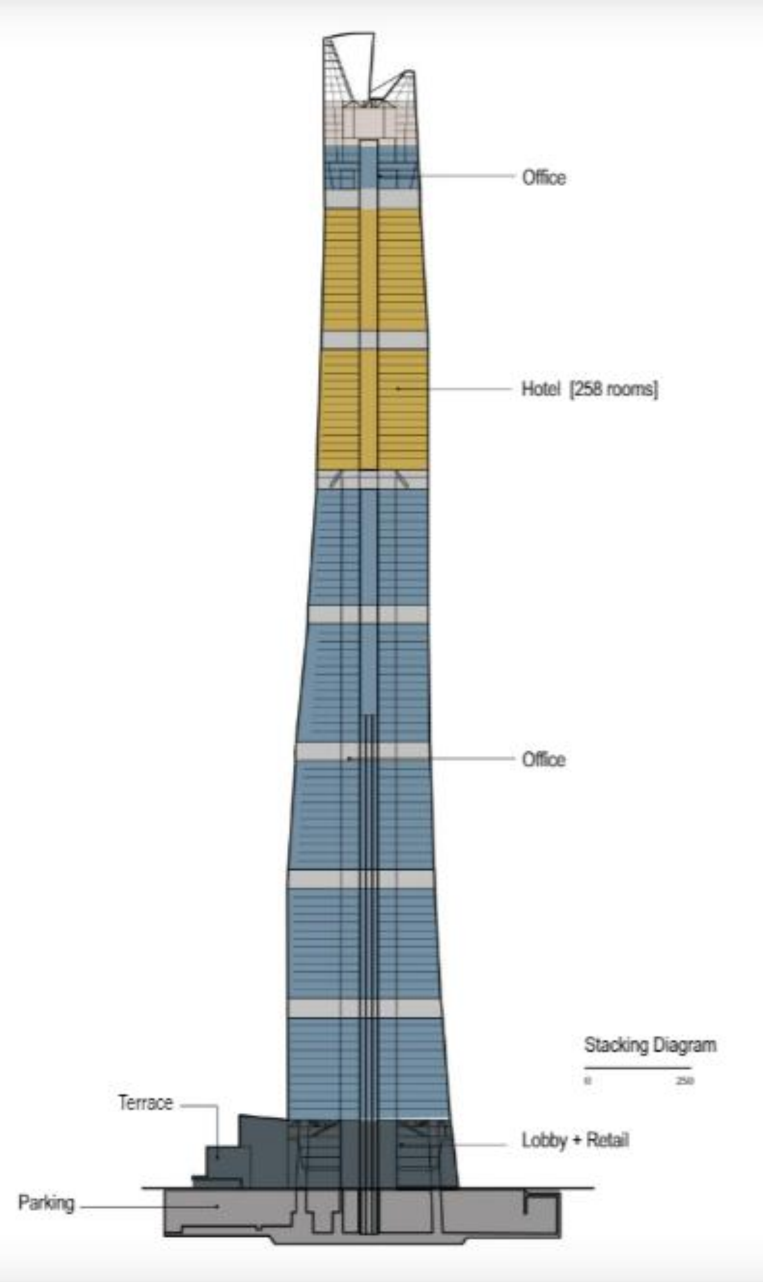
Shanghai Tower is one of the most sustainably advanced tall buildings in the world- designed to achieve both LEED & China Green Building Three Star Rating. to achieve this, many strategies that will generate a positive environmental impact have been incorporated. The foundation of this is the state-of-the-art water resource management practices and high-efficiency building systems. A full 33percent of the site is green space, with landscaping that breathes fresh air into the city and shades paved areas that radiate heat. Locally sourced materials with high recycled content are being used when available.

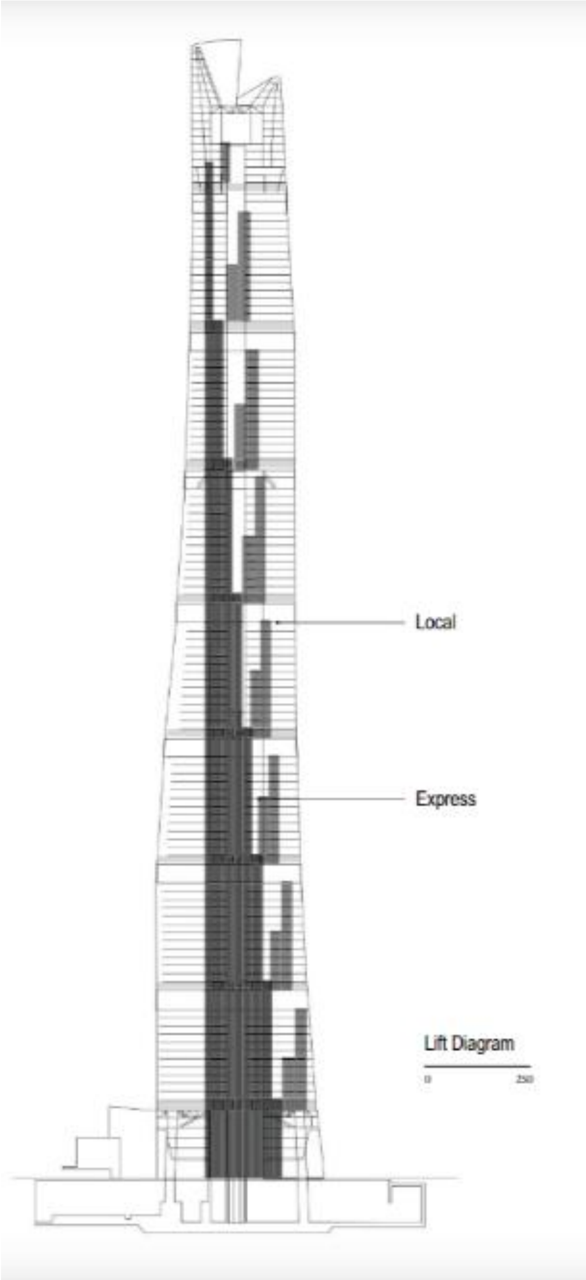




Office Spaces (Level 37)
Takes up a bulk of towers programming with over 50 floors. The floor plans are open and flexible, maximizing the natural daylighting and views of the city

Hotel Spaces (Level 87)
The floor plate above shows the separation of floor plate into four hotel rooms. The J Hotel as it is named, claims to be the world's highest ultra-luxury hotel.





The stacking and the lift's sectional diagrams for Shanghai Tower

Case Study

Supernova Spira, Noida, India

Architect: Benoy, London; ModArch (Local Architects)
Project Advisors: Knight Frank, London
Client: Supertech Ltd.

Introduction

The Supernova Spira will be the tallest building in the National Capital Region of Delhi expanding to a height of 300 metres, a total floor count of 80 floors featuring a helipad on its top along with an observatory. The construction of the building started in 2012. It will be completed by the end of the year 2020.

Typology

The whole project named Supernova by Supertech Limited is a mixed-use development with fully dedicated commercial (Astrilis), residential towers, a mixed-use tower (Spira) and a mall in the campus itself.

SITE AREA-17.3 Acre (approx)
TOTAL BUILTUP-6,97,026 SQ. M
GREEN AREA- 67%
PEAK HEIGHT-300M
TOTAL BUILDINGS-7
BUILDING NAMES-SPIRA (Mixed use)
ASTRALIS (Commercial)
NOVA EAST & WEST (Residential)
AURORA (Exclusive Retail)
QUEEN TOWER (Ultra Luxury Residential)
RADIANCE PLACE (Commercial (MALL)

Approach to the Site

Location: Plot 3, Sector 94, Noida-201301

NEAREST HUBS
Airport: Indra Gandhi International Airport (34km)

Metro Station: Okhla Bird Sanctuary (120m)
RAIL: Connected to INDIAN RAILWAYS
Nearest RAILWAY STATION is ANAND VIHAR TERMINAL 14KM
Other station to reach delhi are:
1.NEW DELHI RAILWAY STATION,
2.OLD DELHI RAILWAY STATION,
3.HAZRAT NIZAMUDDIN RAILWAY STATION,
4.SARAI ROHILLA

BUS: Nearest BUS STATION is
ISBT ANAND VIHAR IN TRANS-YAMUNA AREA
4.7KM
HIGHWAYS: NH 1, NH 2, NH 8, NH 10 AND NH 24
BUS SERVICES: The other 2 inter-state terminals in city are:
ISBT KASHMERE GATE IN NORTHERN DELHI
ISBT SARAI KALE KHAN IN SOUTH DELHI

Design Features

The basement is spread through over the site to provide spaces for the parking and services.

Around 67% of the total site area is dedicated to greenery and landscaping. The services have been spread in the basement at locations but are shared commonly by 2-3 buildings, spira has separate services due to the scale of services req.

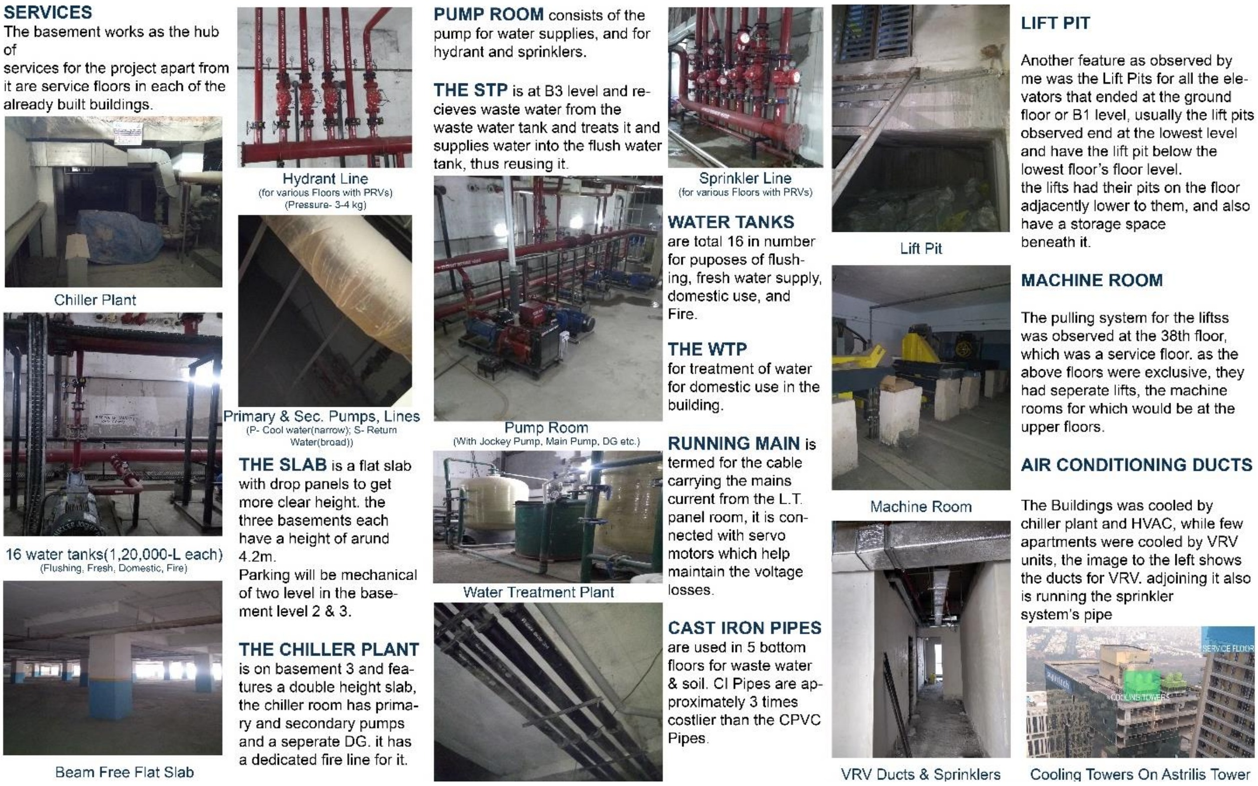
The ramps are provided are on the outer periphery of the buildings towards the site boundary to prevent any vehicular movement in the mid area and facilitate free pedestrian movement.

Form

The form of the tower is set in motion with a difference made in the floor plate notch projection varying at each floor which in turn also handles the wind pressures. Also making it look virtually dynamic.

Area & Parking

The area of 6,97,026 sq. m excludes the three-level basement parking facility.
The campus is lush with services with total 70 passenger and service elevators and 100% power backup.
Building is planned to segregate vehicular and pedestrian traffic, as well as business and casual traffic through landscaping and planning.
There are a total of 8 ramps in number 4 for entry and 4 exits.
They have a separate parking for disabled and VIP parking on the ground level.



Services

My main focus during the case study of the Supernova Spira was the services, which included the Fire Handling, Lifts, Air-Conditioning, Water Handling, Electrical, etc. The service floors were provided after every few sets of floor plates and the mechanical floor didn't have the glass facade, instead it had metal framed louvers running through over, each mechanical floor was a double heighted one.

Stack diagram

Civic centre, New Delhi

Architect: M/S Shiriesh Malpani & Associates
Project Advisors: M/S Gherzi Eastern Ltd.
Management Contractors: M/S IJM Corporation, Malaysia

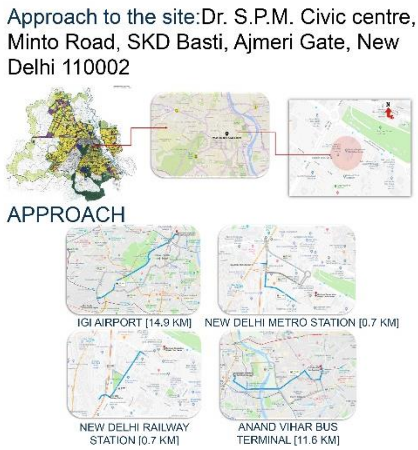
Introduction

The Civic Centre is a complex of multi-storeyed buildings, which comprises of four six-storey building blocks and one 28-storey tower block.

The complex is functionally segregated into distinct zone of institutional and commercial office activity with about 50 % of the space designated for institutional activity and 50 % of the space designated for commercial activity.

The institutional activity of the complex includes offices of MCD. The legislative and executive wing of the top hierarchy of MCD occupies two of the six storey and half of the twenty-eight-storey tower block. Commercial office and cultural activities are on the remaining area.

Approach & details

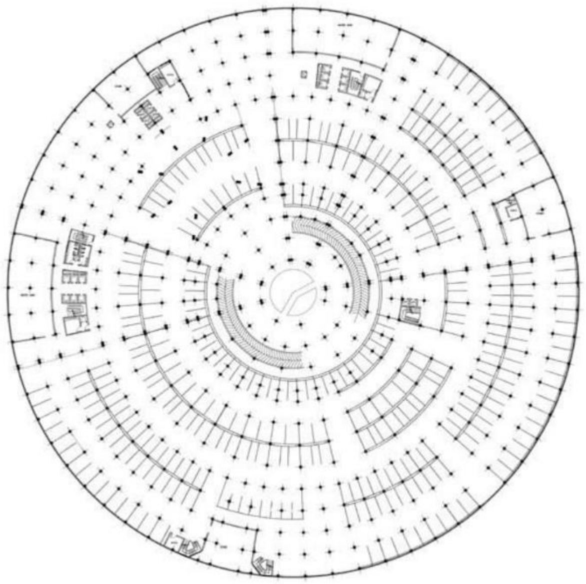


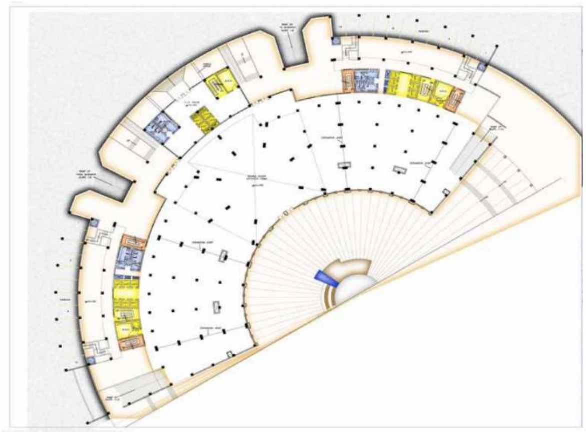
SITE AREA-46,702 SQ. M (11.54 ACRES)
PROPOSED GROUND COVERAGE-23.5%
GROUND FLOOR AREA-10,973 SQ. M
TOTAL COVERED AREA-1,16,000 SQ. M
LANDSCAPING AND GREEN AREA-60%
PEAK HEIGHT-101M

The average area of the typical floor in multi-storeyed block is approximately 2800 sq. m and that of a six-storey block is approximately 1000 sq. m. The configuration of the floor space permits use of one consolidated space or partition into smaller modules. The floors are so configured that accessibility to the circulation core is never more than 25 m of walking distance. The circulation cores have adequate toilets, requisite fire escapes. The maximum wall-to-wall depth is 20 m in the six storey blocks and 18 m in the tower block to ensures adequate daylight and minimize artificial lighting need.

PLANNING:

The architect Mr. Shirish Malpani has designed the building to meet the requirement for which the building has be designed and with respect to the surrounding. There are three levels of basement parking for parking 2500 vehicles at one time with an area of about 70000sqm. F.A.R - 148.38 (permissible F.A.R-150)



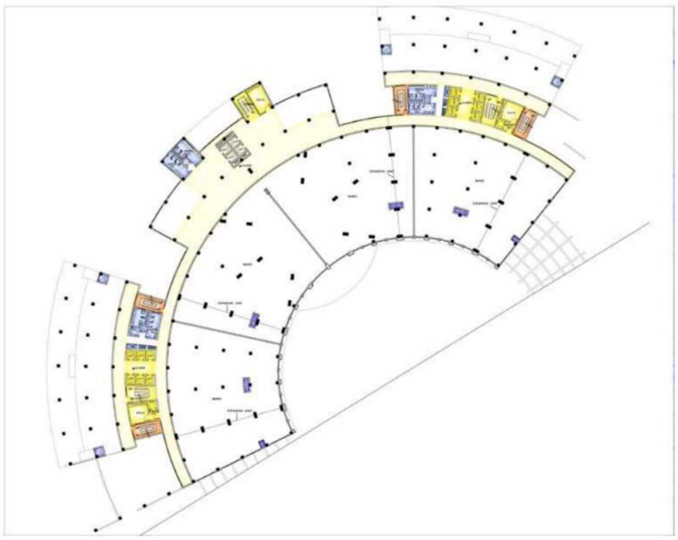


Basement Plan

Ground Floor Plan

First Floor Plan

Second Floor Plan



ARCHITECTURAL CHARACTER OF THE BUILDING:

The building is divided into 2 parts:
a) 28 storey semi-circular complex
b) Four 6 storey building

The building gives a very aesthetic look having a circular block, some rectangular block, landscaping and the simple yet elegant façade treatment. The six storey buildings are constructed in the east, west and south direction. There is no building on the north. It has projected windows having louvers for ventilation.
Firefighting and detecting systems have been provided in the complex. Mechanical ventilation has been provided in the parking area, pantry and toilets. Presently the building the tallest building in Delhi which again is the architectural achievement to the building.

BUILDING SYSTEMS:

Water Supply and Sewage System

City water supply from Delhi Jal Board (018) would be the major source of water to the Complex. Two separate connections would be provided, one for MCD and other for the 28-remaining complex. Tube wells would be developed as an alternate water sources and for other uses like air conditioning etc. Water from tube well feeds the raw water.

HVAC and Building Automation System

The building would be fitted with a central air conditioning system using water cooled centrifugal chillers to provide summer / monsoon cooling and winter heating. The salient feature of the HVAC system design includes optimization of power demand by installation of Energy Recovery Wheel (ERW) in the fresh air system, to reduce the refrigeration load by 80%, this in turn will also reduce the air conditioning plant load by 12 -15%.
The design also envisaged mechanical ventilation for the car parking area, toilets, pantry, and plant room and other similar areas. Mechanical ventilation for basement involves 10 air changes per hour and in case of fire, same would be increased to 30 air changes per hour.

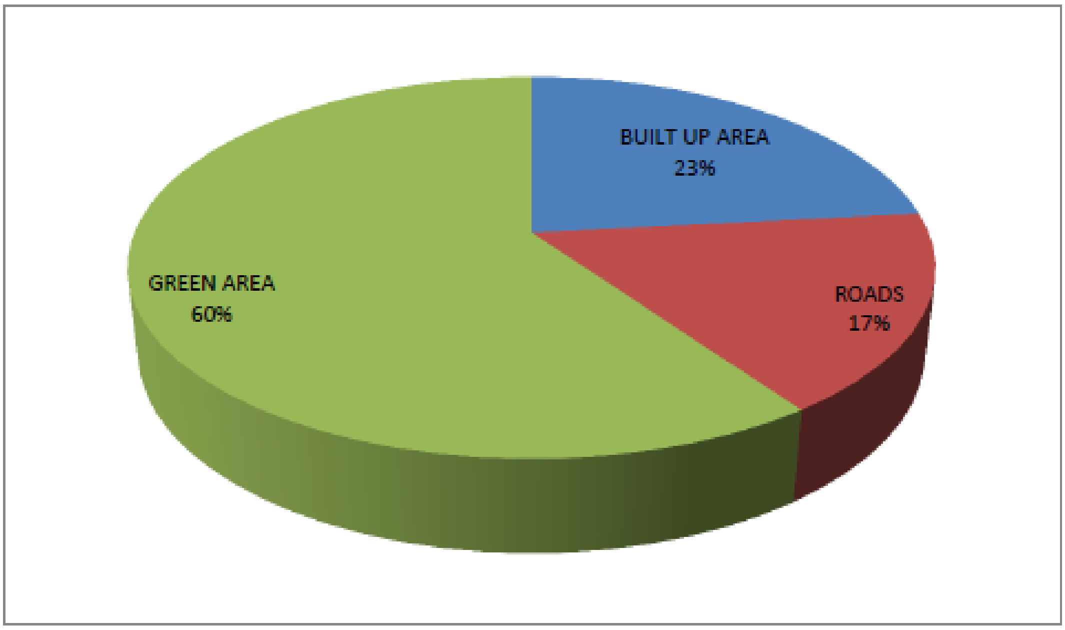
Captive Power Generation

Captive power generation units will be provided for the emergency back-up power requirement. Captive power generation is proposed to be provided for 50 % of the total power requirement. The air conditioning system shuts down in case of power failure. Captive power generation unit include 6 numbers 1500 KVA and 2 numbers 750 KVA DG set for the complex.

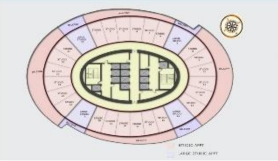
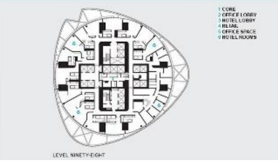
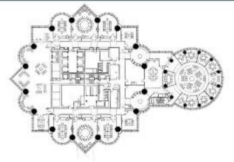
Area Analysis

PLOT AREA	11.54 ACRES
TOTAL COVERED AREA	116755sqm
BUILT UP AREA	10973.97sqm
COMMERCIAL AREA	58377.5sqm
INSTITUTIONAL AREA	58377.5sqm
NO.OF FLOORS	28
GREEN AREA	27855.98sqm
PARKING CAPACITY	2500 VEHICLES
ROAD	7872.23sqm
AUDITORIUM CAPACITY	1000 SEATING
LIBRARY	120000 VOLUMES
ART GALLERY	2000sqm
BANQUET HALL	1500 PERSONS

Area Distribution



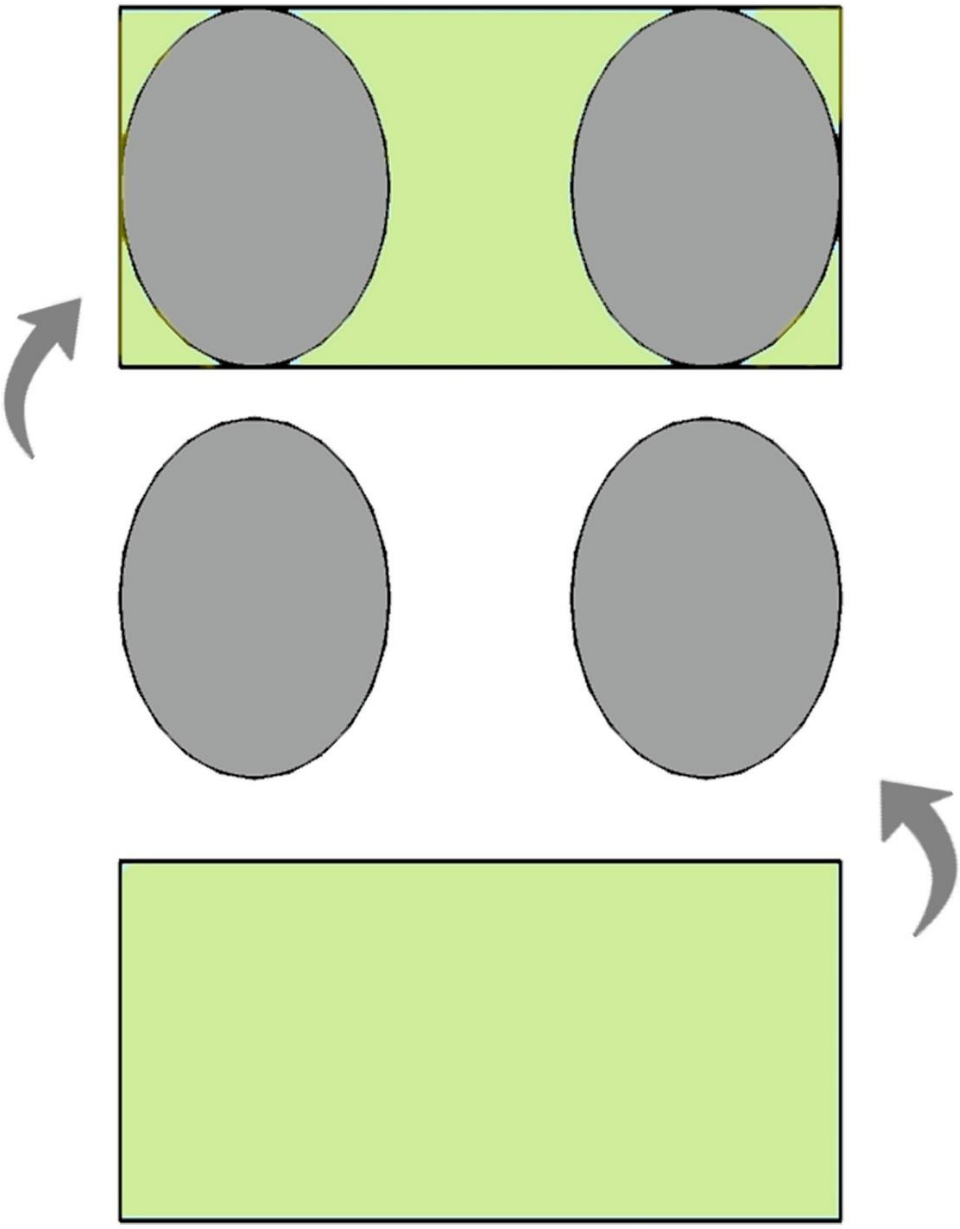
Comparative Analysis

TOPICV	CASE STUDY 1- SUPERNOVA	CASE STUDY 2- MCD CIVIC CENTRE	LITERATURE STUDY 1-SHANGHAI TOWER	LITERATURE STUDY 2- PETRONAS TOWER
LOCATION	SECTOR 94, NOIDA (U.P.)	NEW DELHI	SHANGHAI, CHINA	KUALA LUMPUR, MALAYSIA
ARCHITECT	BENOY,LONDON	SHIRIESH MALPANI & ASSOCIATES	GENSLER	CESAR PELLI & ASSOCIATES
TYPOLOGY	MIXED USED DEVELOPMENT	OFFICE BUILDING	MIXED USE DEVELOPMENT	OFFICE BUILDING & TOURIST
PROJECT YEAR	ESTIMATED COMPLETION 2020	APRIL, 2010	2015	1998
ARCHITECTURAL CHARACTER	VIRTUALLY DYNAMIC FLOOR PLATES	DELHI'S TALLEST BUILDING	ASSYMETRY OF TOWER'S FORM, TAPERING PROFILE 120D ROTATION	SKYBRIDGE
PARKING	7000	2550	1800	-
GREEN BUILDING CERTIFICATION	LEED CERTIFIED (PLATINUM)	-	CHINA GREEN BUILDING 3-STAR	-
PEAK HEIGHT	300M	101M	632M	375M
FLOORS	80 + 3	28 + 3	128	88 + 5
SITE AREA	17.3 ACRES	11.54 ACRES	7.5 ACRES	17.5 ACRES
TOTAL BUILT-UP	6,97,026 SQ.M.	1,16,000 SQ.M.	410,000 SQ.M.	395,000 SQ.M.
GROUND COVERAGE	-	10,973	-	-
LIFT	70 APPROX	43	106	38 EACH TOWER
STAIRCASE	2 IN EACH BLOCK	6 IN EACH BLOCK	2	4
INFERENCES				
PLANNING				

Concept

Form Evolution

The inner forms have been evolved on the study of the wind pressure and forces on a form, we earlier studied the forces of wind acting on a rectangle but a greater wind vortex on the leeward side and huge resistance on the windward face forced us to round the edges , on further rounding the edges, we arrived on the form of an ellipse, which proved very aerodynamic and multiple times better than a rectangle, later we used both the forms and placed the evolved form on the former resulting in a harmonical symphony of two various forms into one.

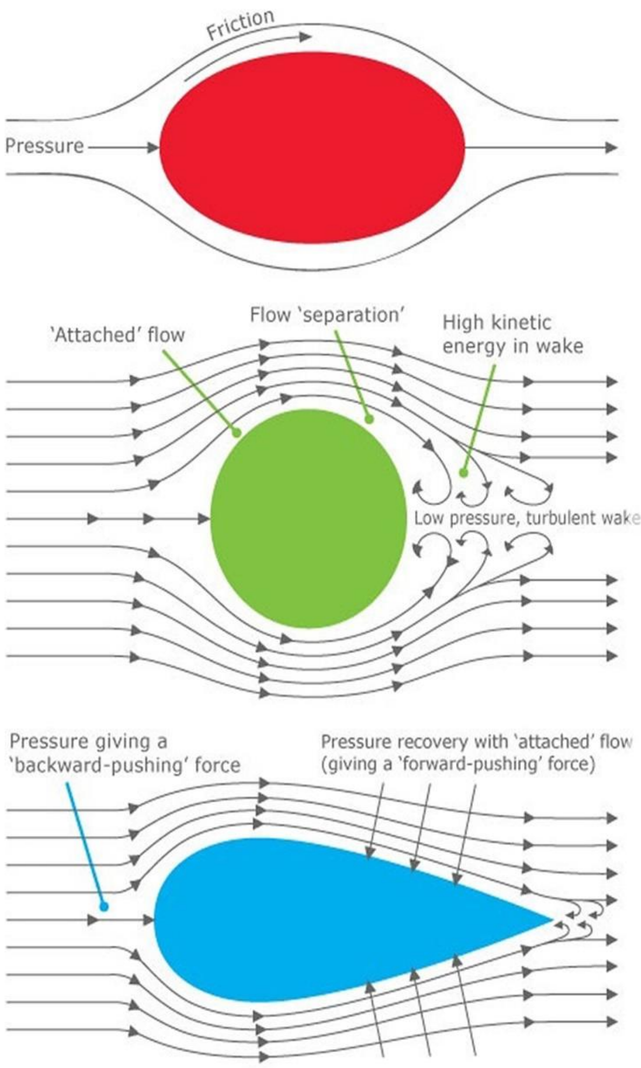


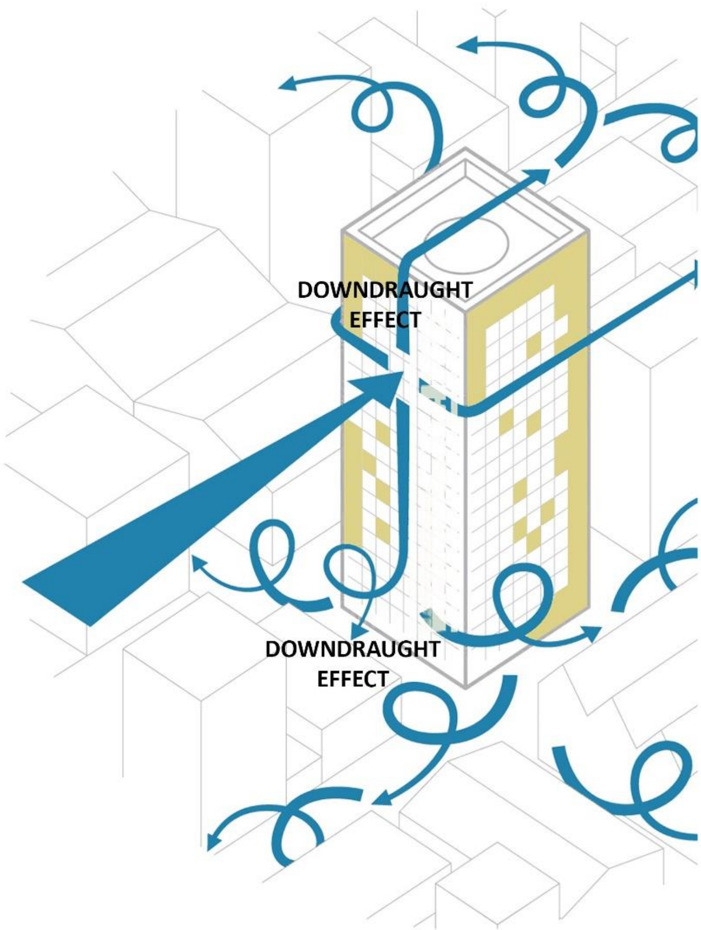
EVOLUTION AND SYNCHRONISED PLACEMENT OF ELLIPSES FROM & ON A RECTANGLE

Effect of winds

Skyscraper's hugely affect the winds in the nearby streets, this is an effect of the downdraught effect. The walkie talkie tower is the best example of this blunder.

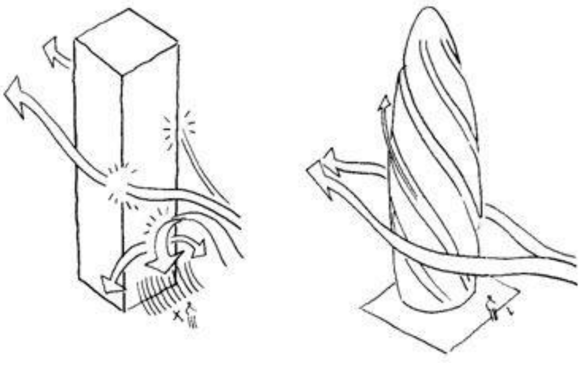
As already discussed, the form plays a major role in the aerodynamics of the building. The total force is termed as 'drag' and is the sum of viscous & pressure forces. Studying all these effects the elongated ellipse proved to be most aerodynamic while any ellipse still was a step ahead of the circular base. So, the form evolution of the floor plates into an ellipse was based on this reason.





The Wind-Flow Studied on Various Forms and The Downdraught Effect Explained.

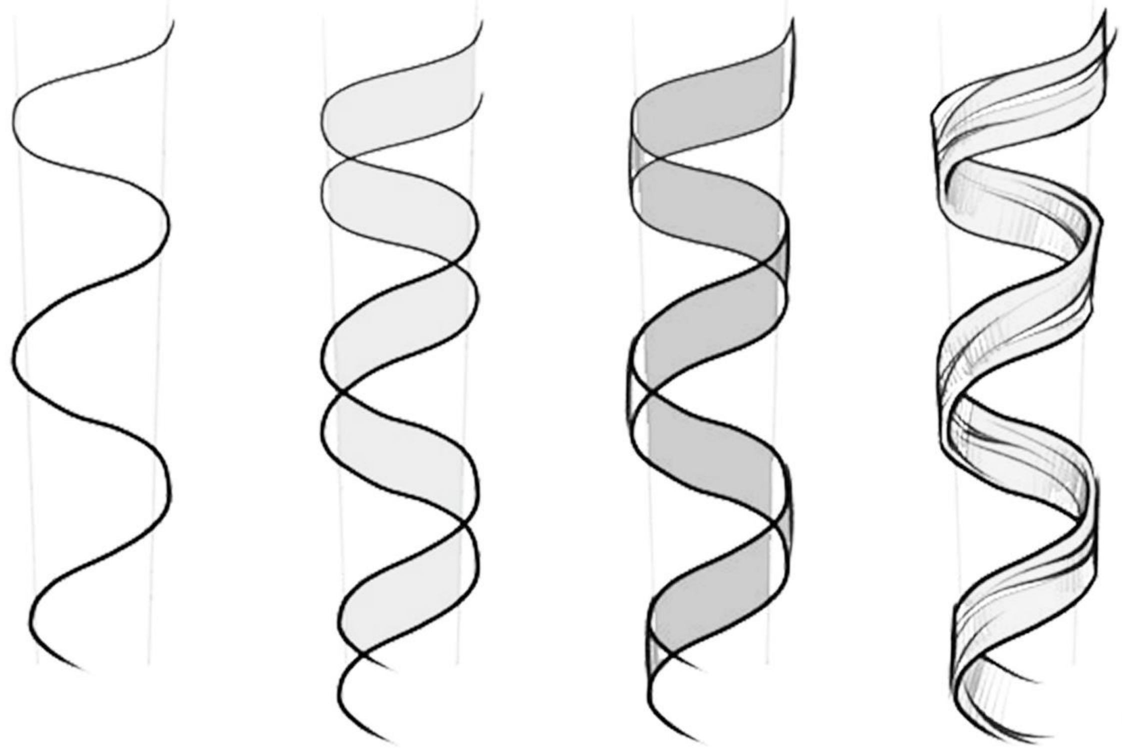
Objects	Pressure force (N)	Viscous force (N)	Total force 'drag' (N)	Drag coefficient C_D	Fineness ratio $FR = c/H$
Reference cylinder	27.95	1.44	29.39	$C_D = 0.3363$	1.000
Original ASDE-X ANTENNA	16.07	2.24	18.31	$C_D = 0.2096$ $RI = 0\%$	1.8382
Ellipse same fineness ratio as antenna	12.52	2.32	14.84	$C_D = 0.1699$ $RI = +19\%$	1.8382
Elongated ellipse	8.29	2.98	11.27	$C_D = 0.1291$ $RI = +38\%$	2.7574



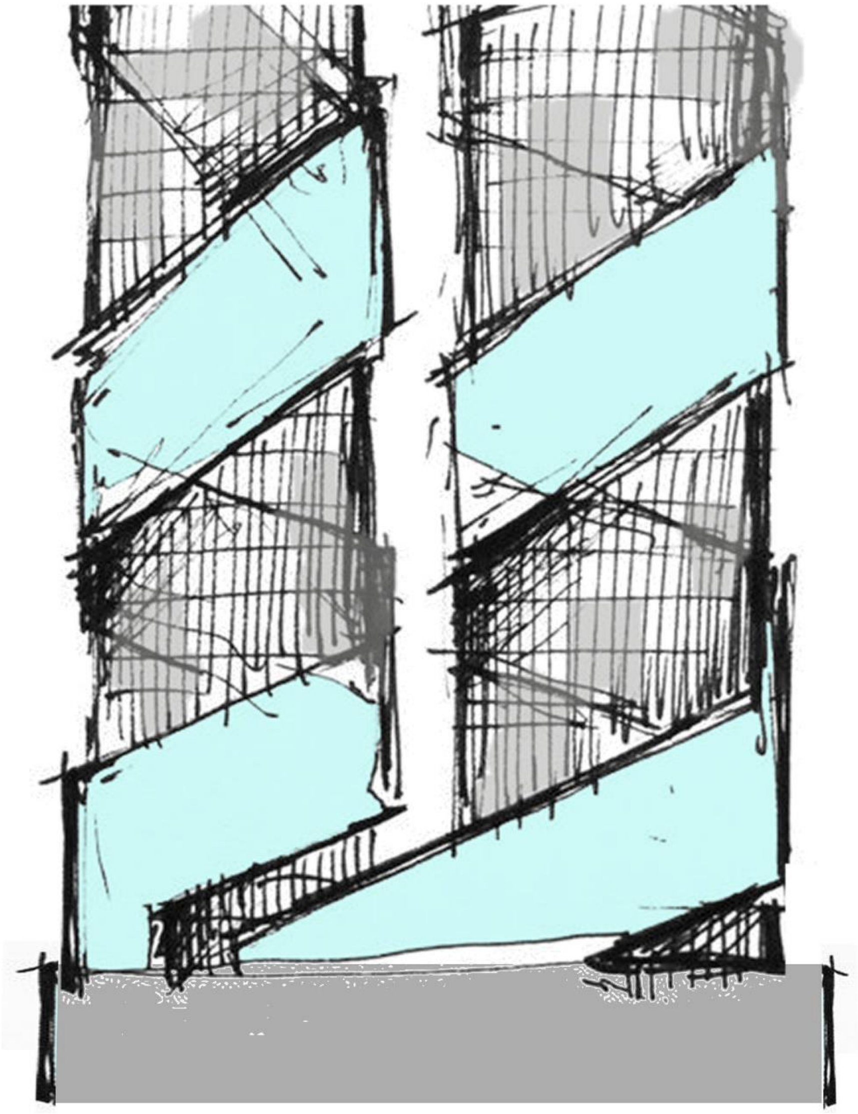
Comparison of Wind Forces on Round Planar Forms (Left) Comparison of Wind Forces on A Basic Rectangular and Evolved Elliptical Base Form

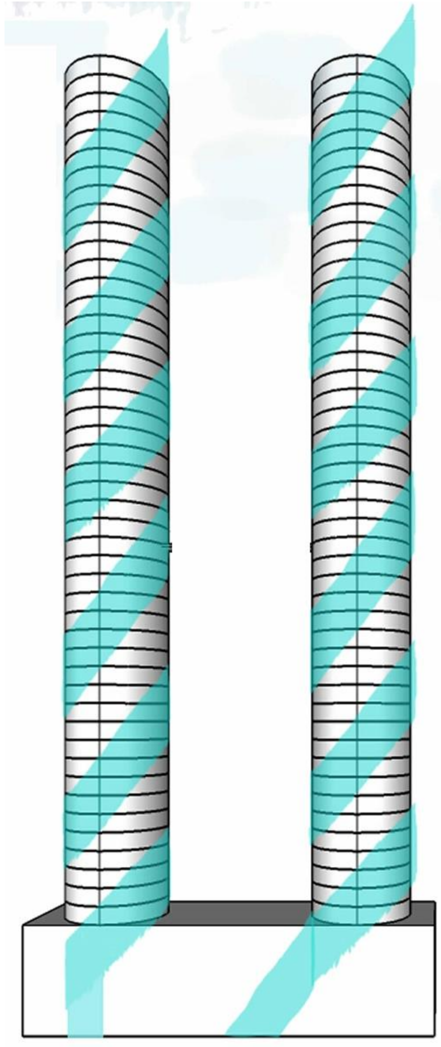
Further Modifications and Additions

Concept for my design has further been evolved from a helix strand into a ribbon signifying a continuous flow, in the case of skyscrapers, the building seems to touch the horizon blending in the sky, the ribbon makes that blend more satisfying by creating a soft sense. Also, it has been influenced by ribbon architecture, Le Corbusier for the first time had used ribbon windows in the villa savoy, and the whole terminology can be said as an invention of Le Corbusier. It also refers an external wall might merge with the load-bearing wall of a building , as it rises upwards to curve into another load bearing wall and finally curve round to form an internal floor, we replaced the load bearing wall with ribbons of glass to allow max. amount of light into building.



Evolution of a Helix String into The Form of a Ribbon

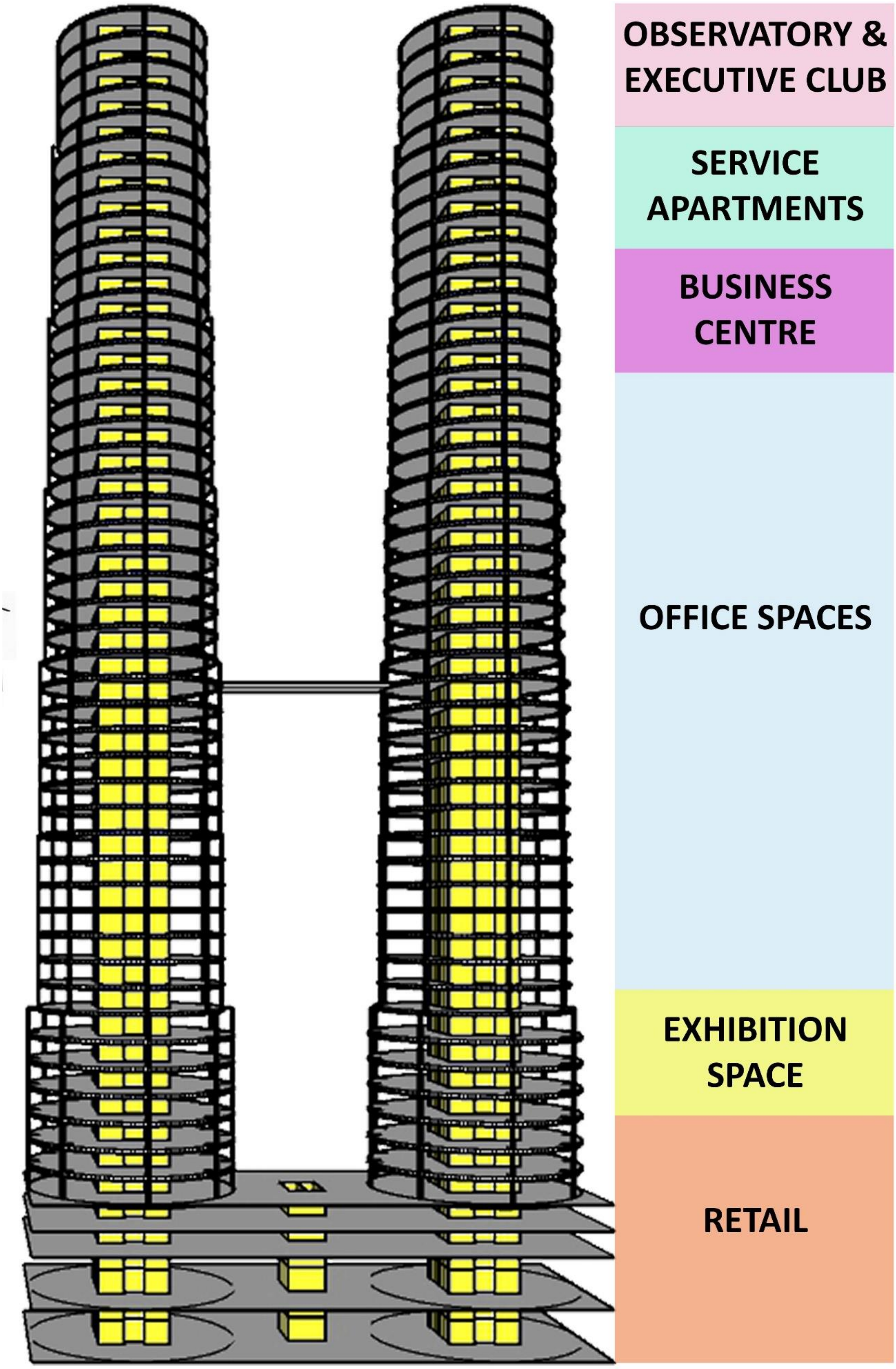




External Facade

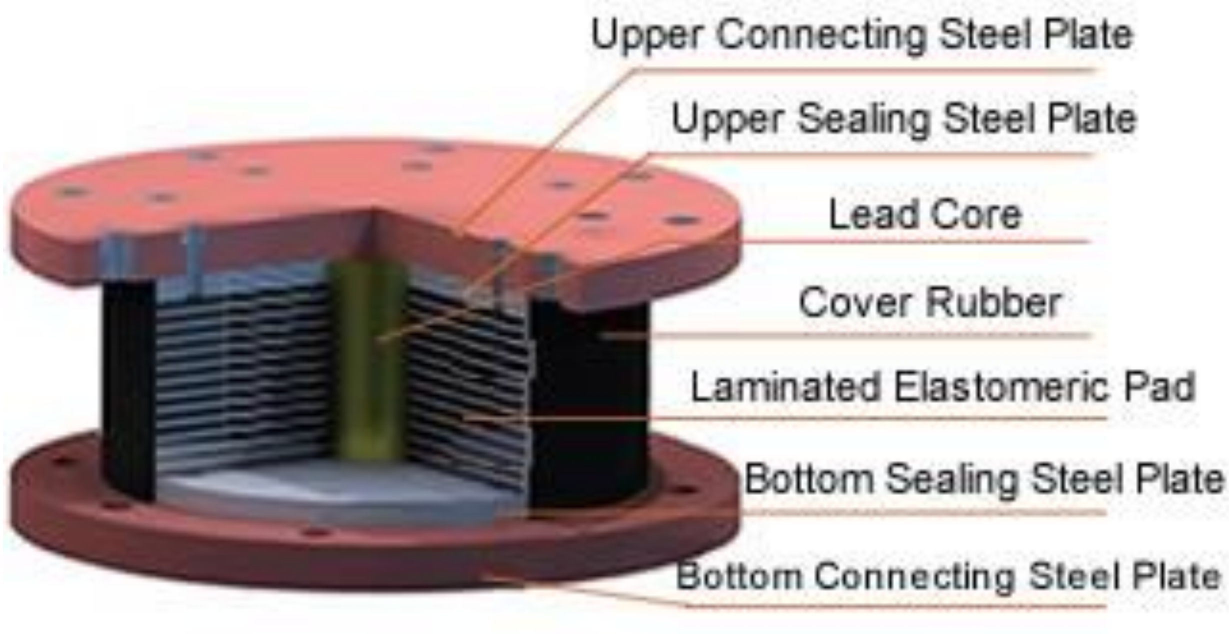
External facade will be of glass in two shades, the lighter tint for ribbon while rest will be darker, the glass will be covered with a non-reflective film to prevent any solar glare.

Vertical Stacking



Earthquake Considerations

Whenever it comes to deisgning a building for a earthquake prone area, there just one thing that could be added to the building which will enable it to stand tall after that earthquake, and it is flexibility, for that the structural system provided will allow the building to be flexible, also the rubber base isolators will be used to bear and absorb vibrations.

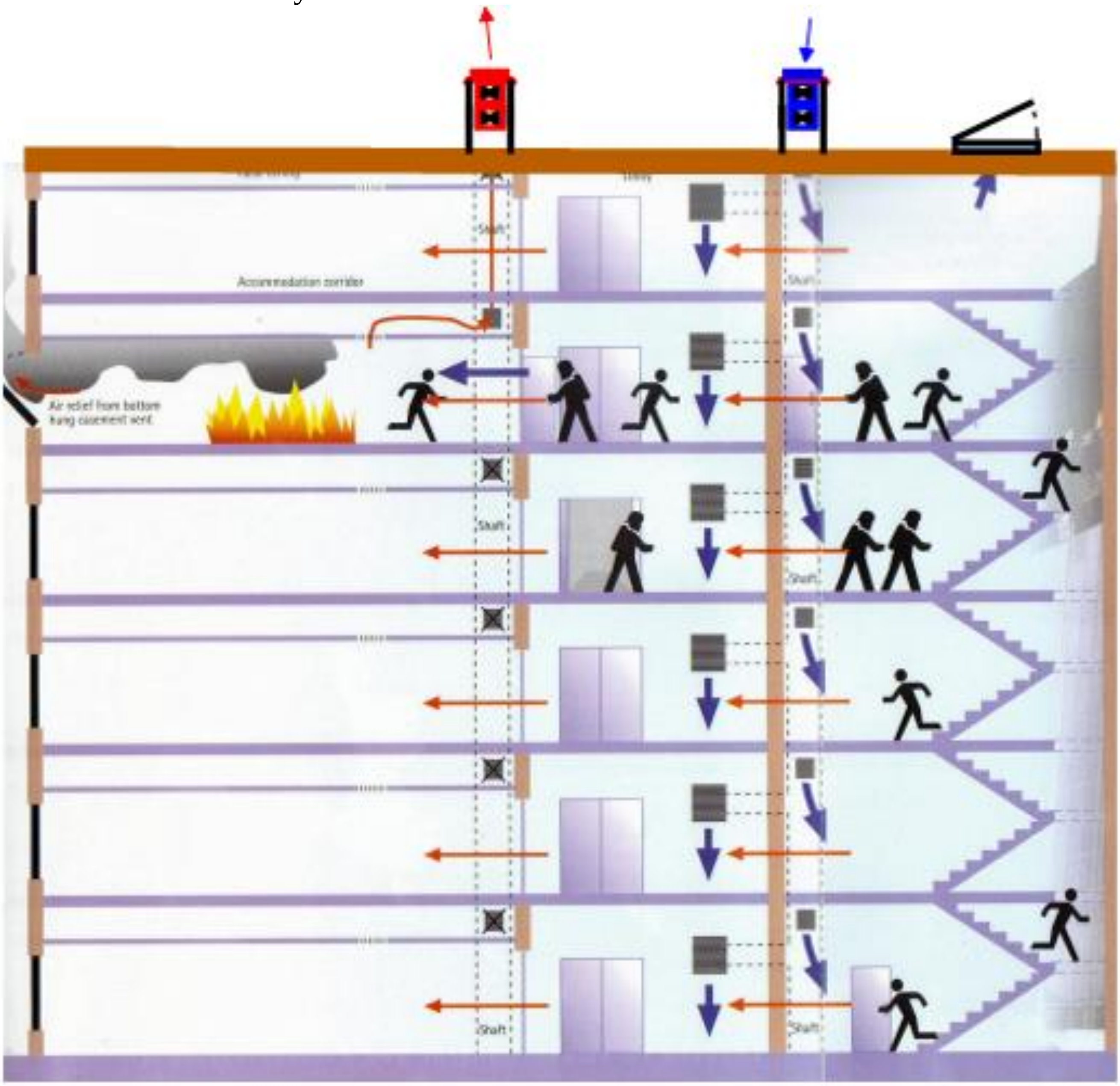


Fire Safety

Effective fire safety in building requires a systematic & diligent approach on the part of the architect to fire prevention, protection from fire, & fire control in all aspects of building design. And any building large or small, fire safety is of utmost importance, not only for the purpose of human safety but also economic stability.

Fire Exit: A way out leading from exit access with or without panic bar provided on the door.
Fireman's Lift: A lift or a group that are installed to enable fire services personnel to reach different floors with minimum delay.
Pressurization: The establishment of a pressure difference across a barrier to protect exit, stairway, lobby, exit passageway or room of a building from smoke penetration. For this purpose pressurization shafts are provided, the adequate pressure for staircase of fire lift lobby is around 25 Pa and the corridor is to be pressurised at around 15 Pa.

Refuge Area: An area within the building for a temporary use during egress. It generally serves as a staging area which is protected from the effect of fire and smoke. As per the NBC, first refuge at 24m height or just next floor after 24m and then after every 15m.



Fire Staircase, Lobby and Pressurization Explained

Area Analysis

Site

Total Site Area ($m^{2)}$	18,494.14 m^2
Proposed Built-Up Area	73,500+476 m^2
F.A.R.	4
Permissible Ground Coverage	7,397 m^2 (@40%)
Ground Covered	3200 m^2
Average Floor Area	685 m^2
Floor Level G to 2 (Podium)	3712 m^2
Floor Level 3 to 8 (Both Tower)	1000 m^2
Floor Level 9 to 14 (Both Tower)	924 m^2
Floor Level 15 to 20 (Both Tower)	875 m^2
Floor Level 21 to 26 (Both Tower)	830 m^2
Floor Level 27 to 32 (Both Tower)	780 m^2
Floor Level 33 to 39 (Both Tower)	730 m^2
Floor Level 40 to 44 (Both Tower)	680 m^2
Floor Level 45 to 49 (Both Tower)	630 m^2

Designed for Population

Retail: 480 pax
Exhibition Space: 235 pax
Office: 3350 pax
Business centre: 300 pax
Serviced Apartments: 102 no(s)
Executive Club cum Observatory: 200 pax

Total: 4565 pax + 102 serviced apartments.

Parking

As Per By-Laws: 1.33 ECS /100m^2
No. Of Parking: 984 ECS

Of which,
Cars (1 ECS): **590** nos. (60% of ECS)
Bus (3.5 ECS): **28** nos. (10% of ECS)
Trucks (3.5 ECS): **28** nos. (10%of ECS)
Motor-Bike (0.25 ECS): **394** nos. (10% of ECS)
Bicycle (0.1 ECS): **984** nos. (10% of ECS)

SPACE NAME	AREA(%)	AREA (SQ. M.)
OFFICE SPACES	50%	36,988
RETAIL CENTRE	20%	14,795.2
BUSINESS CENTRE	10%	7,397.6
OBSERVATORY CUM EXECUTIVE LOUNGE	10%	7,397.6
EXHIBITION SPACE	5%	3,698.8
SERVICE APARTMENTS	5%	3,698.8
Total	100%	73976

RETAIL SECTION	Area required
Back Office (General admin, Record room, Meeting, Staff room, Director’s cabin)	320 m2
Departmental store	150m2 x 20 100m2 x 30 no.s 50m2 x 25no.s
Anchor shops	0.5(floor plate)X3
Shopping arcades	150m2 eachX23
Food court	2/3 floor
Restaurant	2/3 floor

Toilet

	NBC 2005	Men's Toilet	Women's Toilet	Total no. Of Fixtures	Notes
W/C	1 in 25	66	131	197	The number of fixtures in a washroom may vary with the varying floor plate areas.
URINALS	1 in 25	197	-	197	
W/B	1 in 25			197	
DRINKING WATER	1 in 100	-	-	49	
Cleaner's Sink	1 Per Floor	-	-	48	

Height

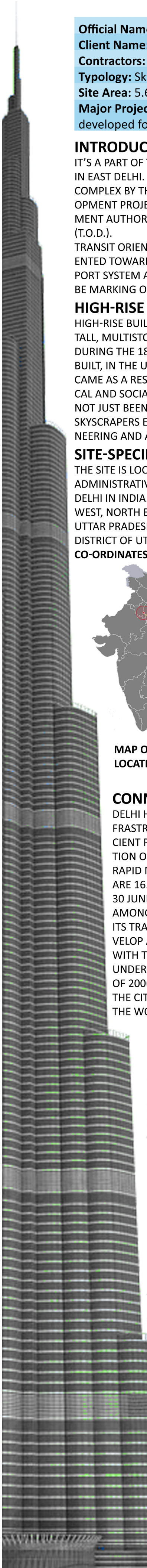
Structural Height:
Antenna Height:
Total Height:
Architectural Height:

Water

Daily Fresh Water Requirement: 50-60 litres per head per day
Water for our building: 3,50,000 litres (approximate)

Rain Water Harvesting

Roof Catchment Capacity = Annual Rainfall(mm) x Rain-water Catchment Surface Area.
= 800x3200
= 25,60,000 Gallons



Official Name: Commercial Twin Towers
Client Name: Delhi Development Authority
Contractors: NBCC
Typology: Skyscraper
Site Area: 5.6 acres
Major Project: Lake View Complex 10.24 Ha land developed for mixed use based on TOD.

INTRODUCTION

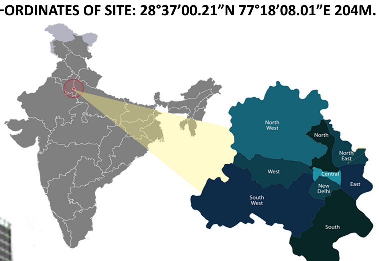
IT'S A PART OF THE REDEVELOPMENT OF THE AREA OF SANJAY LAKE IN EAST DELHI. WHOLE PROJECT HAS BEEN TERMED AS LAKE VIEW COMPLEX BY THE DDA, WHICH WILL HAVE MIXED LAND USE DEVELOPMENT PROJECTS.PROJECT IS PROPOSED BY THE DELHI DEVELOPMENT AUTHORITY AS A PART OF TRANSIT ORIENTED DEVELOPMENT (T.O.D.).
TRANSIT ORIENTED DESIGN IS A CONCEPT OF DESIGN WHICH IS ORIENTED TOWARDS BETTER CONNECTIVITY TO THE PUCLIC TRANSPORT SYSTEM AND THE NEARBY AMENITIES.THE TWIN TOWERS WILL BE MARKING OUT THE COMPLEX, WITH ATLEAST 50-60 STOREYS.

HIGH-RISE ARCHITECTURE

HIGH-RISE BUILDINGS, GENERALLY TERMED SKYSCRAPER ARE VERY TALL, MULTISTORIED BUILDINGS. THE NAME FIRST CAME INTO USE DURING THE 1880S, SHORTLY AFTER THE FIRST SKYSCRAPERS WERE BUILT, IN THE UNITED STATES. THE DEVELOPMENT OF SKYSCRAPERS CAME AS A RESULT OF THE COINCIDENCE OF SEVERAL TECHNOLOGICAL AND SOCIAL DEVELOPMENTS. IN TODAY'S SCENARIO, IT HAS NOT JUST BEEN LIMITED TO SKYSCRAPERS, TERM LIKE MEGATALL SKYSCRAPERS ETC HAVE BEEN IN USE WITH THE INCREASING ENGINEERING AND ARCHITECTURAL MARVELS.

SITE-SPECIFICS

THE SITE IS LOCATED IN EAST DELHI(A.K.A. TRANS YAMUNA), IS AN ADMINISTRATIVE DISTRICT OF THE NATIONAL CAPITAL TERRITORY OF DELHI IN INDIA. IT IS BOUNDED BY THE YAMUNA RIVER ON THE WEST, NORTH EAST DELHI TO THE NORTH, GHAZIABAD DISTRICT OF UTTAR PRADESH STATE TO THE EAST, AND GAUTAM BUDDHA NAGAR DISTRICT OF UTTAR PRADESH TO THE SOUTH.
CO-ORDINATES OF SITE: 28°37'00.21"N 77°18'08.01"E 204M.



MAP OF INDIA SHOWING THE RELATIVE LOCATION OF THE SITE

CONNECTIVITY

DELHI HAS SIGNIFICANT RELIANCE ON ITS TRANSPORT INFRASTRUCTURE. THE CITY SEEKS TO DEVELOP A HIGHLY EFFICIENT PUBLIC TRANSPORT SYSTEM WITH THE INTRODUCTION OF THE DELHI METRO, WHICH IS UNDERGOING A RAPID MODERNIZATION & EXPANSION AS OF 2006. THERE ARE 16.6 MILLION REGISTERED VEHICLES IN THE CITY AS OF 30 JUNE 2014, WHICH IS THE HIGHEST IN THE WORLD AMONG ALL CITIES.DELHI HAS SIGNIFICANT RELIANCE ON ITS TRANSPORT INFRASTRUCTURE. THE CITY SEEKS TO DEVELOP A HIGHLY EFFICIENT PUBLIC TRANSPORT SYSTEM WITH THE INTRODUCTION OF THE DELHI METRO, WHICH IS UNDERGOING A RAPID MODERNIZATION & EXPANSION AS OF 2006. THERE ARE 16.6 MILLION REGISTERED VEHICLES IN THE CITY AS OF 30 JUNE 2014, WHICH IS THE HIGHEST IN THE WORLD AMONG ALL CITIES.

RAIL: CONNECTED TO INDIAN RAILWAYS
NEAREST RAILWAY STATION IS ANAND VIHAR TERMINAL 6.2KM
OTHER STATION TO REACH DELHI ARE:
1.NEW DELHI RAILWAY STATION,
2.OLD DELHI RAILWAY STATION,
3.HAZRAT NIZAMUDDIN RAILWAY STATION,
4.SARAI ROHILLA

BUS: NEAREST BUS STATION IS
ISBT ANAND VIHAR IN TRANS-YAMUNA AREA 5.8KM
HIGHWAYS: NH 1, NH 2, NH 8, NH 10 AND NH 24
BUS SERVICES:THE OTHER 2 INTER-STATE TERMINALS IN CITY ARE:
ISBT KASHMERE GATE IN NORTHERN DELHI
ISBT KAUSHAMBI, GHAZIABAD
ISBT SARAI KALE KHAN IN SOUTH DELHI

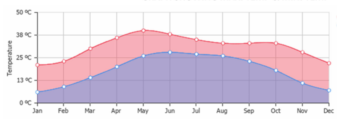
AIRPORTS: INDIRA GANDHI INTERNATIONAL AIRPORT (IGI); BOTH DOMESTIC AND INTERNATIONAL CONNECTIONS 30KM

METRO: AT **TRILOKPURI SANJAY LAKE METRO STATION (PINK LINE)** CONNECTED WITH DELHI METRO'S MAJOR BLUE LINE AT KARKARDUMA & ANAND VIHAR METRO STATION. TRILOKPURI METRO WILL BE CONNECTED WITH MAYUR VIHAR POCKET 1 METRO TO COMPLETE THE PINK LINE.

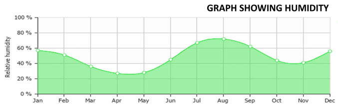
CLIMATIC STUDY:

AVG. TEMPERATURE:12^{O}-32^{O}C
AVG. MAX. TEMPERATURE:20^{O}-39^{O}C
AVG. MIN. TEMPERATURE:12^{O}-32^{O}C
AVG. RAIN: 0-8 CM

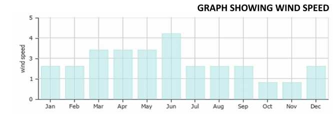
GRAPH SHOWING MAX. TEMP & MIN. TEMP



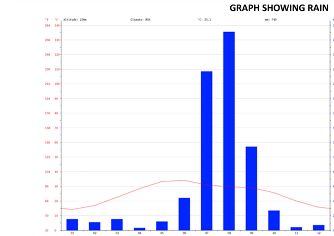
GRAPH SHOWING HUMIDITY



GRAPH SHOWING WIND SPEED



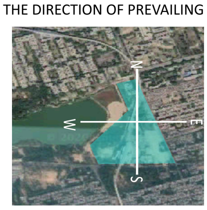
GRAPH SHOWING RAIN



SINCE, **SIESMIC STUDY** BECOMES A KEY FACTOR IN DESIGNING A HIGH-RISE BUILDING, WE STUDIED THE SIESMIC CONDITIONS FOR OUR SITE, IT FALLS IN SIESMIC ZONE 4, WHICH EXPERIENCES EARTHQUAKES OF INTENSITY 6 & HIGHER ON RICHTER SCALE AND VIII ON THE MODIFIED MERCALLI SCALE.

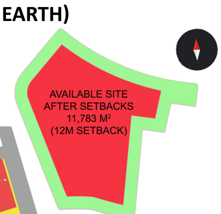
SOIL PROFILE IS ANOTHER DRIVING FACTOR IN HIGH-RISE DESIGN, THE SOIL TYPE OF THE SITE IS SILTEY CLAY AND HAS A BEARING CAPACITY OF 95.69 KN/M^2. 204M.

WIND STUDY IS SO FAR THE MOST IMPORTANT FACTOR FOR ANY HIGH RISE BUILDING'S CONSTRUCTION,DESIGN, OR HABITABILITY. THE MAXIMUM WIND VELOCITY AT OUR SITE THROUGHOVER THE YEAR IS 12.6KMPH IN THE MONTH OF MAY, STUDIED AT AN HEIGHT OF 10 METRES FROM THE GROUND LEVEL, WHILE THE CALMEST EXPERIENCED VELOCITY WENT DOWN TO AROUND 5.6KMPH IN THE MONTH OF NOVEMBER.WITH NORTH-WEST& WEST AS THE DIRECTION OF PREVAILING WINDS.



SITE(REF: GOOGLE EARTH)

EAST DELHI MAP



TWIN TOWER SITE

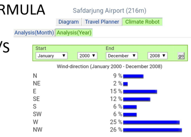
10.26 HA T.O.D. SITE AT SANJAY LAKE

WIND

THE STUDY OF THE VELOCITY OF WIND BECOMES A MAJOR FACTOR WHILE DESIGNING THE SKYSCRAPERS. THE SPEED OF WIND AT THE SITE RANGES FROM 5.6KM/H IN THE MONTH OF NOVEMBER TO 12.6 KM/H IN THE MONTH OF MAY.
WHILE THIS SPEED STATED IS AT A HEIGHT OF 10M FROM THE GROUND. TO CALCULATE THE SPEED AT ANY HEIGHT WE USE THE FORMULA

$$V_Z = V_B K_1 K_2 K_3$$

WHERE, V_Z-DESIGN WIND SPEED AT ANY HT. Z IN M/S
K_1-PROBABILITY FACTOR(RISK COEFF.)
K_2- TERRAIN, HT. & STRUCTURE SIZE FACTOR
K_3- TOPOGRAPHY FACTOR



WIND LOADS

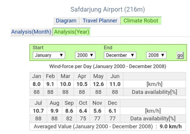
DESIGN WIND PRESSURE IS GIVEN BY THE FORMULA,

$$P_D = 0.6 V_Z^2$$

WHERE, P_D-DESIGN WIND PRESSURE IN N/M^2 AT HEIGHT D.
V_Z-WIND VELOCITY AT HEIGHT Z MT
WHILE THE WIND LOAD ON INDIVIDUAL MEMBERS IS GIVEN BY

$$F = (C_{PE} - C_{PI}) A \; PD$$

WHERE, C_{PE}= EXTERNAL PRESSURE COEFFICIENT,
C_{PI}= INTERNAL PRESSURE COEFFICIENT,
A=SURFACE AREA OF STRUCTURAL ELEMANT OR CLADDING UNIT,
PD=DESIGN WIND PRESSURE



STRUCTURAL SYSTEM

FOR CONTEMPORARY HIGH-RISE OFFICE BUILDINGS, IT IS IMPORTANT TO ADOPT A STRUCTURAL SYSTEM TO COPE WITH AN OPEN-PLAN, IN WHICH ALL OFFICE WORKERS PERFORM IN A COMMON SPACE. SEVERAL STRUCTURAL SOLUTIONS HAVE BEEN DEVELOPED AND ARE COMBINED TO MEET THE ARCHITECTURAL REQUIREMENTS, SUCH AS COLUMN-FREE SPACES AND MAXIMUM LEASING DEPTH ALLOWED BY THE SITE REGULATIONS.STRUCTURAL SYSTEMS FOR HIGH-RISE BUILDINGS ARE DIVIDED INTO TWO BROAD CATEGORIES, WHICH ARE INTERIOR AND EXTERIOR STRUCTURES. THIS CLASSIFICATION IS BASED ON THE DISTRIBUTION OF THE COMPONENTS OF THE PRIMARY LATERAL LOAD RESISTING SYSTEM OVER THE BUILDING.

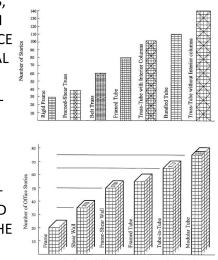


Figure 3: Classification of tall building structural systems by Fazlur Khan (above: steel; below: concrete).

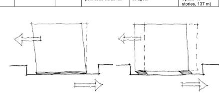
Table 2-1: Interior Structures.

Category	Sub-Category	Material / Configuration	Efficient Height Limit	Advantages	Disadvantages	Building Examples
Rigid Frames	–	Steel	30	Provide flexibility in floor planning. Fast construction.	Expensive moment connections. Expensive fire proofing.	860 & 880 Lake Shore Drive Apartments (Chicago, USA, 26 stories, 82 m), Business Men's Assurance Tower (Kansas City, USA, 19 stories), Seagram Building, 30th to the top floor (New York, USA, 38 stories, 157 m)
		Concrete	20	Provide flexibility in floor planning. Easily moldable.	Expensive formwork. Slow construction.	Ingalls Building (Cincinnati, USA, 16 stories, 65 m)
Braced Hinged Frames	–	Steel Shear Trusses + Steel Hinged Frames	10	Efficiently resist lateral loads by axial forces in the shear truss members. Allows shallower beams compared with the rigid frames without diagonals.	Interior planning limitations due to diagonals in the shear trusses. Expensive diagonal connections.	Low-rise buildings
Shear Wall / Hinged Frames	–	Concrete Shear Wall + Steel Hinged Frame	35	Effectively resists lateral shear by concrete shear walls.	Interior planning limitations due to shear walls.	77 West Wacker Drive (Chicago, USA, 50 stories, 203.6 m), Casselden Place (Melbourne, Australia, 43 stories, 160 m)
Shear Wall (or Shear Truss) - Frame Interaction System	Braced Rigid Frames	Steel Shear Trusses + Steel Rigid Frames	40	Effectively resists lateral loads by producing shear truss - frame interacting system.	Interior planning limitations due to shear trusses.	Empire State Building (New York, USA, 102 stories, 381 m), Seagram Building, 17th to 29th floor (New York, USA, 38 stories, 157 m)
	Shear Wall / Rigid Frames	Concrete Shear Wall + Steel Rigid Frame	60	Effectively resists lateral loads by producing shear wall - frame interacting system.	Interior planning limitations due to shear walls.	Seagram Building, up to the 17th floor (New York, USA, 38 stories, 157 m)
		Concrete Shear Wall + Concrete Frame	70	"	"	311 South Wacker Drive (Chicago, USA, 75 stories, 284 m), Cook County Administration Building, former Brunswick Building (Chicago, USA, 38 stories, 145 m)
Outrigger Structures	–	Shear Cores (Steel Trusses or Concrete Shear Walls) + Outriggers (Steel Trusses or Concrete Walls) + (Belt Trusses) + Steel or Concrete Composite (Super) Columns	150	Effectively resists bending by exterior columns connected to outriggers extended from the core.	Outrigger structure does not add shear resistance.	Taipei 101 (Taipei, Taiwan, 101 stories, 509 m), Jin Mao Building (Shanghai, China, 88 stories, 421 m)

Table 2-2: Exterior Structures.

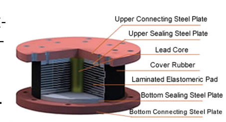
Category	Sub Category	Material / Configuration	Efficient Height Limit	Advantages	Disadvantages	Building Examples
Tube	Framed Tube	Steel	80	Efficiently resists lateral loads by locating lateral systems at the building perimeter.	Shear lag hinders true tubular behavior. Narrow column spacing obstructs the view.	Aon Center (Chicago, USA, 83 stories, 346 m)
		Concrete	60	"	"	Water Tower Place (Chicago, USA, 74 stories, 262 m)
	Braced Tube	Steel	100 (With Interior Columns) – 150 (Without Interior Columns)	Efficiently resists lateral shear by axial forces in the diagonal members. Wider column spacing possible compared with framed tubes. Reduced shear lag.	Bracings obstruct the view.	John Hancock Center (Chicago, USA, 100 stories 344 m)
		Concrete	100	"	"	Onterie Center (Chicago, 58 stories, 174 m), 780 Third Avenue (New York, USA, 50 stories, 174 m)
	Bundled Tube	Steel	110	Reduced shear lag.	Interior planning limitations due to the bundled tube configuration.	Sears Tower (Chicago, USA, 108 stories, 442 m)
		Concrete	110	"	"	Carnegie Hall Tower (New York, USA, 62 stories, 230.7 m)
	Tube in Tube	Ext. Framed Tube (Steel or Concrete) + Int. Core Tube (Steel or Concrete)	80	Effectively resists lateral loads by producing interior shear core - exterior framed tube interacting system.	Interior planning limitations due to shear core.	181 West Madison Street (Chicago, USA, 50 stories, 207 m)
Diagrid	–	Steel	100	Efficiently resists lateral shear by axial forces in the diagonal members.	Complicated joints.	Hearst Building (New York, USA, 42 stories, 182 m), 30 St Mary Axe, also known as Swiss Re Building (London, UK, 41 stories, 181 m)
		Concrete	60	"	Expensive formwork. Slow construction.	O-14 Building (Dubai)
Space Truss Structures	–	Steel	150	Efficiently resists lateral shear by axial forces in the space truss members.	Obstruct the view. May obstruct the view.	Bank of China (Hong Kong, China, 72 stories, 367 m)
Superframes	–	Steel	160	Could produce supertall buildings.	Building form depends to a great degree on the structural system.	Chicago World Trade Center (Chicago, USA, 168 stories, Unbuilt)
		Concrete	100	"	"	Parque Central Tower (Caracas, Venezuela, 56 stories, 221 m)
Exo-skeleton	–	Steel	100	Interior floor is never obstructed by perimeter columns.	Thermal expansion / contraction. Systemic thermal bridges.	Hotel de las Artes (Barcelona, Spain, 43 stories, 137 m)

STRUCTURAL SYSTEM USED IN OUR BUILDING WILL BE THE OUTRIGGER & BELT TRUSS FOR THE INTERIOR AND BRACED TUBE FOR THE OUTER STRUCTURE.



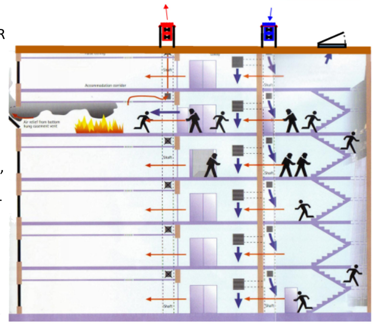
EARTHQUAKE

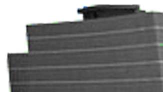
AS ALREADY DISCUSSES OUR SITE FALLS IN THE SIESMIC ZONE-4, THEREFORE EARTHQUAKES CONSIDERATIONS BECOME IMPORTANT, THEREFORE WE'LL BE USING RUBBER BASE ISOLATORS TO SAFEGUARD OUR BUILDING FROM EARTHQUAKES.



FIRE

IN ANY BUILDING HIGH OR LOW RISE, FIRE SAFETY IS ONE OF THE MAIN CONERNS, OUR BUILDINGS WILL BE EQUIPPED WITH ALL MEASURES LIKE THE FIREMAN'S & EVACUATION LIFT, FIRE STAIRCASE, PRESSURIZATION SHAFT, SPRINKLER SYSTEMS, WET RISERS, & REFUGE AREAS (FIRST AT 24M, FOLOWED BY EACH AT NEXT 15M). THE FIRE-SHAFT AND THE FIRE DOORS WILL BE OF FIRE RATING IN TERMS OF TIME.

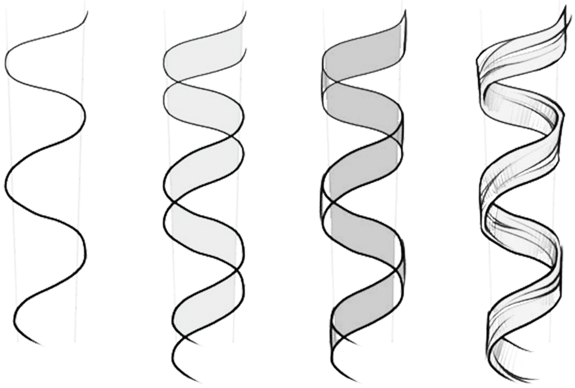




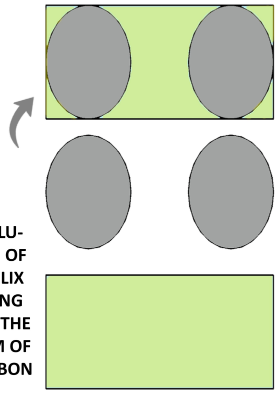
COMMERCIAL TWIN

CONCEPT

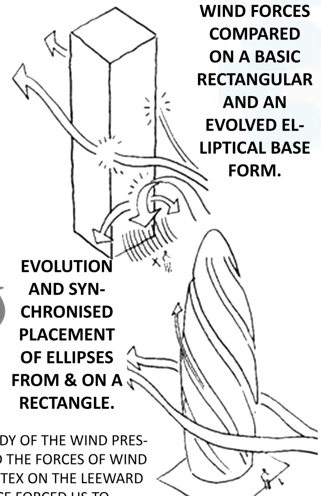
FORM EVOLUTION



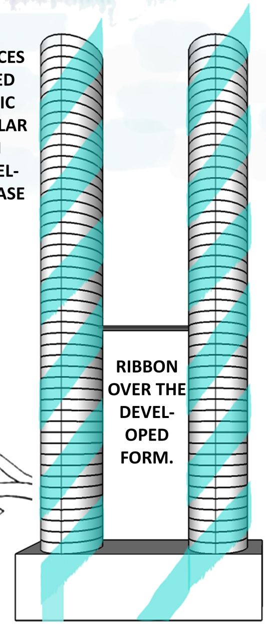
EVOLUTION OF A HELIX STRING INTO THE FORM OF A RIBBON



EVOLUTION AND SYNCHRONISED PLACEMENT OF ELLIPSES FROM & ON A RECTANGLE.



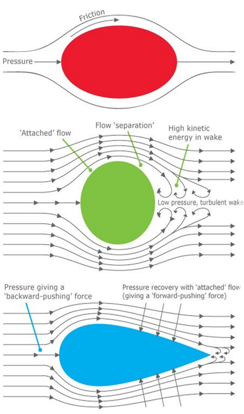
WIND FORCES COMPARED ON A BASIC RECTANGULAR AND AN EVOLVED ELLIPTICAL BASE FORM.

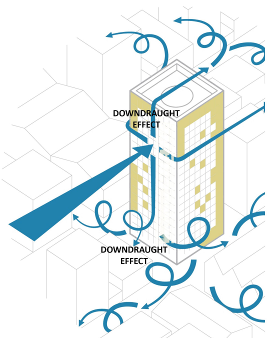


RIBBON OVER THE DEVELOPED FORM.

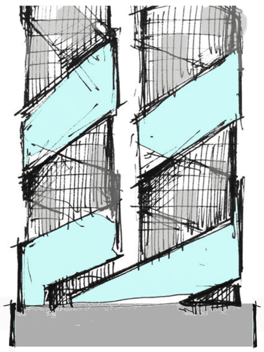
CONCEPT FOR MY DESIGN HAS BEEN EVOLVED FROM A HELIX STRAND INTO A RIBBON SIGNIFYING A CONTINUOUS FLOW, IN THE CASE OF SKYSCRAPERS, THE BUILDING SEEM TO TOUCH THE HORIZON BLENDING IN THE SKY, THE RIBBON MAKES THAT BLEND MORE SATISFYING BY CREATING A SOFT SENSE. ALSO IT HAS BEEN INFLUENCED BY RIBBON ARCHITECTURE, LE CORBUSIER FOR THE FIRST TIME HAD USED RIBBON WINOWS IN THE VILLA SAVOY, AND THE WHOLE TERMINOLOGY CAN BE SAID AS AN INVENTION OF LE CORBUIER. IT ALSO REFERS AN EXTERNAL WALL MIGHT MERGE WITH THE LOAD-BEARING WALL OF A BUILDING , AS IT RISES UPWARDS TO CURVE INTO ANOTHER LOAD BEARING WALL AND FINALLY CURVE ROUND TO FORM AN INTERNAL FLOOR, WE REPLACED THE LOAD BEARING WALL WITH RIBBONS OF GLASS TO ALLOW MAX. AMT OF LIGHT INTO BUILDING.

THE INNER FORMS HAVE BEEN EVOLVED ON THE STUDY OF THE WIND PRESSURE AND FORCES ON A FORM, WE EARLIER STUDIED THE FORCES OF WIND ACTING ON A RECTANGLE BUT A GREATER WIND VORTEX ON THE LEEWARD SIDE AND HUGE RESISTANCE ON THE WINDWARD FACE FORCED US TO ROUND THE EDGES , ON FURTHER ROUNDING THE EDGES, WE ARRIVED ON THE FORM OF AN ELLIPSE, WHICH PROVED VERY AERODYNAMIC AND MULTIPLE TIMES BETTER THAN A RECTANGLE, LATER WE USED BOTH THE FORMS AND PLACED THE EVOLVED FORM ON THE FORMER RESULTING IN A HARMONICAL SYMPHONY OF TWO VARIOUS FORMS INTO ONE.





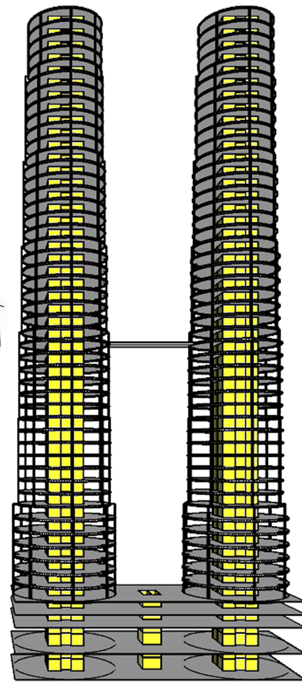
Objects	Pressure force (N)	Viscous force (N)	Total force 'drag' (N)	Drag coefficient C_D	Fineness ratio $FR = c/H$
Reference cylinder	27.95	1.44	29.39	$C_D = 0.3363$	1.000
Original ASDE-X ANTENNA	16.07	2.24	18.31	$C_D = 0.2096$ $RI = 0\%$	1.8382
Ellipse same fineness ratio as antenna	12.52	2.32	14.84	$C_D = 0.1699$ $RI = +19\%$	1.8382
Elongated ellipse	8.29	2.98	11.27	$C_D = 0.1291$ $RI = +38\%$	2.7574



EFFECT OF WINDS

SKYSCRAPER'S HUGELY AFFECT THE WINDS IN THE NEARBY STREETS, THIS IS AN EFFECT OF THE DOWNDRAUGHT EFFECT. THE WALKIE TALKIE TOWER IS THE BEST EXAMPLE OF THIS BLUNDER.

AS ALREADY DISCUSSED, THE FORM PLAYS A MAJOR ROLE IN THE AERODYNAMICS OF THE BUILDING. THE TOTAL FORCE IS TERMED AS 'DRAG' AND IS THE SUM OF VISCOUS & PRESSURE FORCES. STUDYING ALL THESE EFFECTS THE ELONGATED ELLIPSE PROVED TO BE MOST AERODYNAMIC WHILE ANY ELIPSE STILL WAS A STEP AHEAD OF THE CIRCULAR BASE.



OBSERVATORY & EXECUTIVE CLUB

SERVICE APARTMENTS

BUSINESS CENTRE

OFFICE SPACES

EXHIBITION SPACE

RETAIL

FINAL FORM

1. THE ENTRIES FOR DIFFERENT AREAS ARE PROVIDED SEPERATELY.

2. THE LOWER PODIUM FLOORS HOUSE THE RETAIL SECTION AND ENTRANCE LOBBIES, WHICH IS LINKED TO THE MAIN PEDESTRIAN ACCESS. IT ALSO SERVES AS CONNECTING POINT OF BOTH THE BLOCKS.

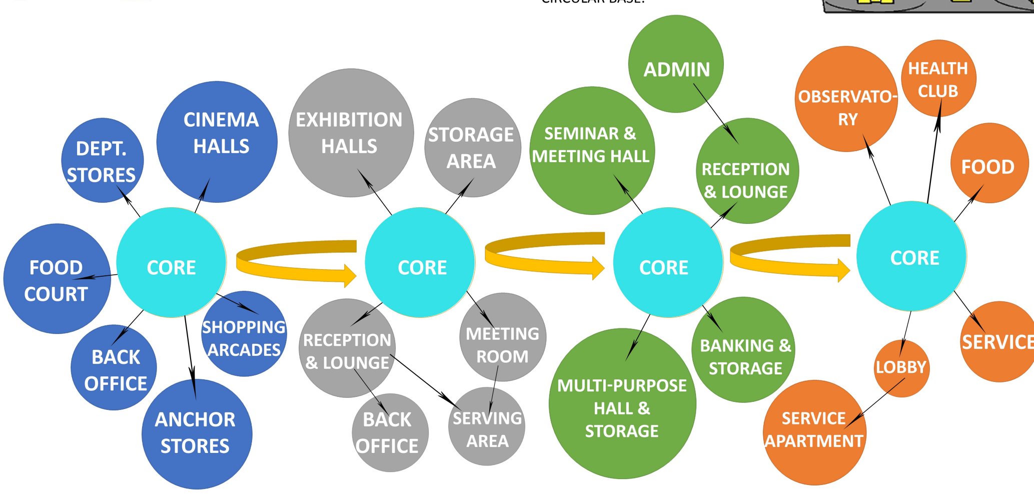
3. THE OFFICE AREA, THE THIRD VERTICAL ZONE FROM GROUND IS DISTRIBUTED IN BOTH THE BLOCKS.

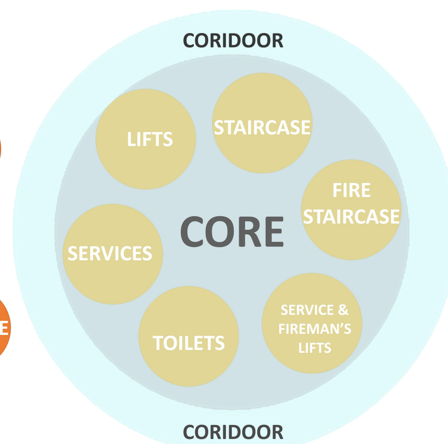
4. THE CONNECTING BRIDGE BETWEEN BOTH THE BUILDING IS AT THE LEVEL OF OFFICE SPACES.

5. STEPPED FLOOR PLATES AND CURVED EDGES REDUCES WIND LOAD THE STRUCTURE SYSTEM IS OUTRIGGER BELT-TRUSS & BRACED TUBE.

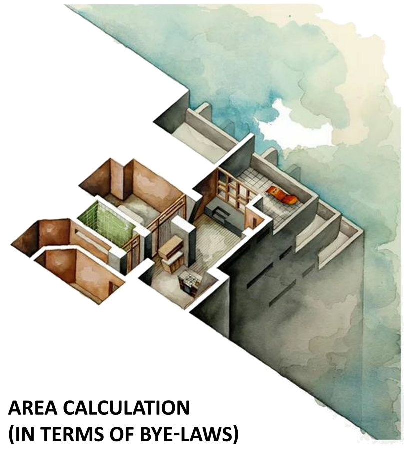
EXTERNAL FACADE

EXTERNAL FACADE WILL BE OF GLASS IN TWO SHADES, THE LIGHTER TINT FOR RIBBON WHILE REST WILL BE DARKER, THE GLASS WILL BE COVERED WITH A NON-REFLECTIVE FILM TO PREVENT ANY SOLAR GLARE.

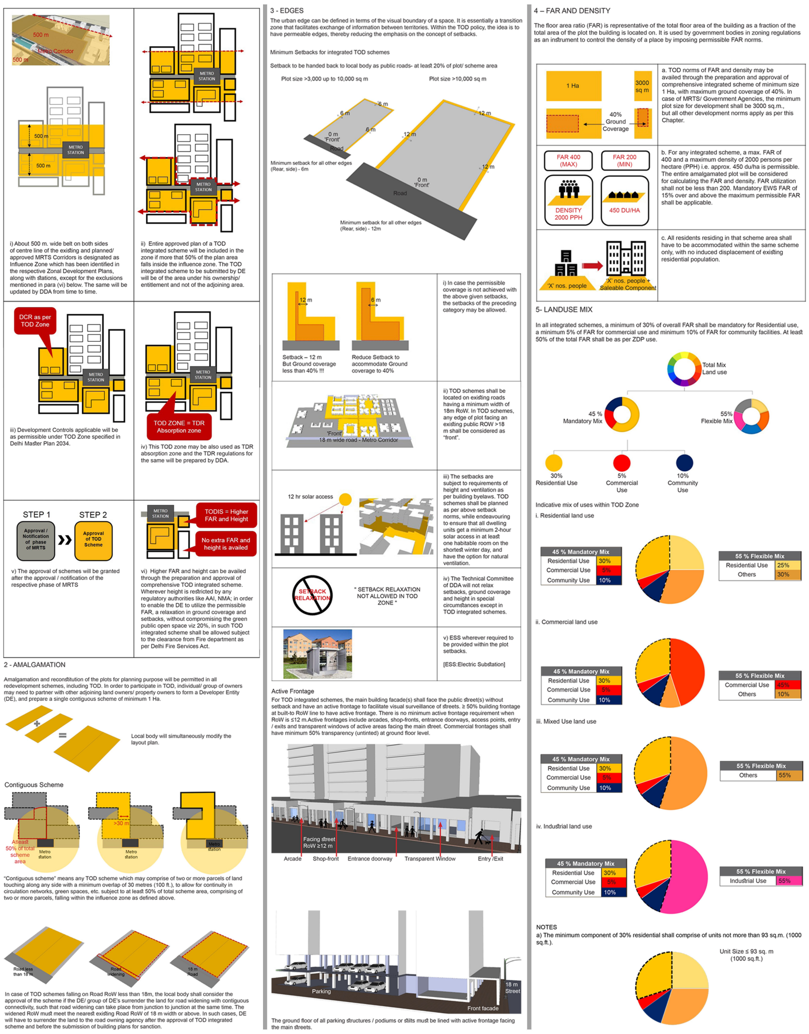




TOWERS|SANJAY LAKE|EAST DELHI| RISHABH SIN



T.O.D. NORMS



AREA CALCULATION
(IN TERMS OF BYE-LAWS)

TOTAL SITE AREA (M²)= 18,494.14 M²

PROPOSED BUILTUP AREA= 73,500+476 M²

F.A.R.= 4

GROUND COVERAGE= 40% = 7,397 M²
PROPOSED NUMBER OF FLOORS= 50

AVERAGE FLOOR AREA (M²): 685(WITHOUT PODIUM/-BLOCK)

PODIUM FLOOR (SINGLE BLOCK)
(G+2)= 9600 M²
BELOW DETAILS ARE INCLUSIVE AREAS OF BOTH THE BLOCKS
3-8 FLOORS= 10,560
(880/BLOCK/FLOOR)
9-14 FLOORS=9,840
(820/BLOCK/FLOOR)
15-20 FLOORS=9,000
(750/BLOCK/FLOOR)
21-26 FLOORS=8,400
(700/BLOCK/FLOOR)
27-32 FLOORS=7,800
(650/BLOCK/FLOOR)
33-38 FLOORS=7,200
(600/BLOCK/FLOOR)
39-44 FLOORS=6,600
(550/BLOCK/FLOOR)
45-49 FLOORS=4,950
(495/BLOCK/FLOOR)

TOTAL AREA ACHIEVED 73,950

SETBACKS
FRONT SETBACK=3M (FOR ROAD WIDENING)
SIDE SETBACK= 12M
REAR SETBACK=12M

Total Site Area	18,494 m2
Proposed Built-Up	73,950 m2
F.A.R.	4
Ground coverage	3,200 m2
Proposed number of floors	Podium(3 floors) + 47 + 4 (mechanical)

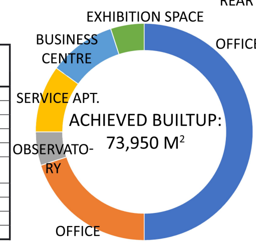
SPACE NAME	AREA(%)	AREA (SQ. M.)
OFFICE SPACES	50%	36,988
RETAIL CENTRE	20%	14,795.2
BUSINESS CENTRE	10%	7,397.6
OBSERVATORY CUM EXECUTIVE LOUNGE	10%	7,397.6
EXHIBITION SPACE	5%	3,698.8
SERVICE APARTMENTS	5%	3,698.8
Total	100%	73976

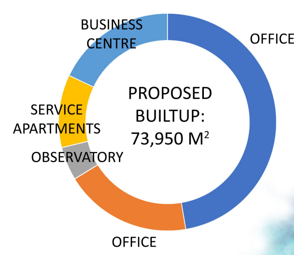
RETAIL SECTION	Area required
Back Office (General admin, Record room, Meeting, Staff room, Director's cabin)	320 m2
Departmental store	150m2 x 20 100m2 x 30 no.s 50m2 x 25no.s
Anchor shops	0.5(floor plate)X3
Shopping arcades	150m2 eachX23
Food court	2/3 floor
Restaurant	2/3 floor
Cinema for 300X4	1080m2+200m2 (Ticket counter, lobby & food court)

	Name of Building	Number of cores	Location of core		Core integrity		Core Area (m²)	Core/ GFA (%)
			Center	Outside	Yes	No		
WORLD	Taipei 101 Tower	Single	X			X	665	25
	Shanghai WFC	Single	X		X		750	30
	Petronas T. 1-2	Single	X			X	530	25
	Sears Tower	Single	X			X	1113	22
	Jin Mao Tower	Single	X			X	800	29
	Two International Finance Center	Single	X		X		740	26
	CITIC Plaza	Single	X			X	480	22
	Shun Hing Square	Single	X			X	570	26
	Central Plaza	Single	X		X		560	25
	Bank of China	Double	X			X	800	30

	NBC 2005	Men's Toilet	Women's Toilet	Total no. Of Fixtures	Notes
W/C	1 in 25	66	131	197	The number of fixtures in a washroom may vary with the varying floor plate areas.
URINALS	1 in 25	197	-	197	
W/B	1 in 25			197	
DRINKING WATER	1 in 100	-	-	49	
Cleaner's Sink	1 Per Floor	-	-	48	

VEHICLE TYPE	ECS(1/100m2)	SHARE IN ECS	NO. OF PARKING
Car	1	60%	1233
Motorcycle	0.25	10%	74
Cycle	0.1	10%	74
Bus	3.5	10%	74
Truck	3.5	10%	74





STRUCTURAL HEIGHT: 190.8 M
ANTENA HEIGHT: 9.2 M
TOTAL HEIGHT: 190.8 + 9.2 = 200 M²
ARCHITECTURAL HEIGHT : 9.2 M

DAILY **FRESH WATER** REQUIREMENT PER PERSON PER DAY FOR A COMMERCIAL BUILDING- 80-100 GALLONS PER DAY.
TOTAL WATER REQUIREMENT FOR OUR BUILDING:
4,43,700 GALLONS

RAIN WATER HARVESTING

ROOF CATCHMENT CAPACITY= ANNUAL RAINFALL(MM) X RAINWATER CATCHMENT SURFACE AREA.
=800*3200= 25,60,000 GALLON
RATIONAL METHOD TO PREDICT PEAK RUNOFF
Q = CIA
C- RUNOFF COEFFICIENT   I-RAINFALL AVGERAGE
A-CATCHMENT AREA   Q-PEAK RUNOFF

AREA ANALYSIS

GH|GUIDE:PROF.SANGEETA SHARMA,AR.NAVEEN SINGH

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

KEY PLAN

N

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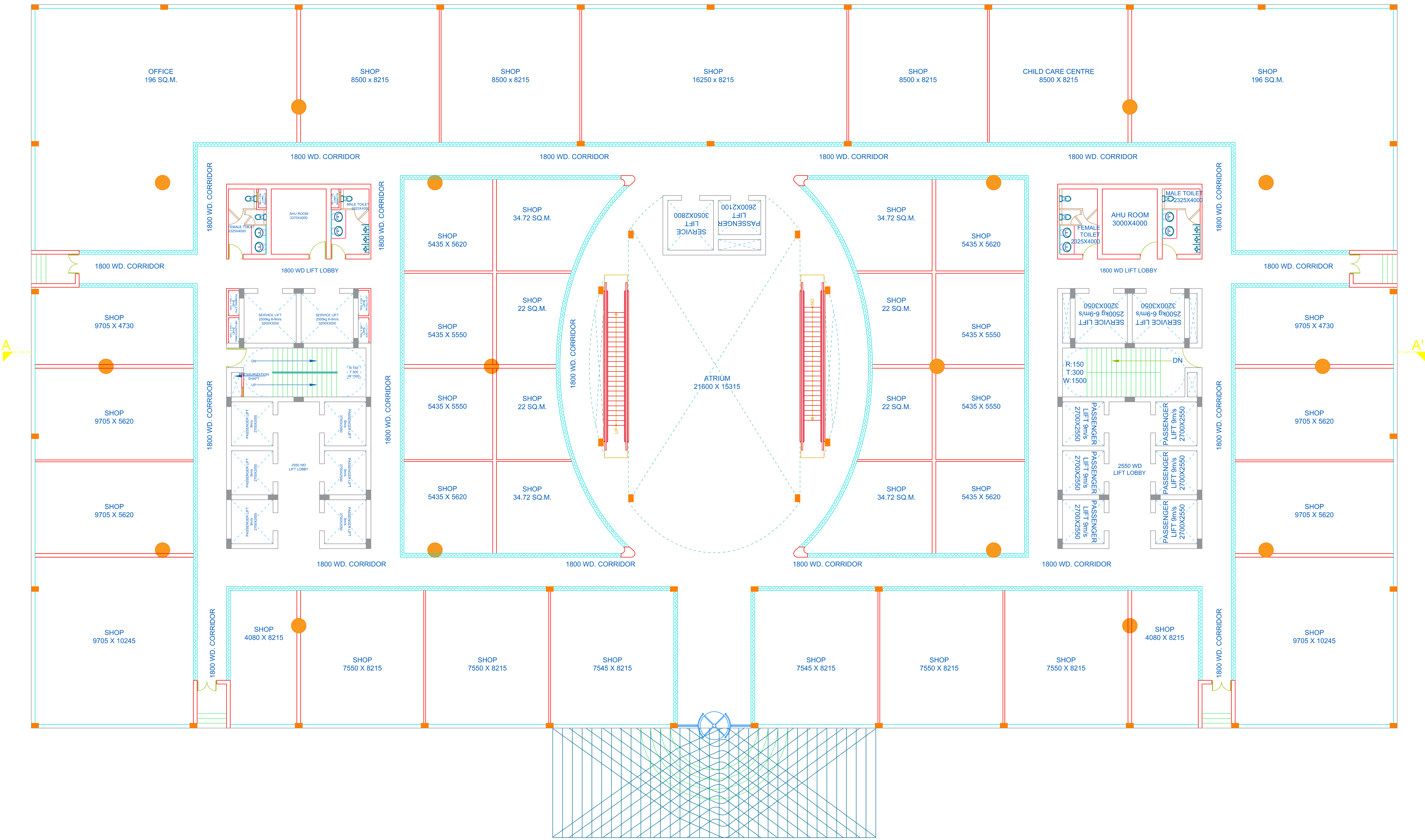

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

GROUND FLOOR RETAIL

3712 M^2

N

NOT TO SCALE

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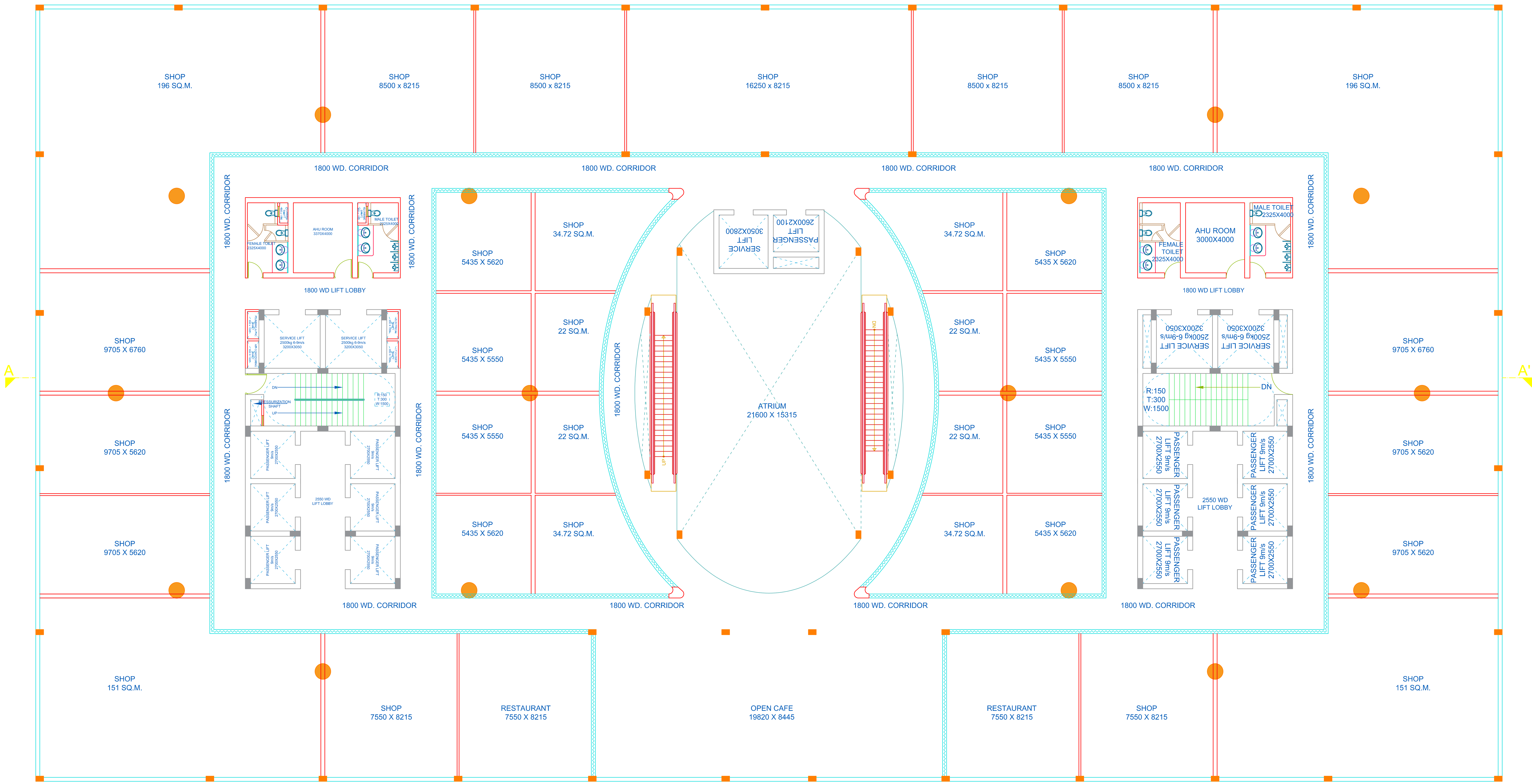

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

TYPICAL FLOOR RETAIL (1&2)

N

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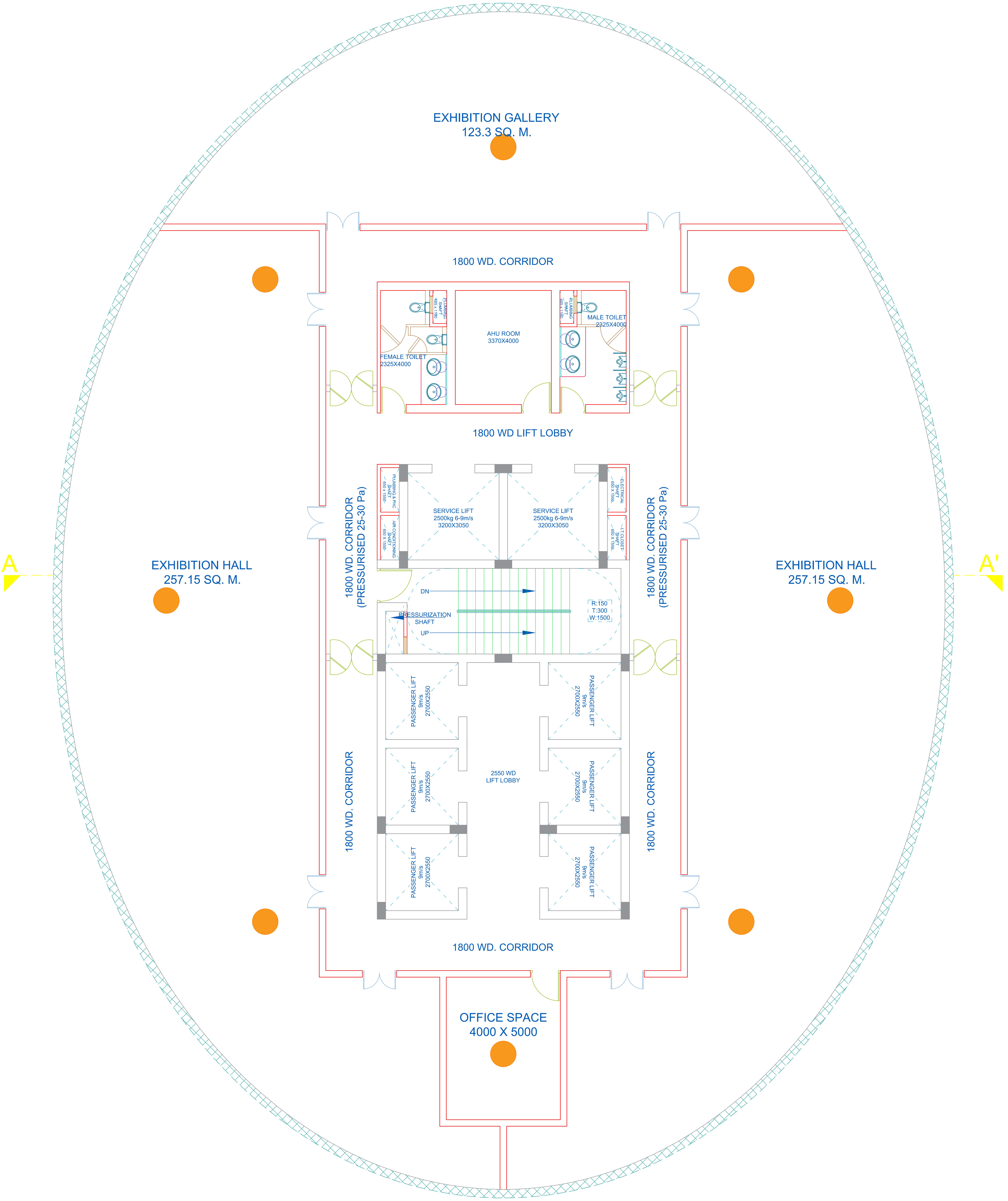

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LVLS - 3,4) (PLAN OF TOWER A)
USE- EXHIBITION SPACE
FLOOR AREA- 1000 m^2

N

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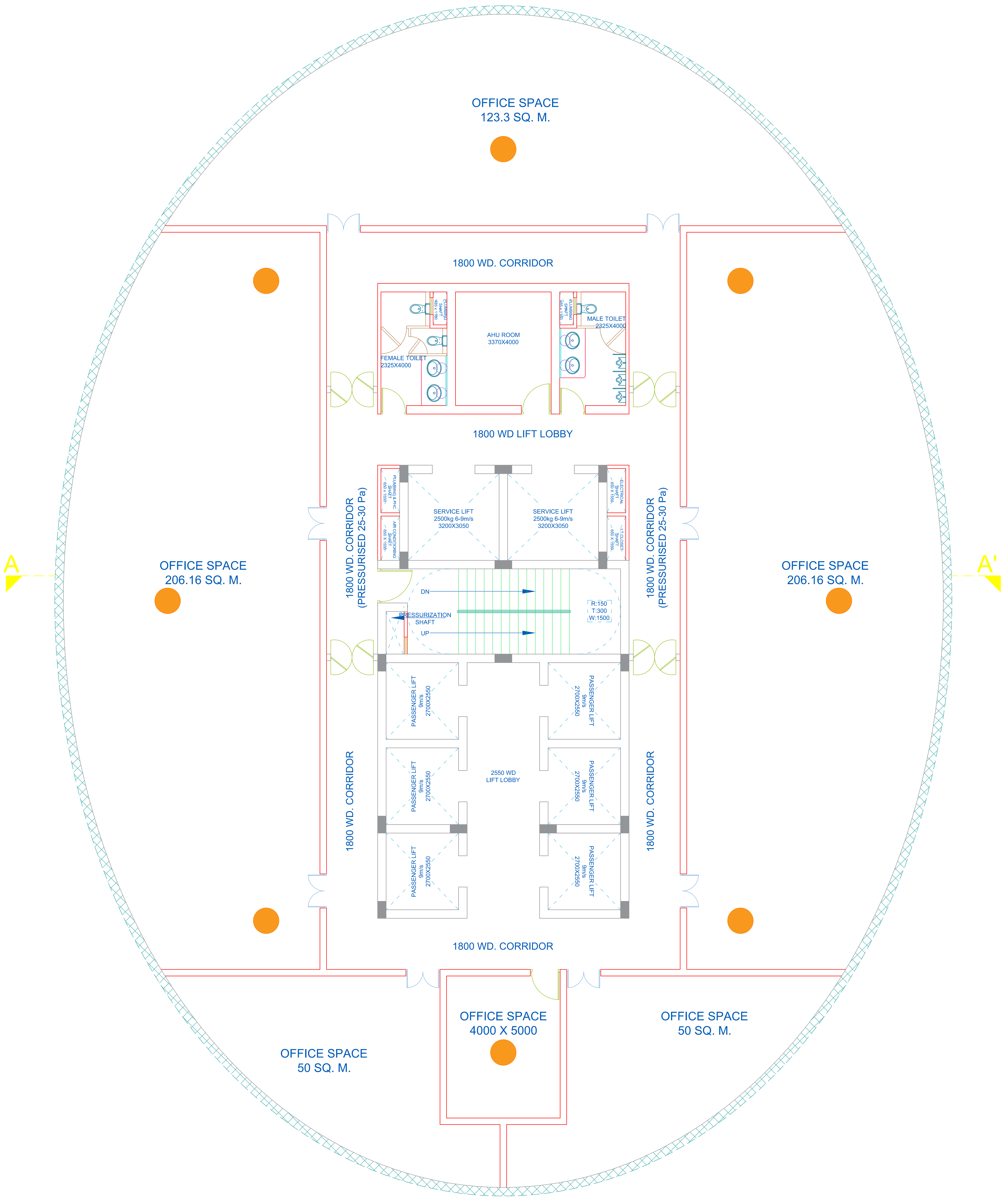

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LVLS- 5-8)(PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 1000 SQ. M.

N

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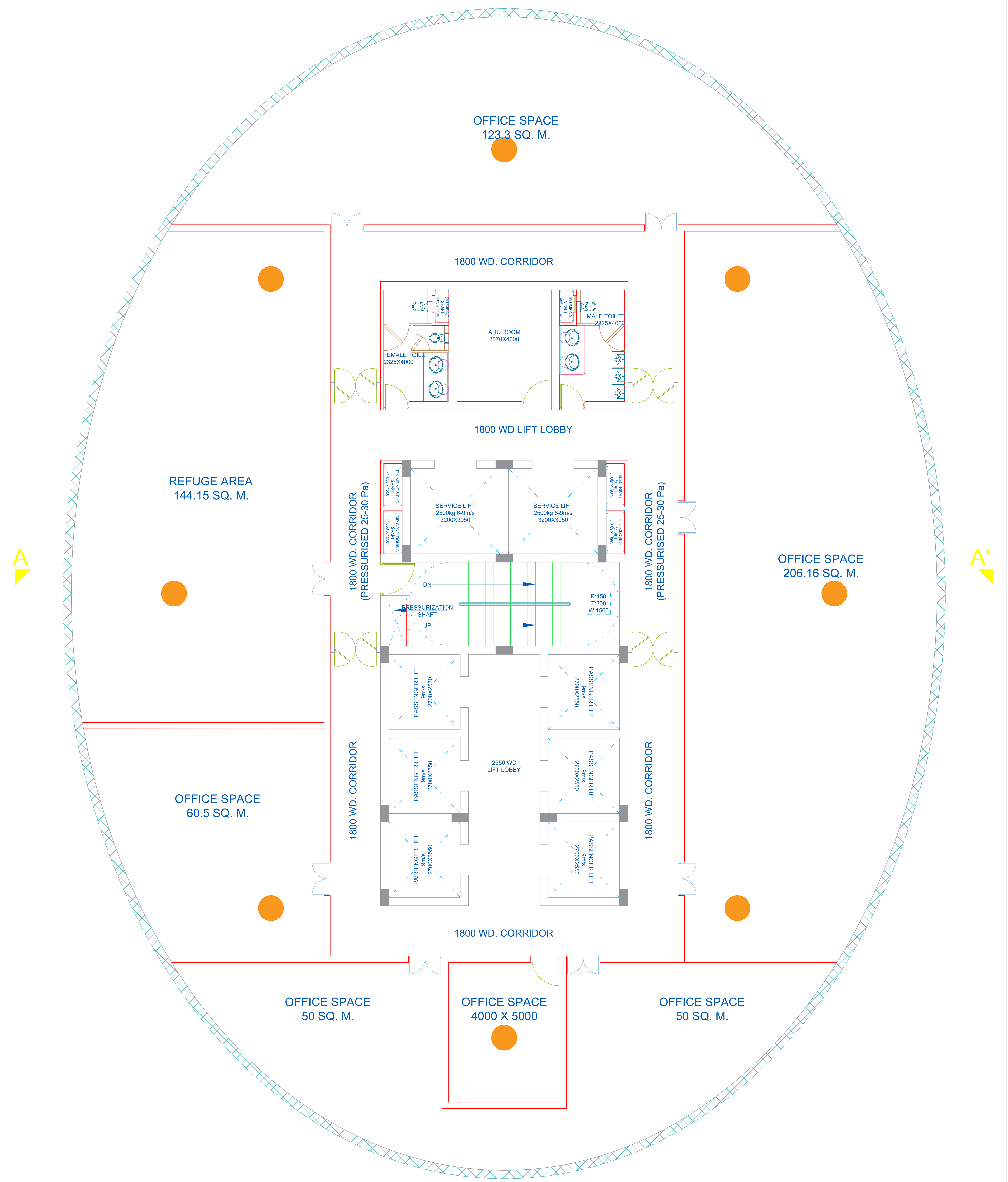
B.ARCH 2019-20	
B.B.D.U	
SCALE:	N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVL- 6)
(PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 1000 M^2

N

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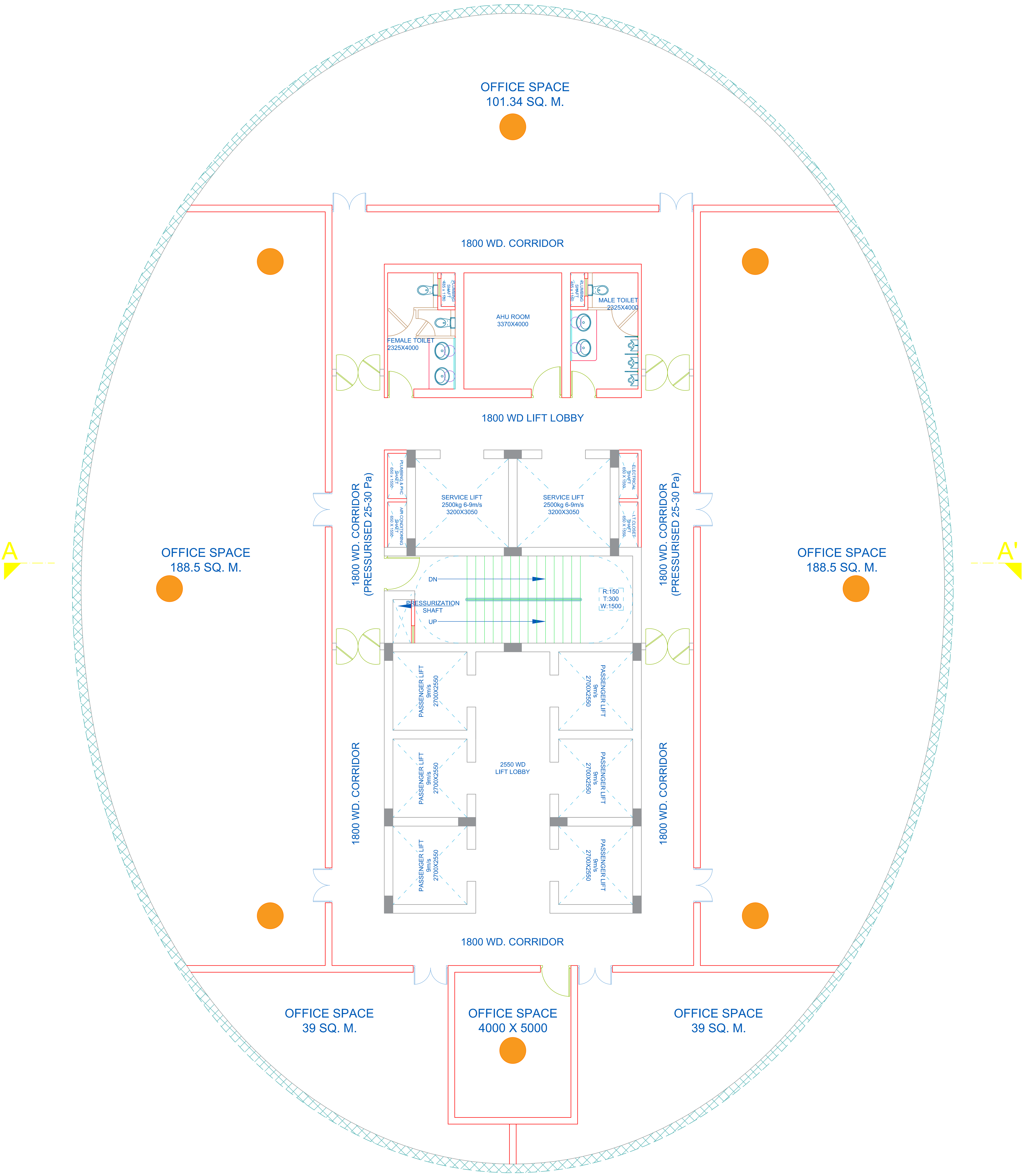
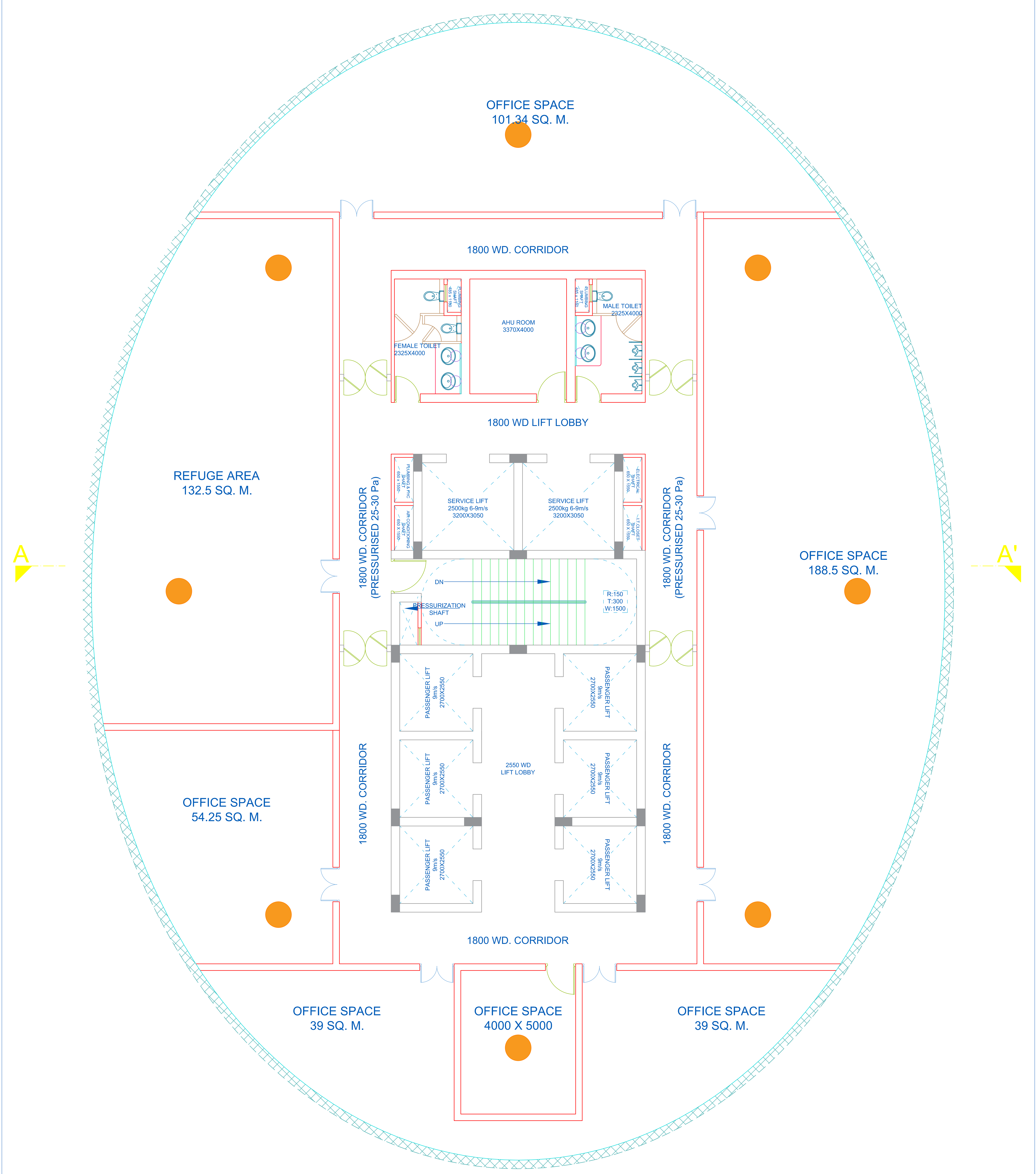
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U

SCALE: N.T.S.



THE 50 TWINS SKY COMMERCIAL TWIN TOWERS, DELHI	FLOOR (LVLS- 9, 11-13) (PLAN OF TOWER A) USE- OFFICE SPACES FLOOR AREA- 924 M^2	RISHABH SINGH 5th YEAR 10th SEM. B.ARCH 2019-20 B.B.D.U SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVLs- 10, 14) (PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 924 M^2

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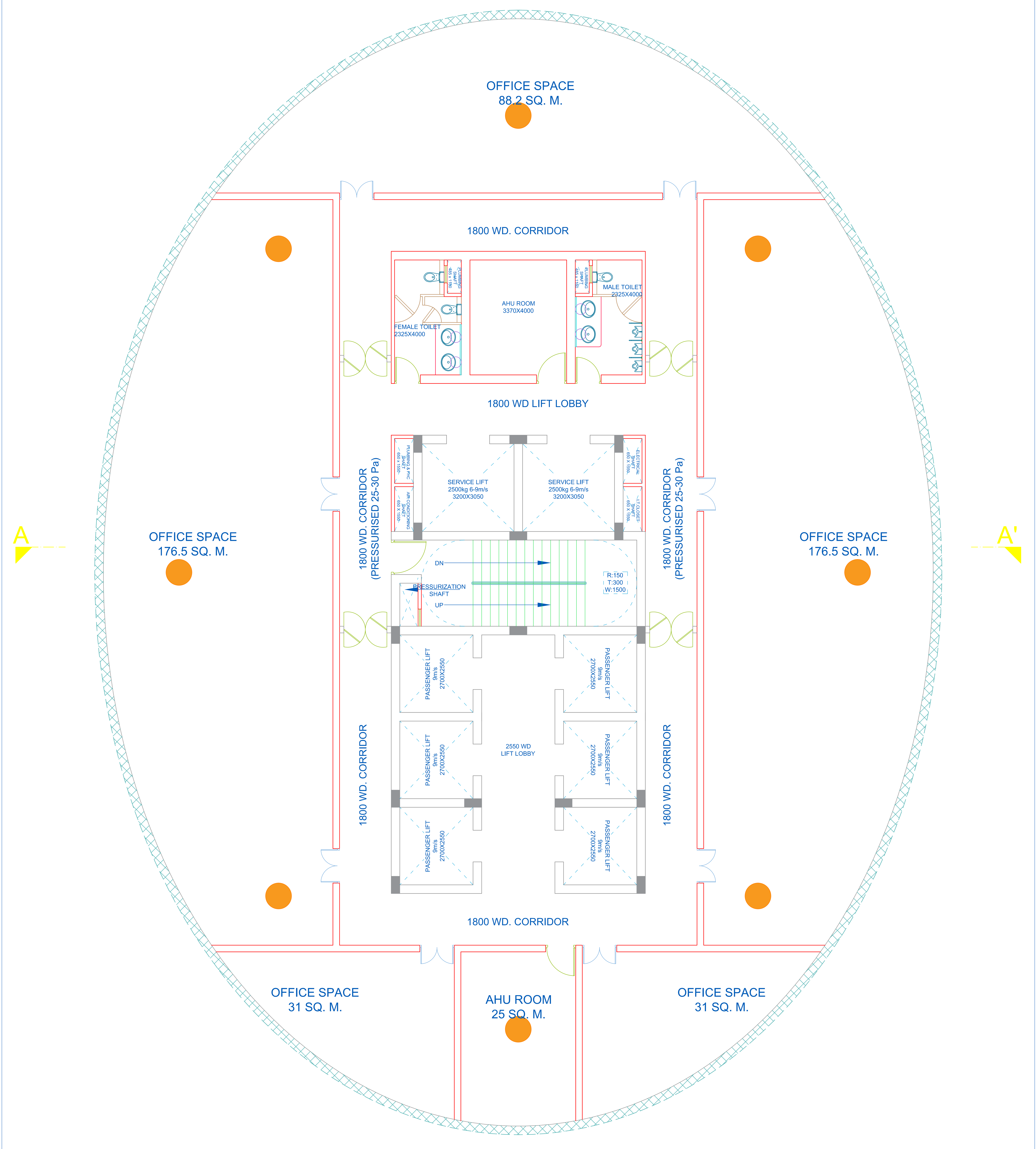
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LVLS- 15-17, 19,20)
(PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 875 M^2

N

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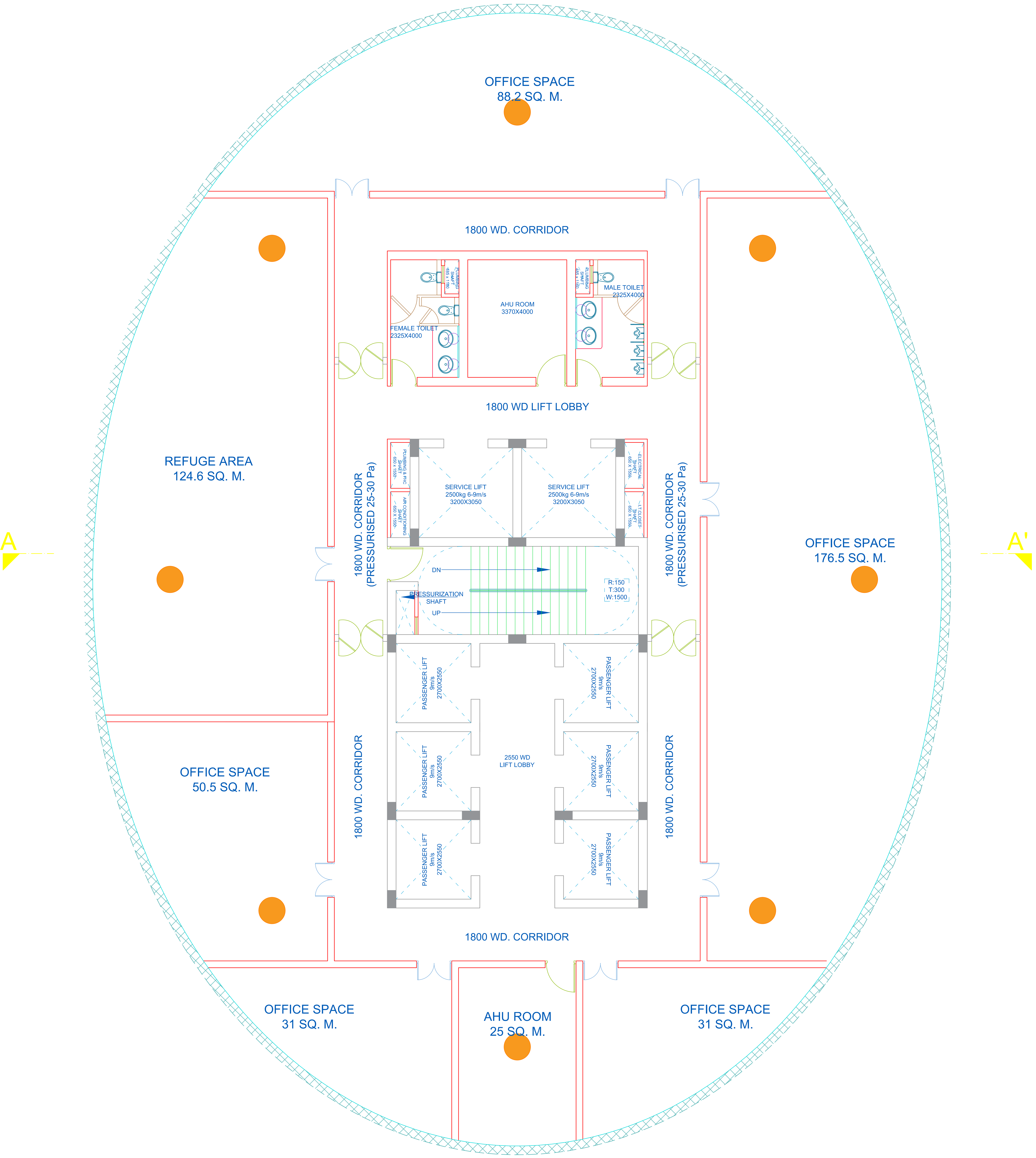
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVL- 18)
(PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 875 M^2

N

RISHABH SINGH
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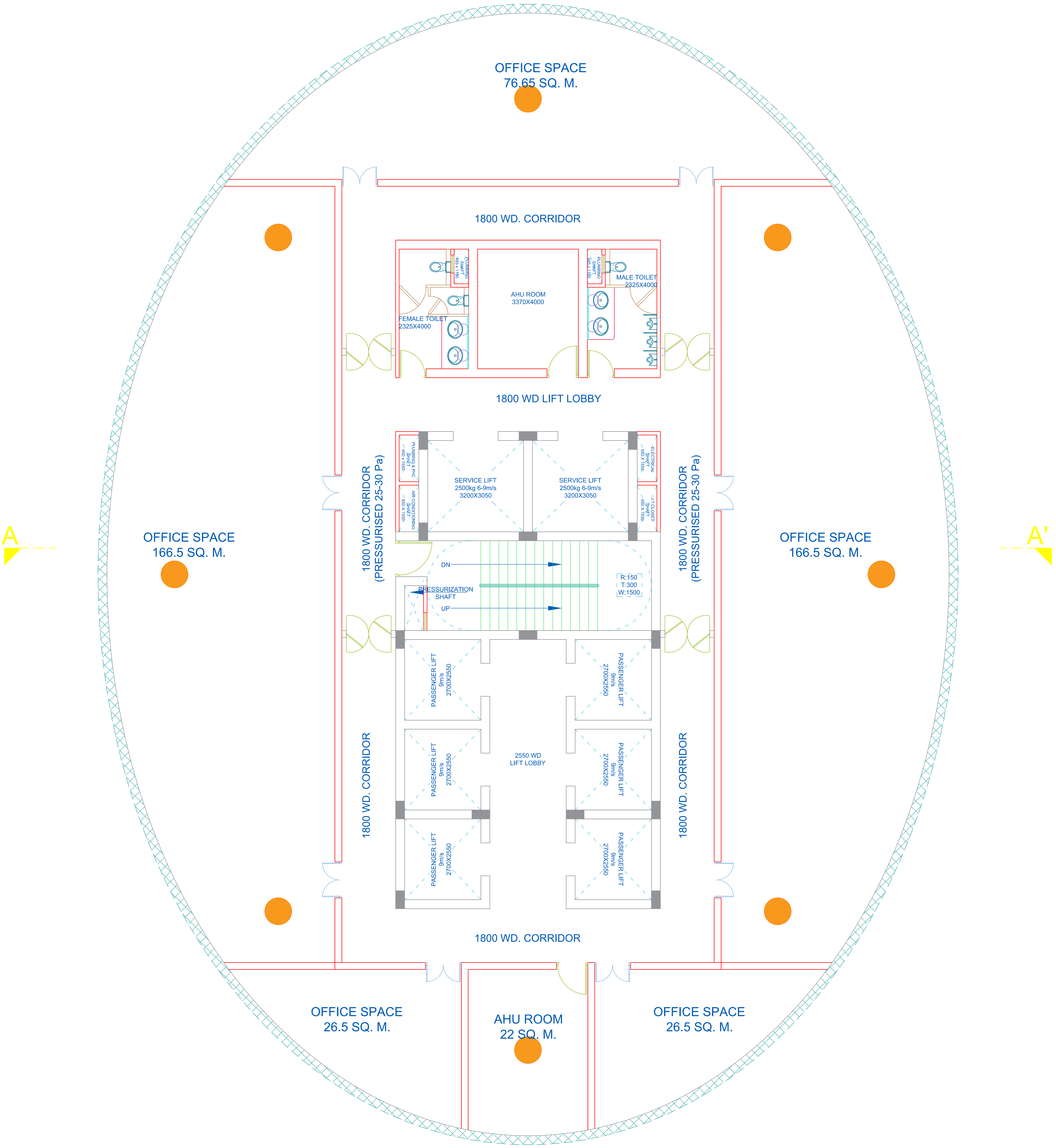
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LVLS- 21, 23-25)
(PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 830 M^2

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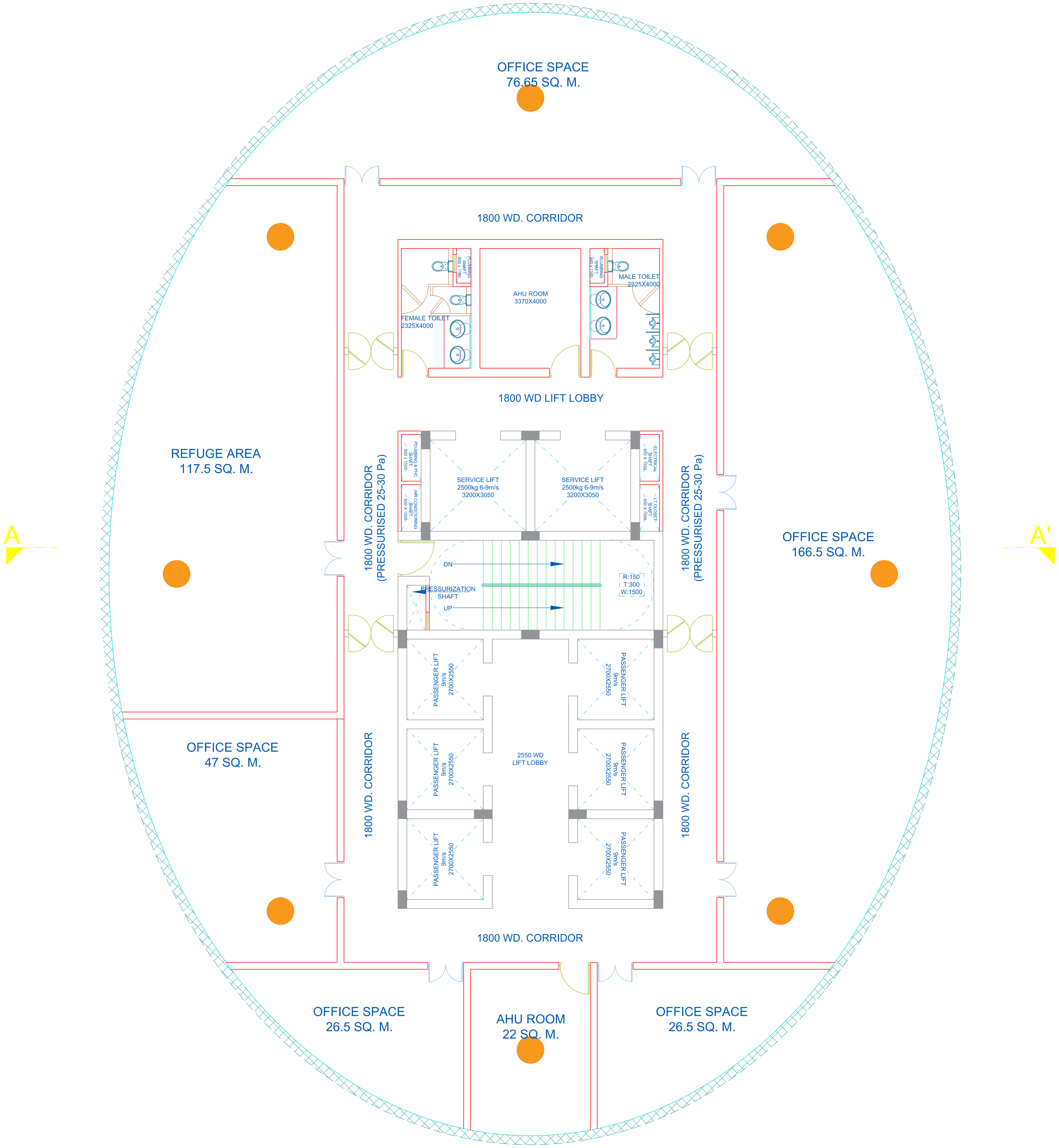
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVLS- 22, 26) (PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 830 M^2

N

RISHABH SINGH
5th YEAR 10th SEM.
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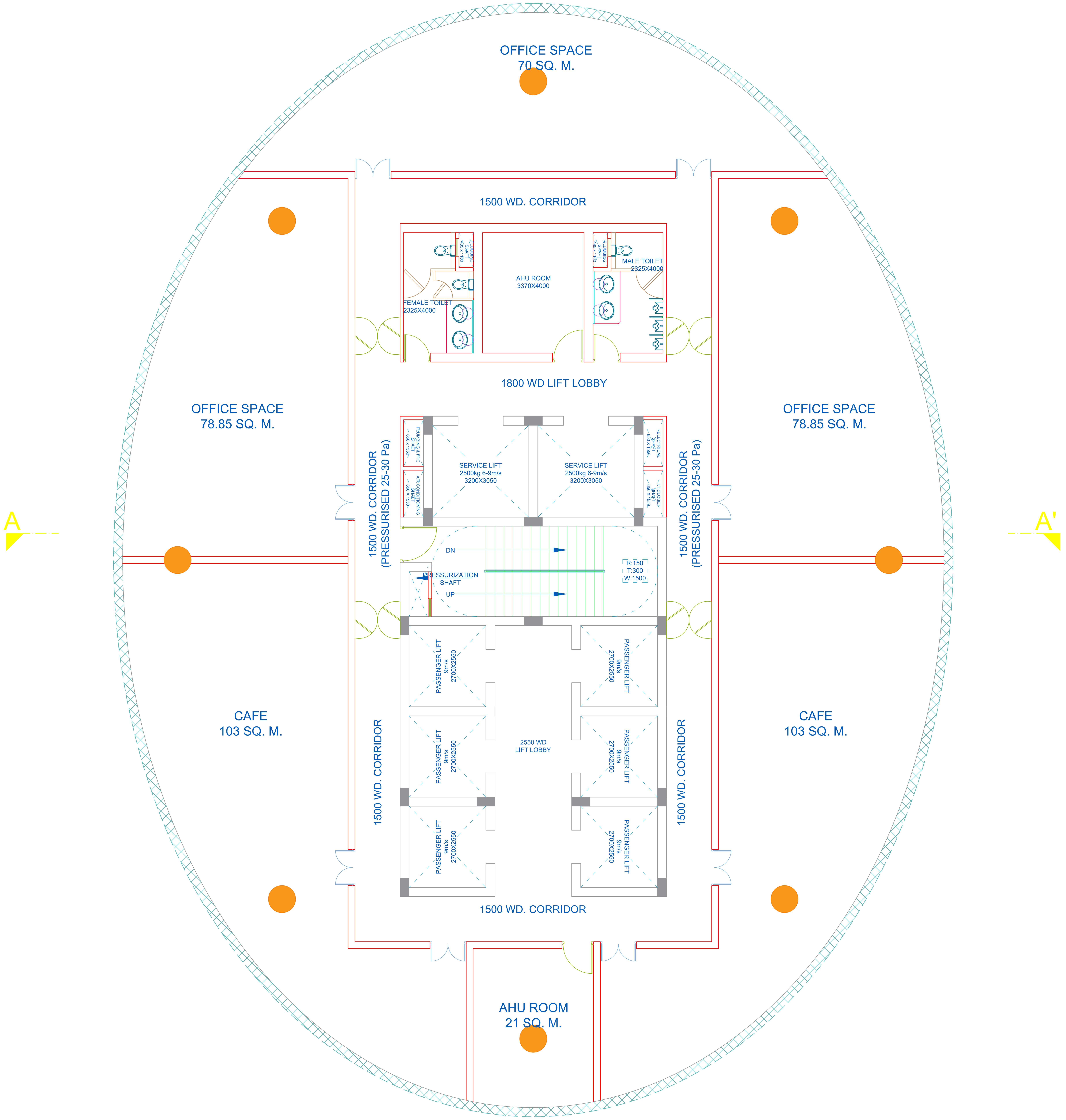
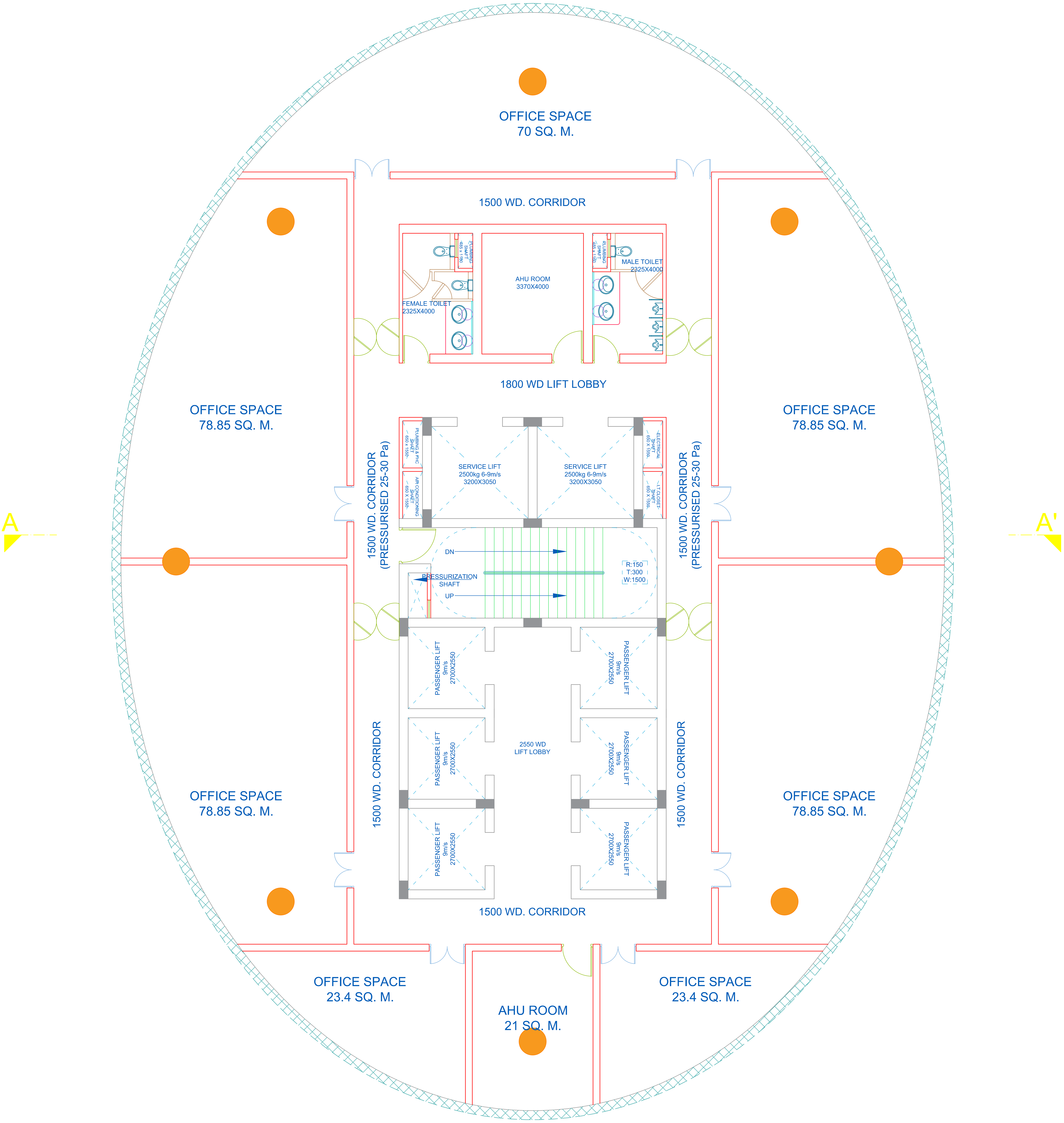
SCALE: N.T.S.



THE 50 TWINS SKY	FLOOR(LVL:27; SKY-LOBBY)	N	RISHABH SINGH
	(PLAN OF TOWER A)		5th YEAR 10th SEM.
	USE- OFFICE CUM CAFE		B.ARCH 2019-20
COMMERCIAL TWIN TOWERS, DELHI	FLOOR AREA- 780 M^2		B.B.D.U
			SCALE: N.T.S.

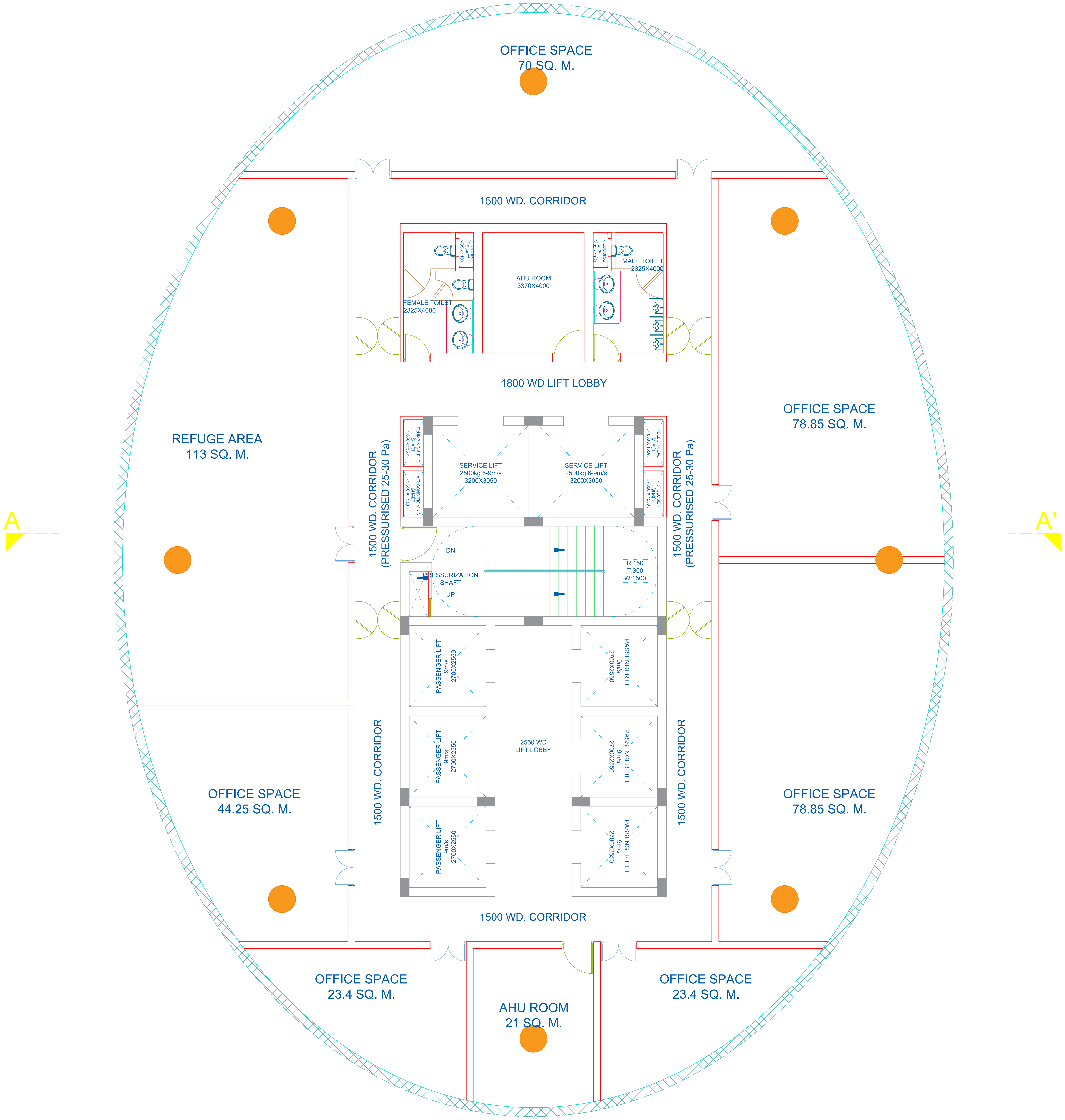


THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LVLS- 28, 29, 31, 32)
(PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 780 M^2

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVL- 30)
(PLAN OF TOWER A)
USE- OFFICE SPACES
FLOOR AREA- 780 M^2

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
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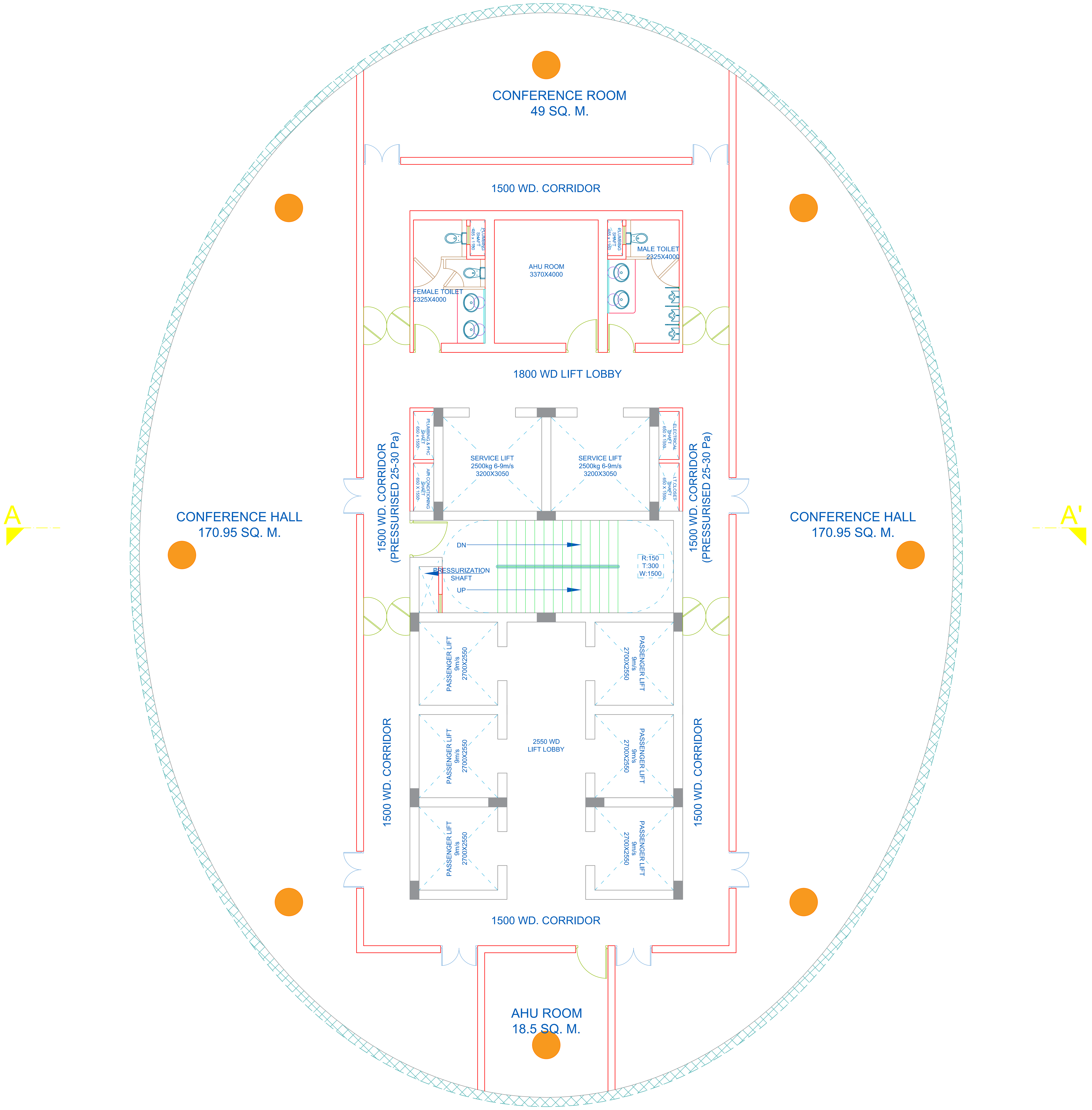
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LVL33,35) (PLAN OF TOWER A)
USE- BUSINESS CENTRE
FLOOR AREA- 730 M^2

RISHABH SINGH
5th YEAR 10th SEM.
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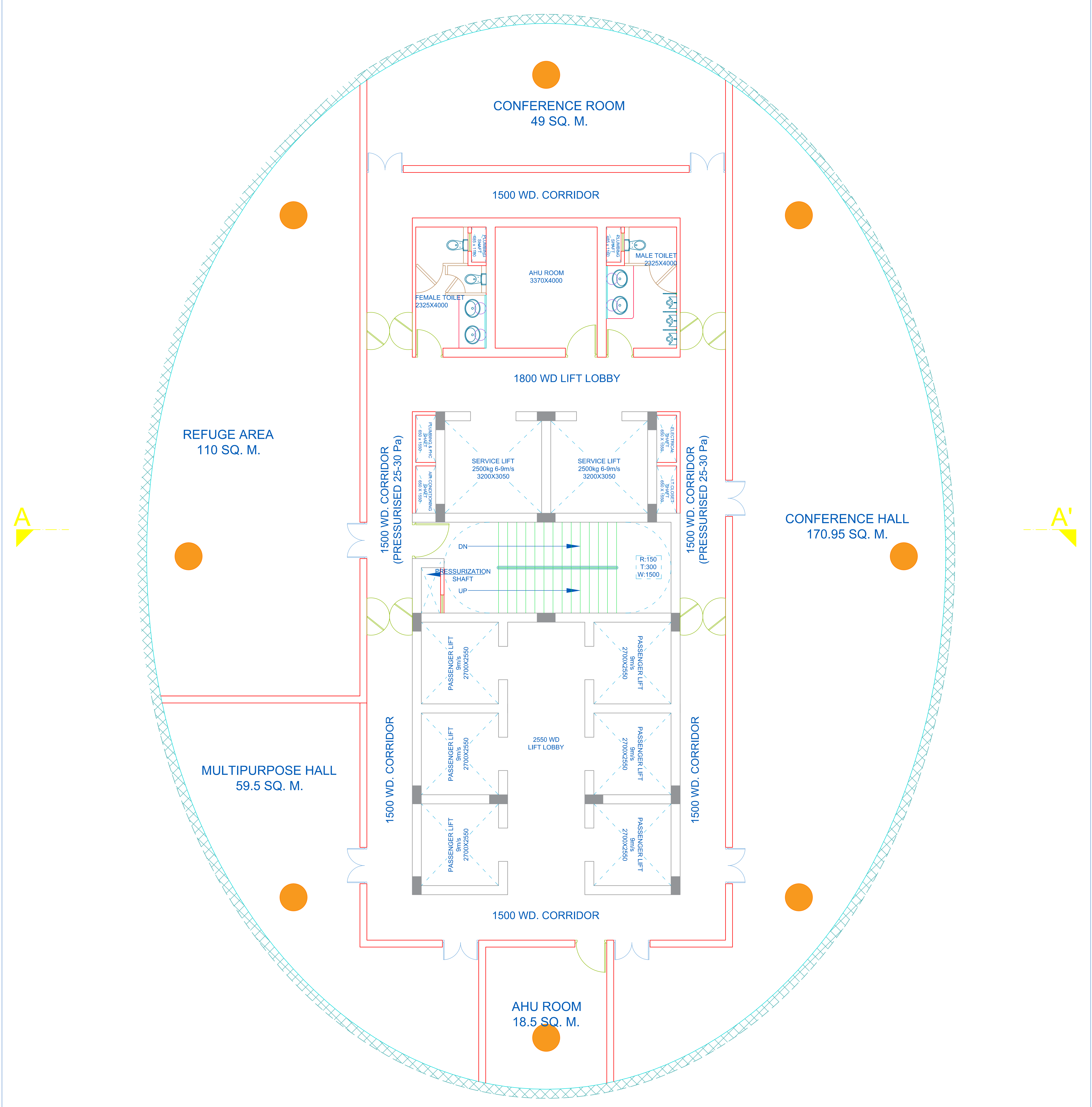
B.B.D.U
SCALE: N.T.S.

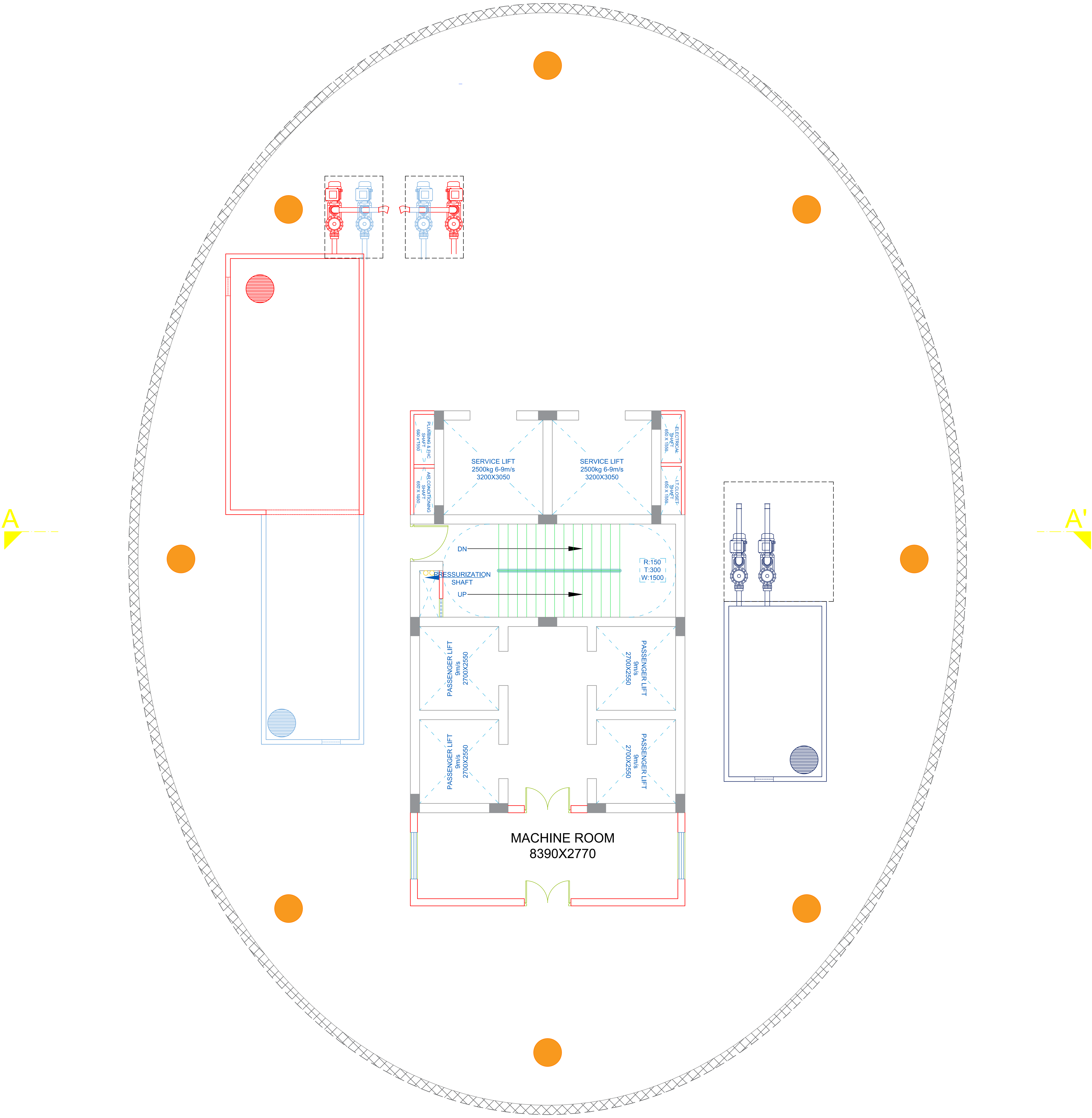


THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVL- 34)
(PLAN OF TOWER A)
USE- BUSINESS CENTRE
FLOOR AREA- 730 M^2

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

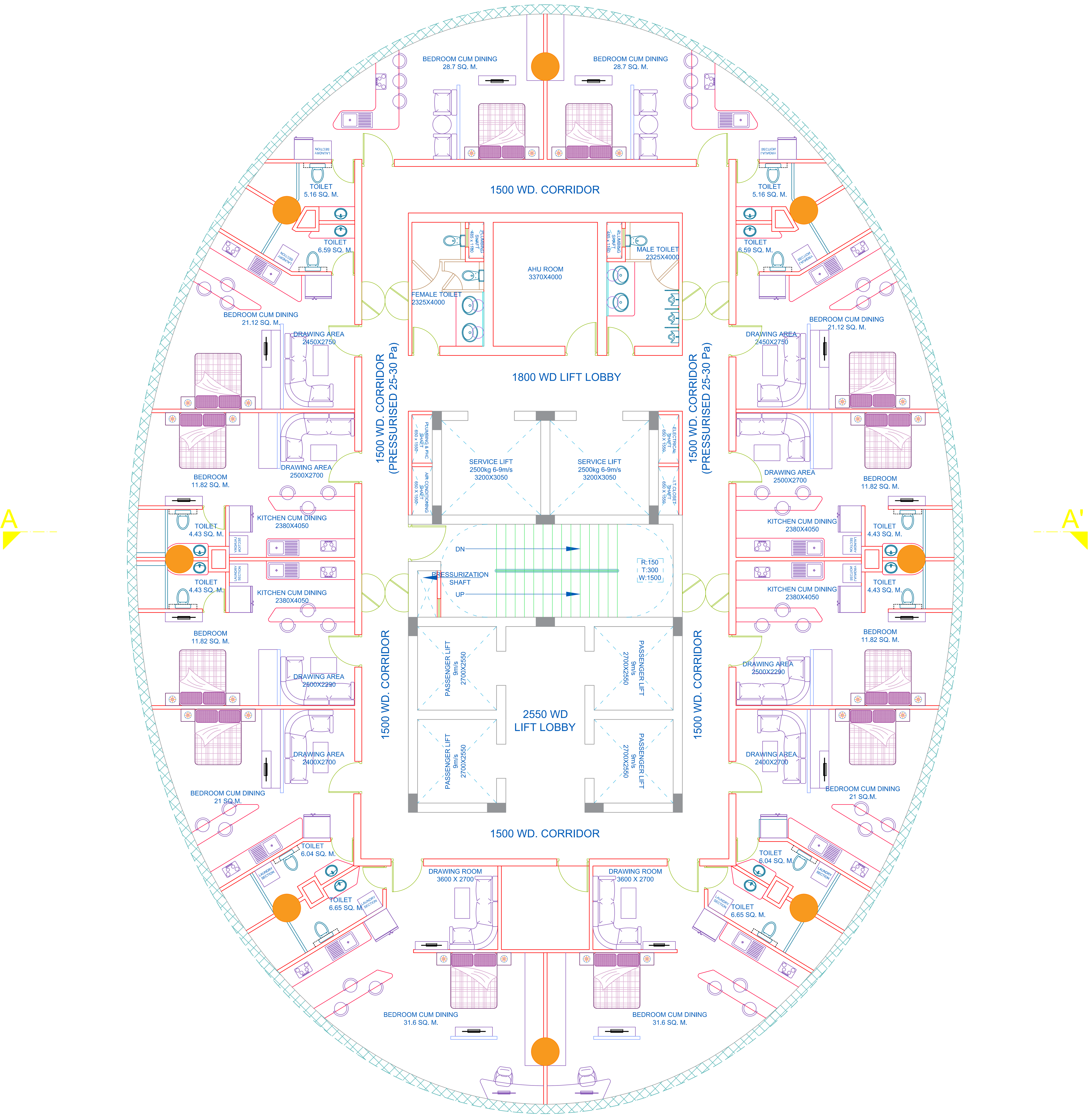
FLOOR (LVL- 36) (PLAN OF TOWER A)

USE- MECH. FLOOR (SER.)

FLOOR AREA- 730M^2

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U

SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LVLS- 37,39) (PLAN OF TOWER A)
USE- SERV. APARTMENTS
FLOOR AREA- 730 M^2

N

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
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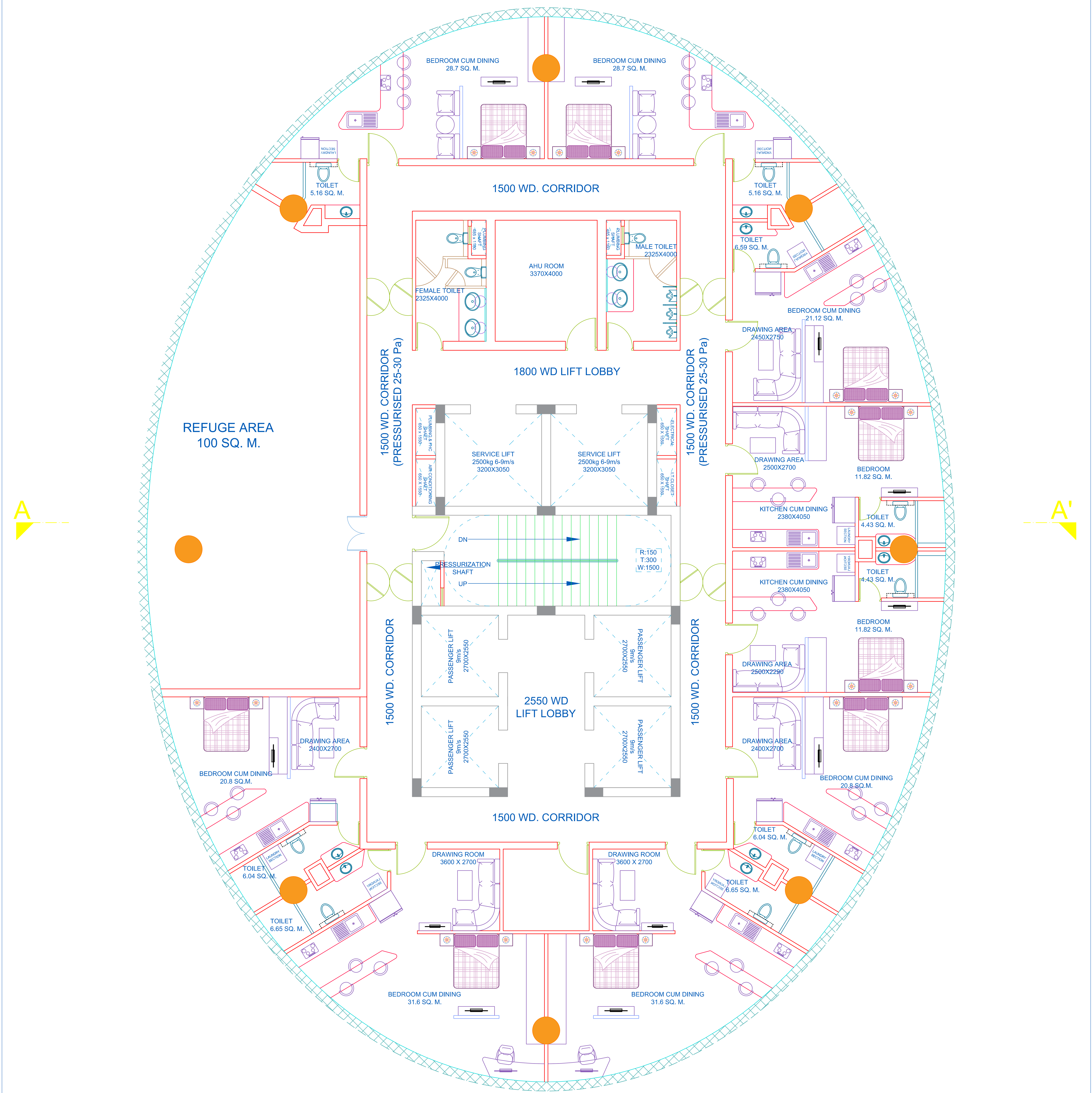
SCALE: N.T.S.



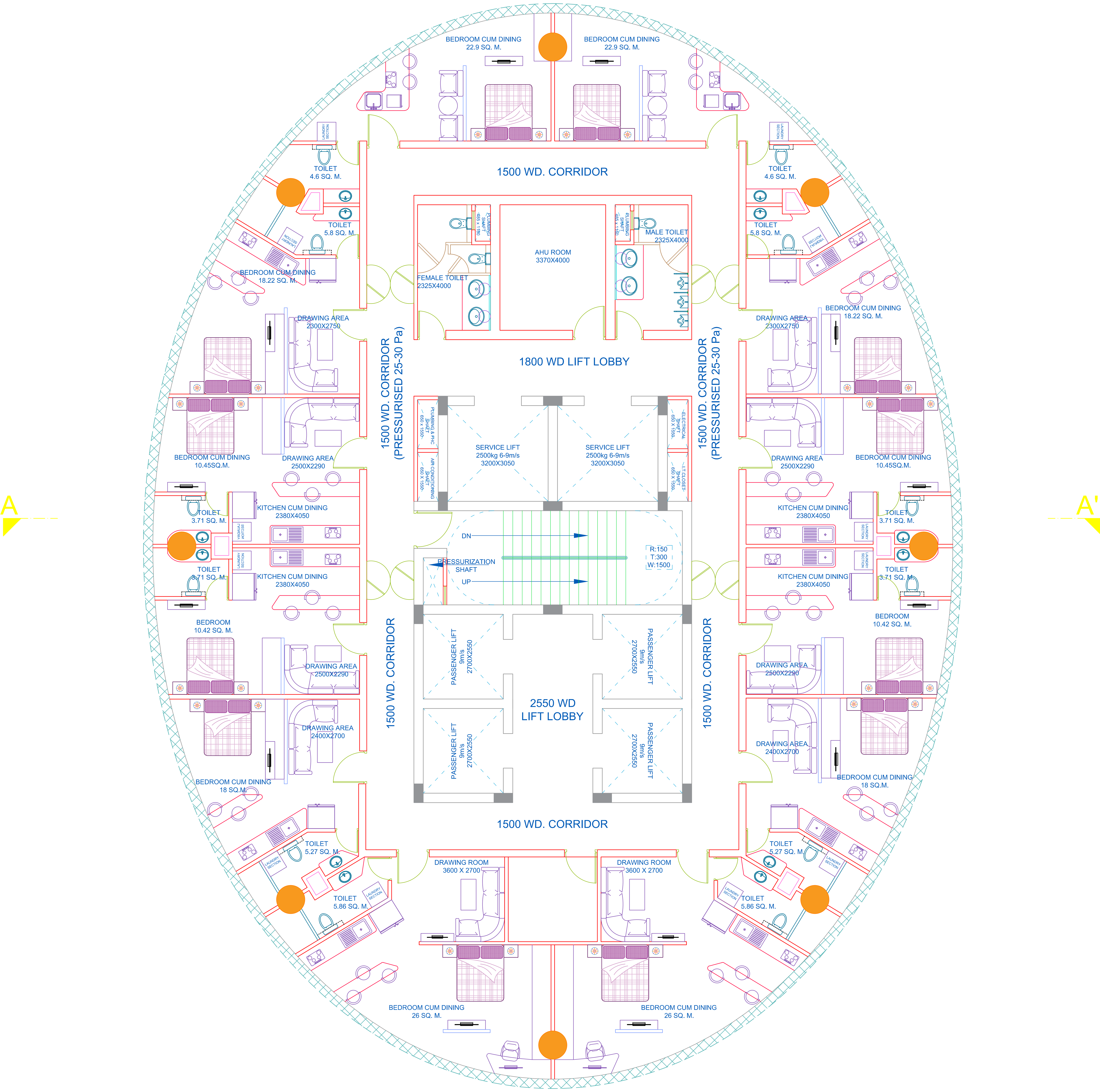
THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVL- 38)
(PLAN OF TOWER A)
USE- SERVICED APTMNT.
FLOOR AREA- 730 M^2

N

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U
SCALE: N.T.S.

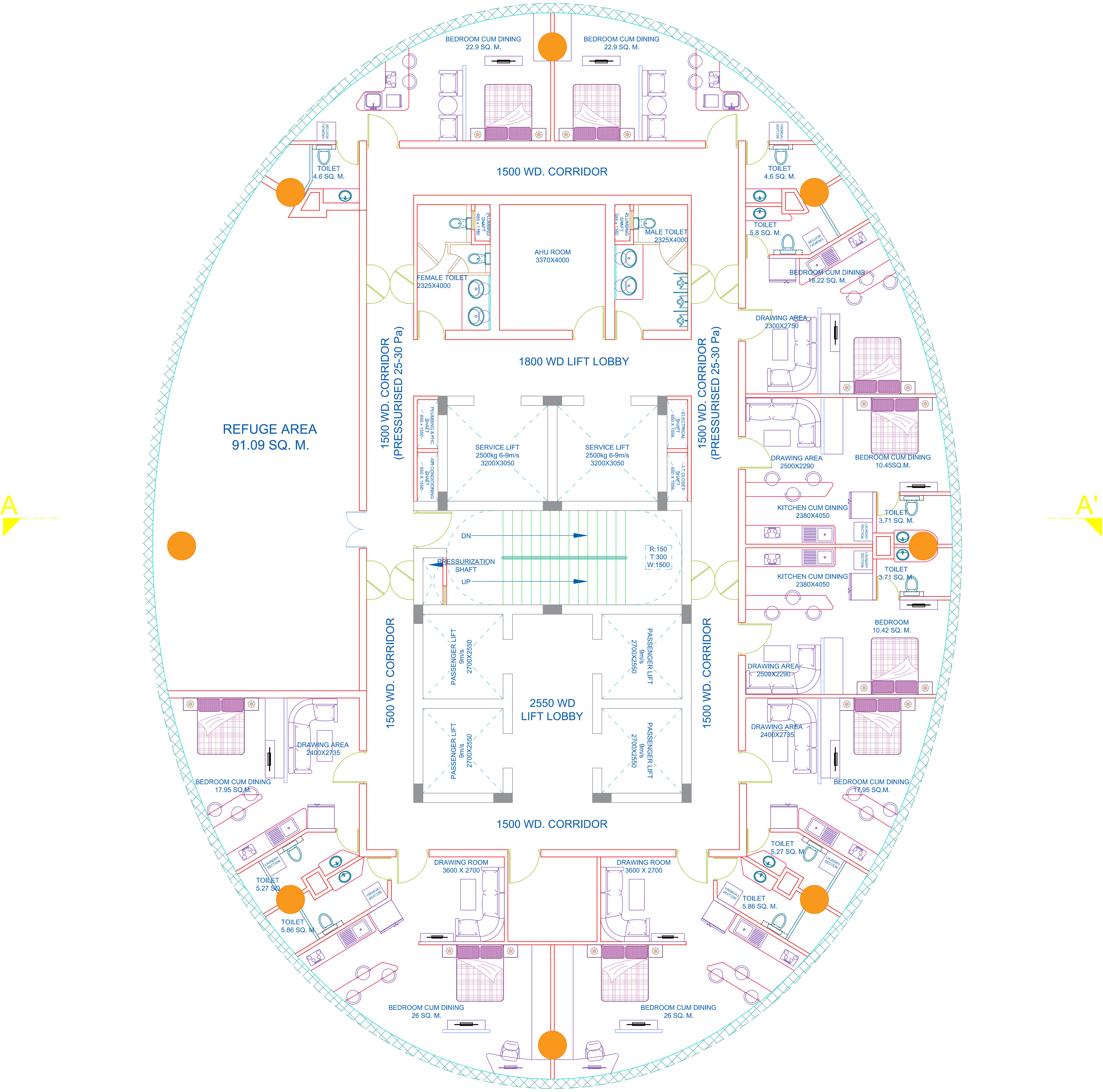


THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LEVELS-40, 41, 43, 44) (PLAN OF TOWER A)
USE- SERV. APARTMENTS
FLOOR AREA- 680 M^2

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U
SCALE: N.T.S.



THE 50 TWINS SKY

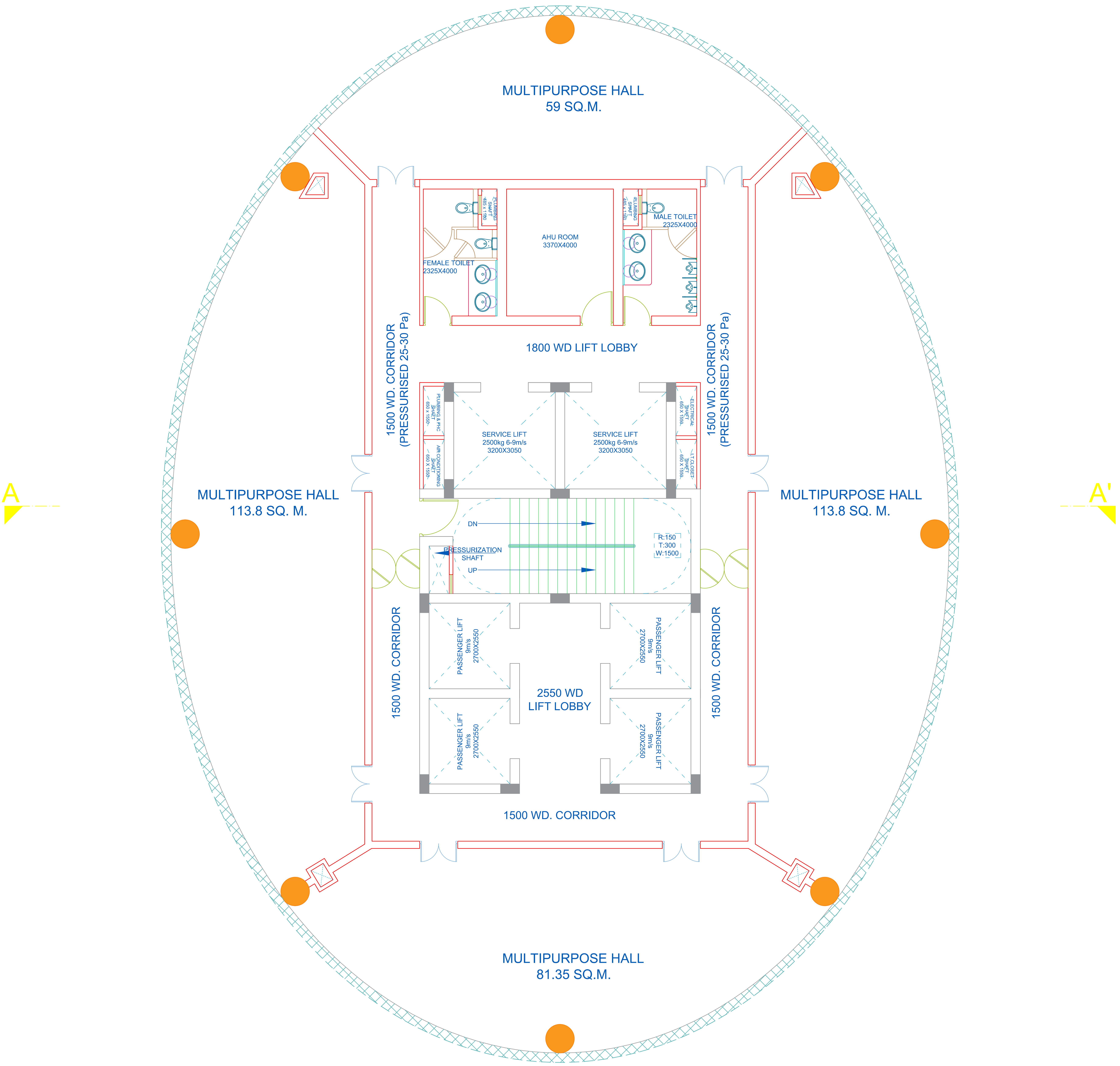
COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LVL- 42)
(PLAN OF TOWER A)
USE- SERVICED APTMNT.
FLOOR AREA- 680 M^2

N

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U

SCALE: N.T.S.



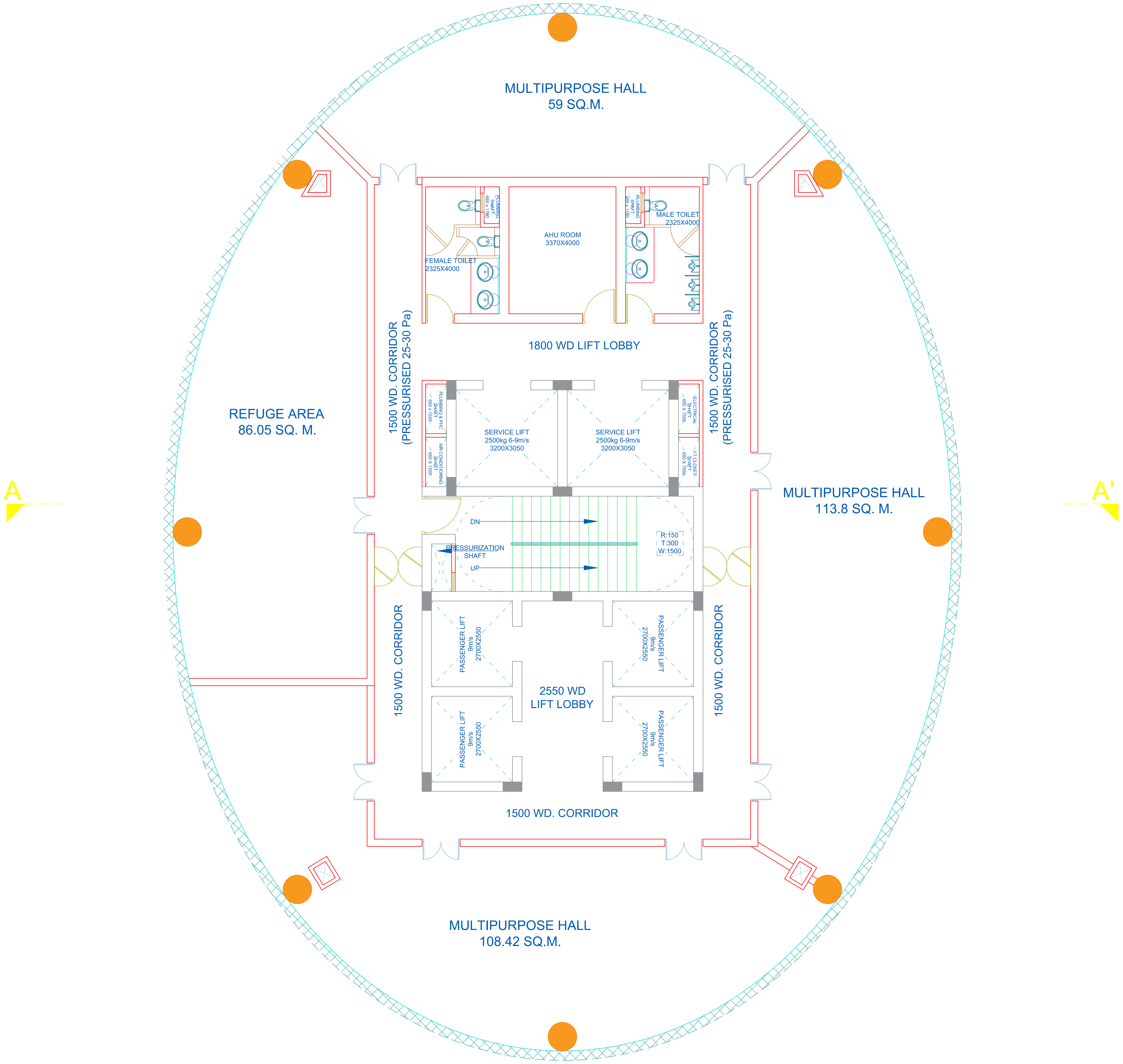
THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LEVELS- 45,47,48)
(PLAN OF TOWER - A)
USE - EXECUTIVE CLUB
FLOOR AREA- 630 M^2

N

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U
SCALE: N.T.S.



THE 50 TWINS SKY COMMERCIAL TWIN TOWERS, DELHI	REFUGE FLOOR (LVL- 46) (PLAN OF TOWER A) USE- EXECUTIVE CLUB FLOOR AREA- 630 M^2	N	RISHABH SINGH 5th YEAR 10th SEM. B.ARCH 2019-20 B.B.D.U SCALE: N.T.S.

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

EXECUTICE CLUB FLOOR (LEVELS- 49)
USE- EXECUTIVE CLUB AREAS AND SKY BRIDGE, SWIMMING POOL STRUCTURAL MEMBER AND SERVICES
FLOOR AREA- 630 M^2 (EACH TOWER)

N

NOT TO SCALE

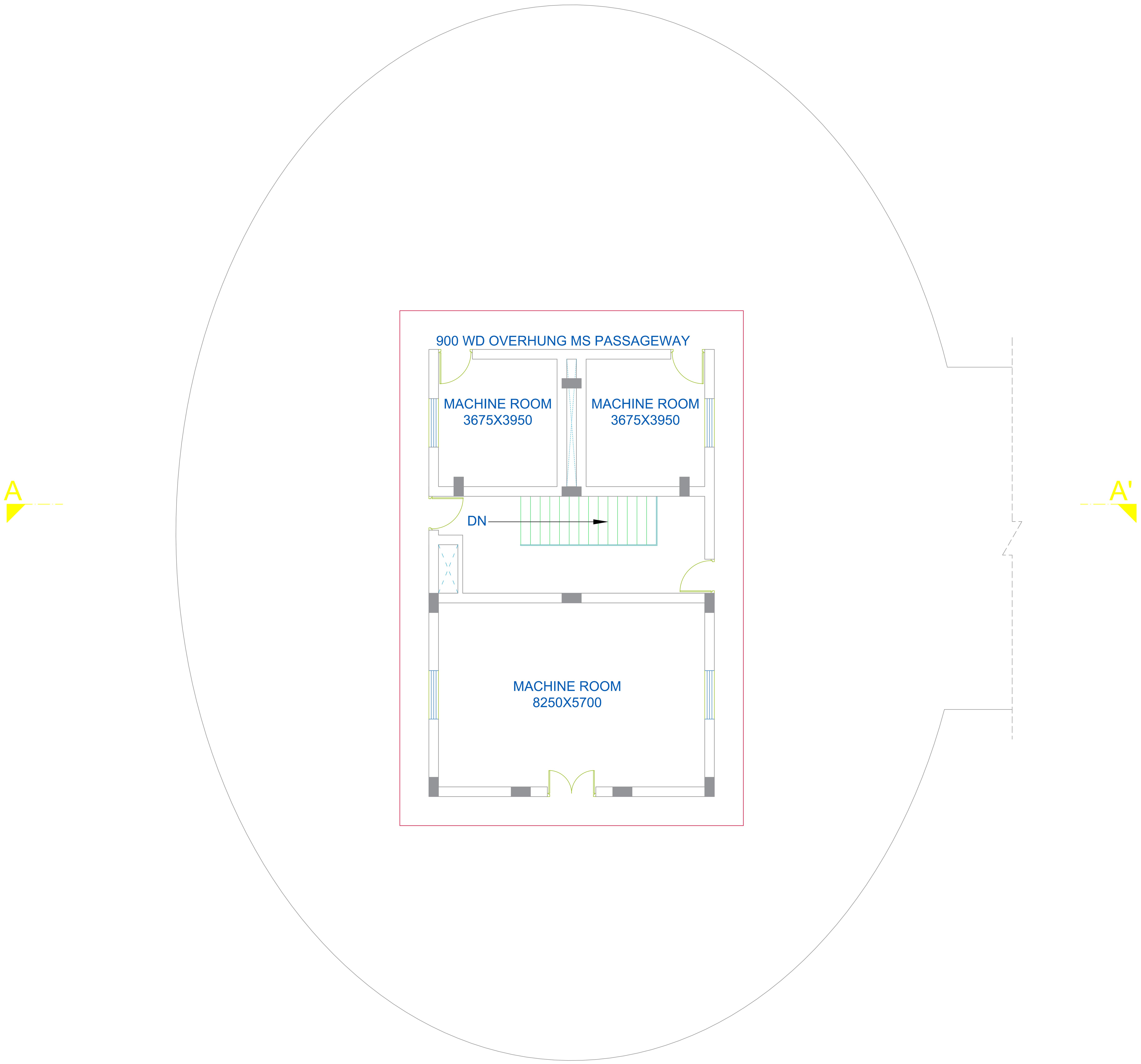
RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
ARCH. DESIGN
B.B.D.U

THE 50 TWINS SKY
COMMERCIAL TWIN TOWERS, DELHI

TERRACE FLOOR
LEVEL 50

N
NOT TO SCALE

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
ARCH. DESIGN
B.B.D.U



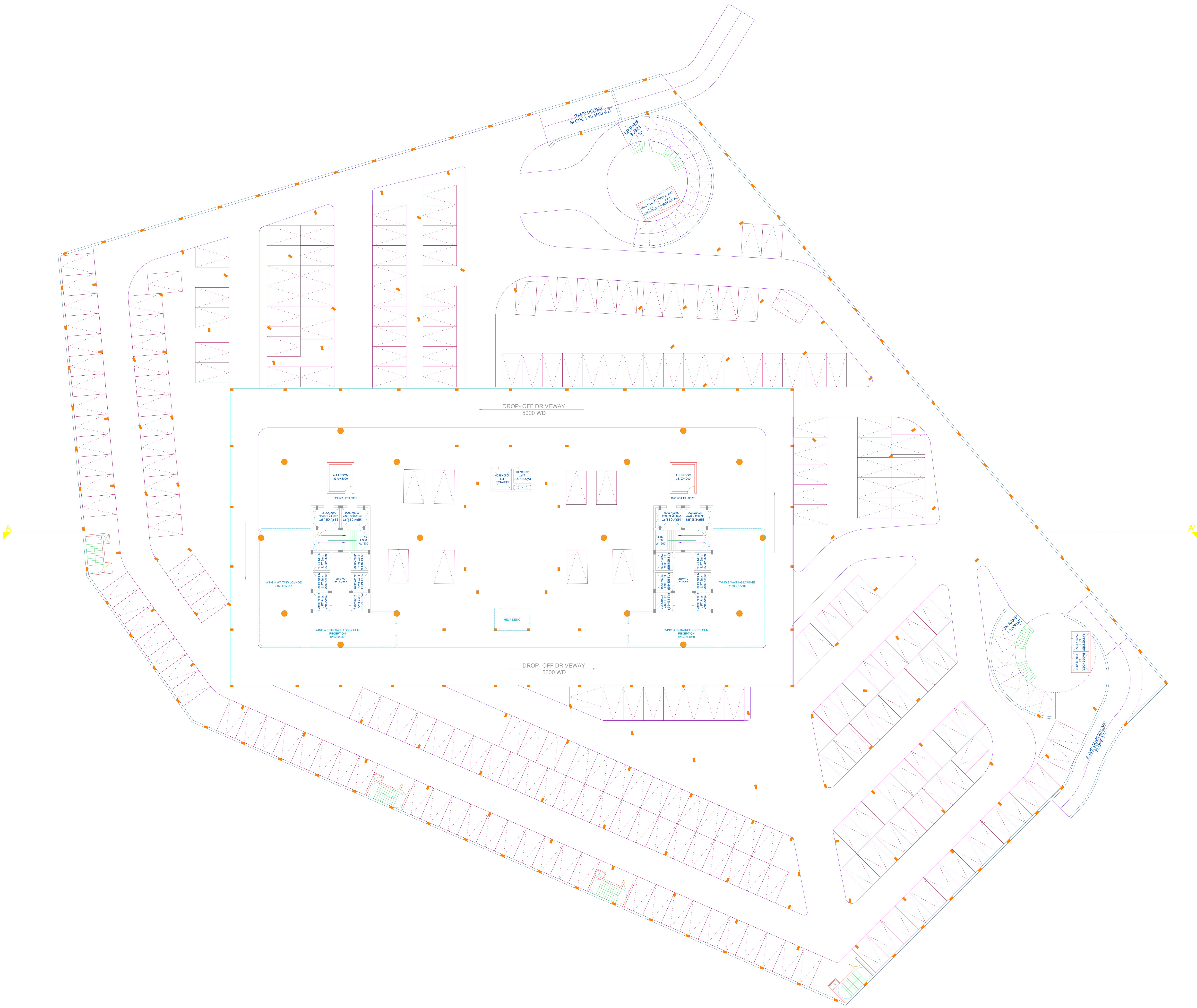
THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

MACHINE ROOM FLOOR
(TOWER A)

N

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U
SCALE: N.T.S.



NOTE:
NUMBER OF CARS - 265
EACH PASSAGE LEAST 4500 WD, UNLESS STATED OTHERWISE

THE 50 TWINS SKY
COMMERCIAL TWIN TOWERS, DELHI

BASEMENT PLAN (B1) INCLUDING ENTRY LOBBY
$13{,}600\ M^2$

N

NOT TO SCALE

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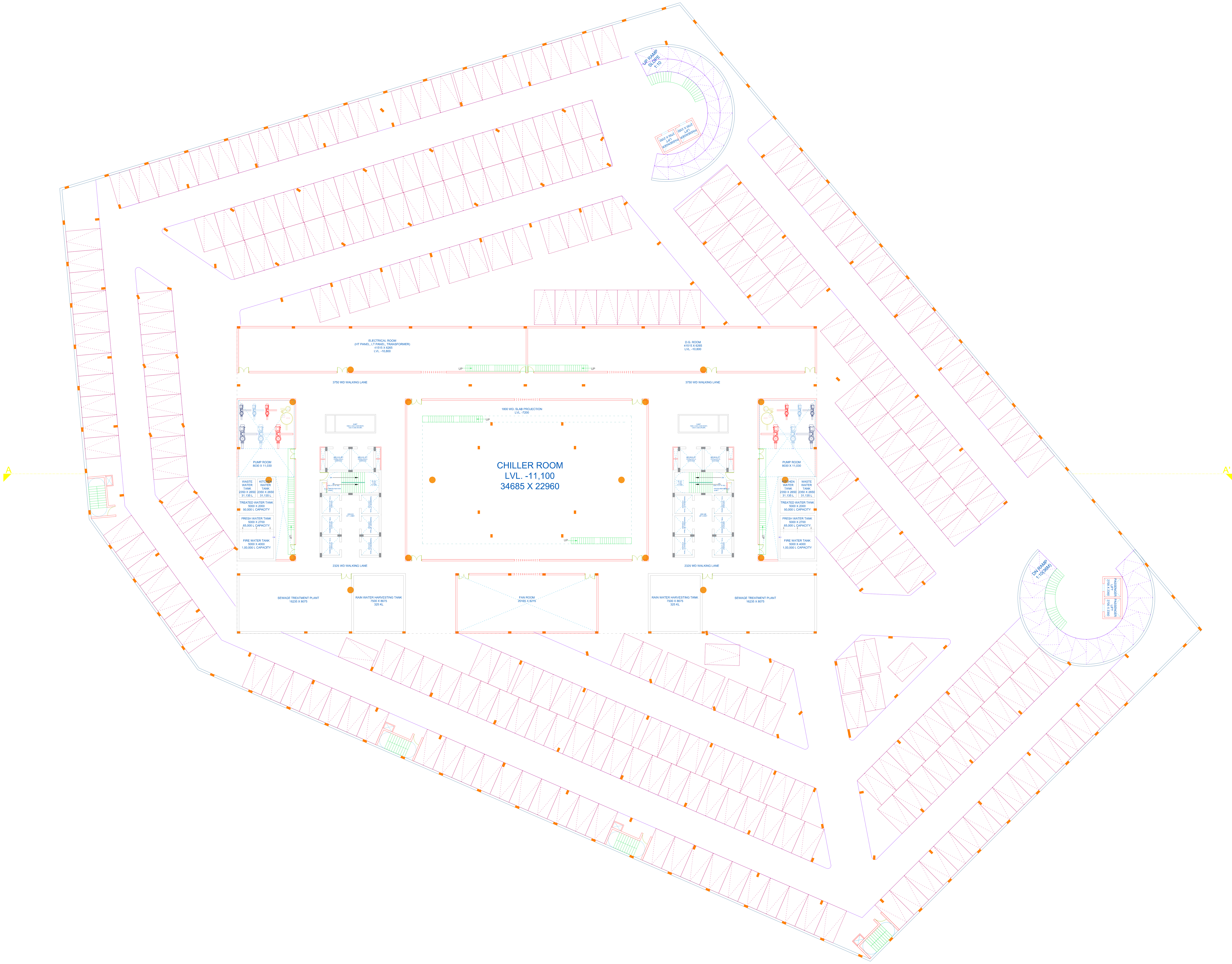
5th YEAR 10th SEM.
B.ARCH 2019-20
ARCH. DESIGN
B.B.D.U



NOTE:
NUMBER OF CARS - 334
EACH PASSAGE LEAST 4500
WD, UNLESS STATED
OTHERWISE

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

BASEMENT PLAN (B2&B3 TYPICAL)

13,600 M^2

N

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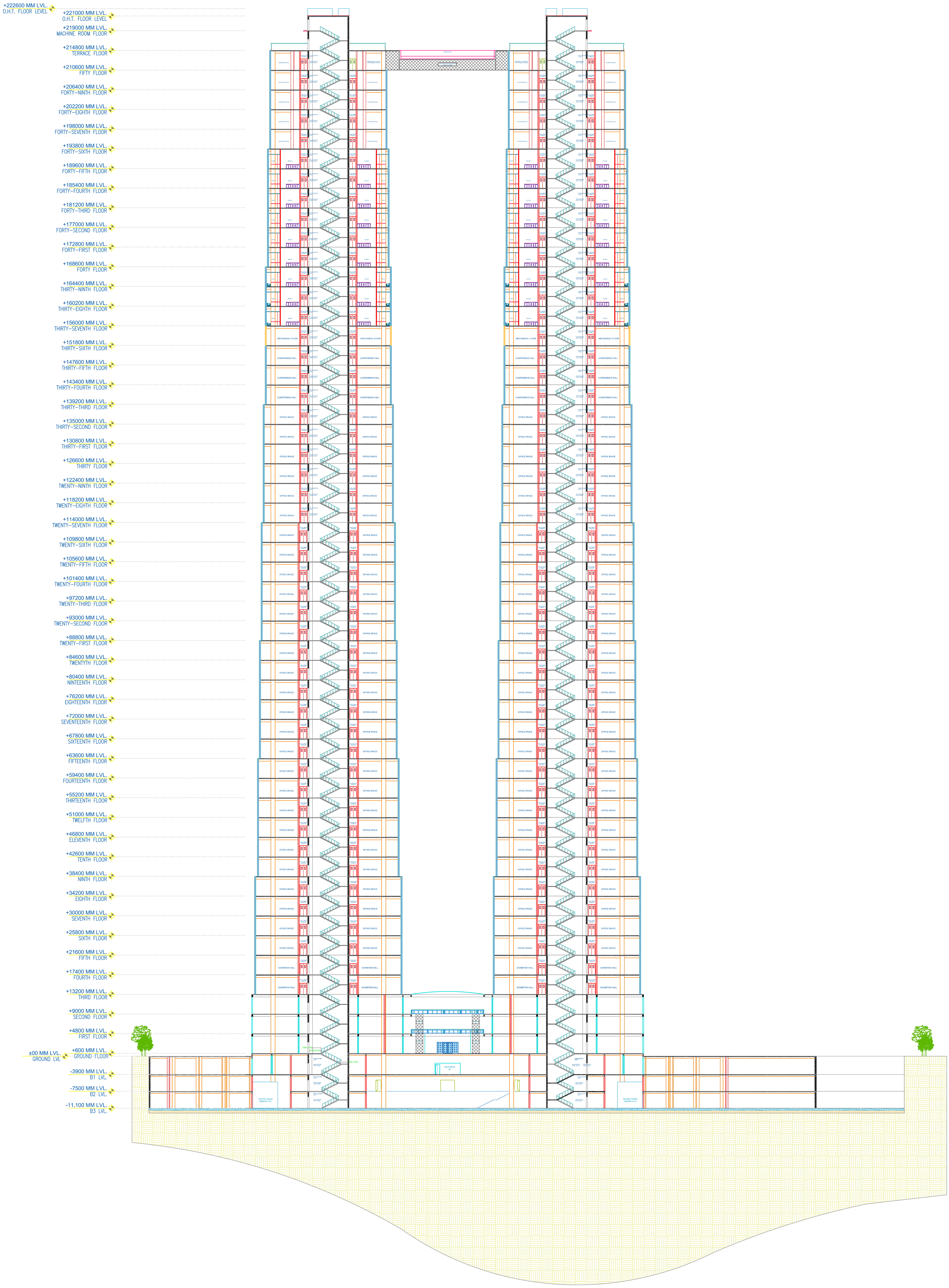

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

SECTIONAL ELEVATION
AT A - A'

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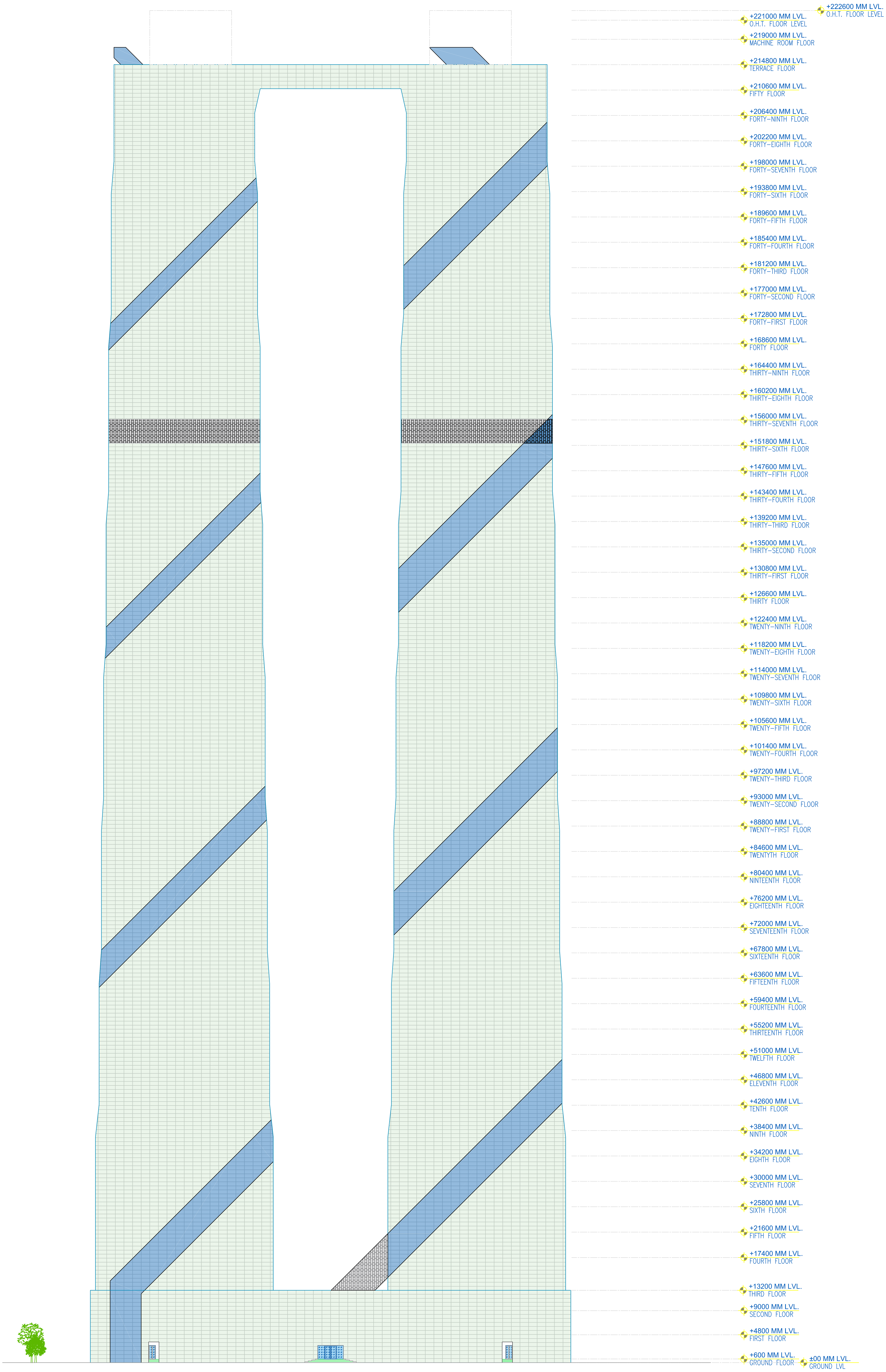
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FRONT ELEVATION

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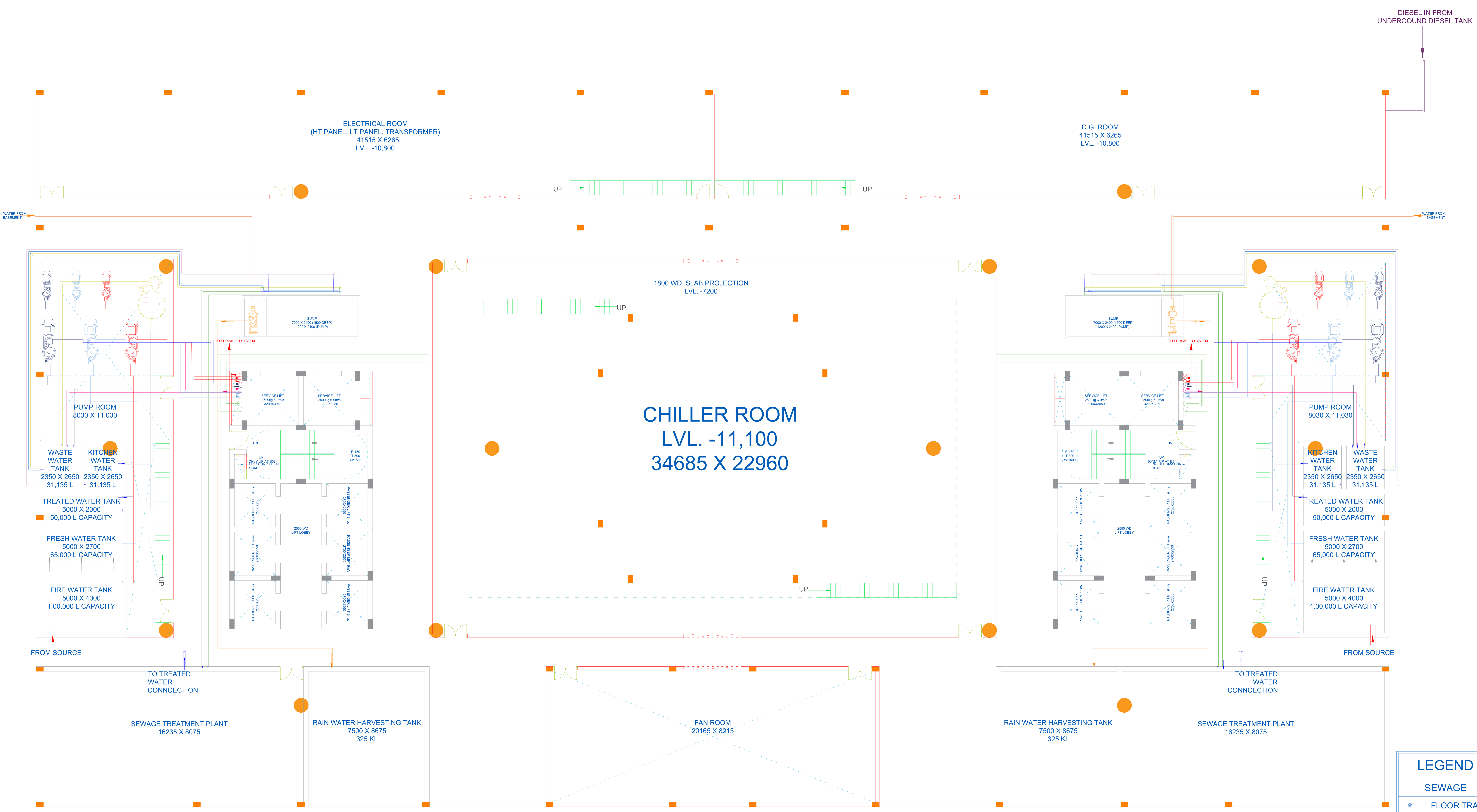
SCALE: N.T.S.



LEGEND

SEWAGE	SUPPLY
FLOOR TRAP	FIRE SUPPLY 100-200 Ø
P / S TRAP	TREATED WATER SUPPLY 75 Ø
OIL AND GREASE TRAP	S. POOL SUPPLY & RET. 50-100 Ø
WASTE WATER PIPE 100 Ø	FRESH WATER SUPPLY 50-75 Ø
SOIL PIPE 100 Ø	RAIN WATER PIPE 100-Ø
KITCHEN WASTE PIPE 100 Ø	VENT PIPE
WASTE WATER PIPE 100Ø SERVICED APT.	CHILLER PLANT WATER PIPES
COMBINED AT M. FLOOR	PRESS. SUPPLY FROM FAN ROOM

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

BASEMENT PLUMBING DETAILS(B2, B3 DOUBLE HEIGHT)

N

NOT TO SCALE

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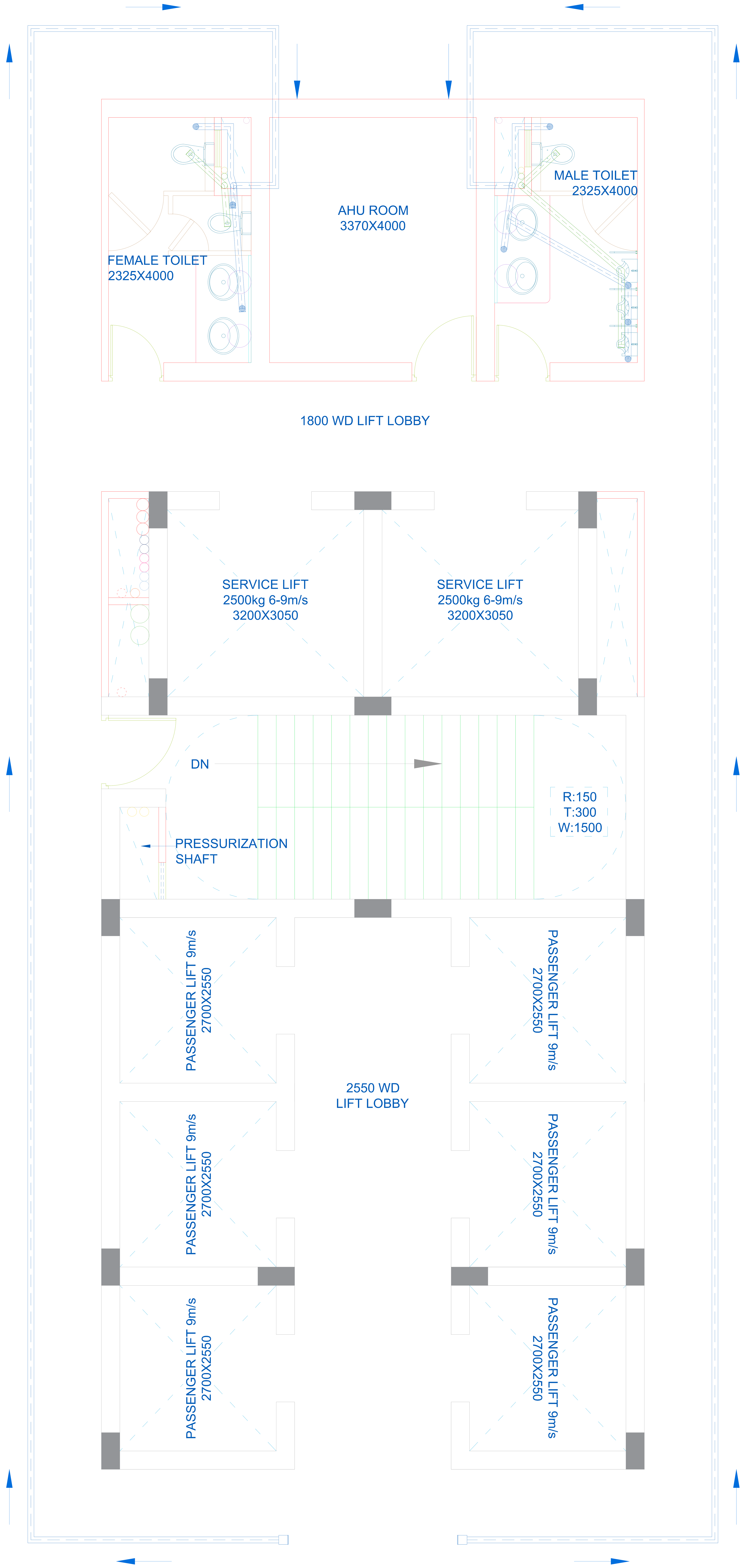

LEGEND

SEWAGE		SUPPLY	
	FLOOR TRAP		FIRE SUPPLY 100-200 Ø
	P / S TRAP		TREATED WATER SUPPLY 75 Ø
	OIL AND GREASE TRAP		S. POOL SUPPLY & RET. 50-100 Ø
	WASTE WATER PIPE 100 Ø		FRESH WATER SUPPLY 50-75 Ø
	SOIL PIPE 100 Ø		RAIN WATER PIPE 100-Ø
	KITCHEN WASTE PIPE 100 Ø		VENT PIPE
	WASTE WATER PIPE 100Ø SERVICED APT. COMBINED AT M. FLOOR		CHILLER PLANT WATER PIPES
			PRESS. SUPPLY FROM FAN ROOM

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

TYPICAL WASTE WATER MANAGEMENT (1250 C TO EXTERIOR PERIPHERY OF CORE.)

N

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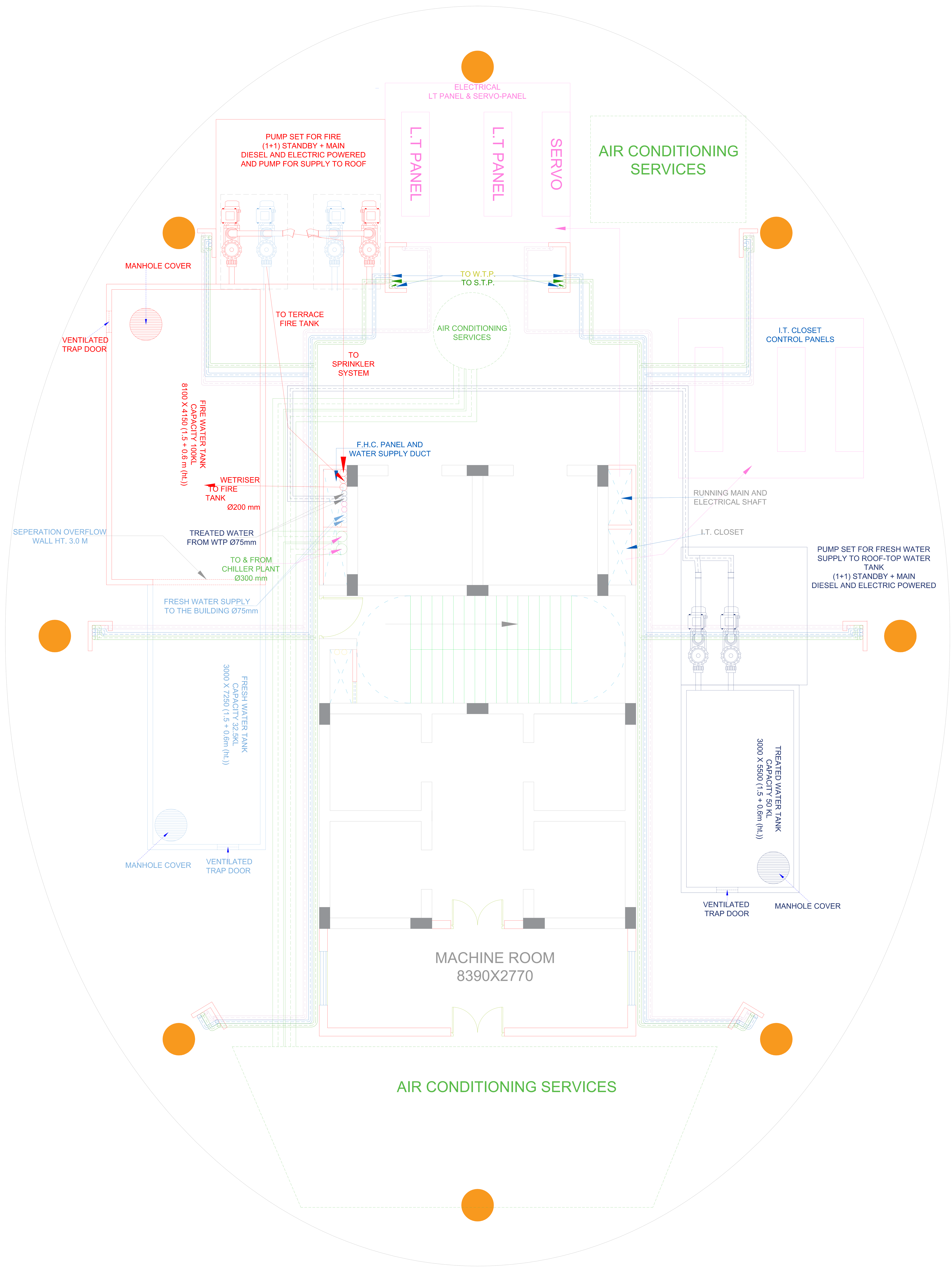
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LEVELS- 36)
(TOWER A)
MECHANICAL FLOOR
PLUMBING

N

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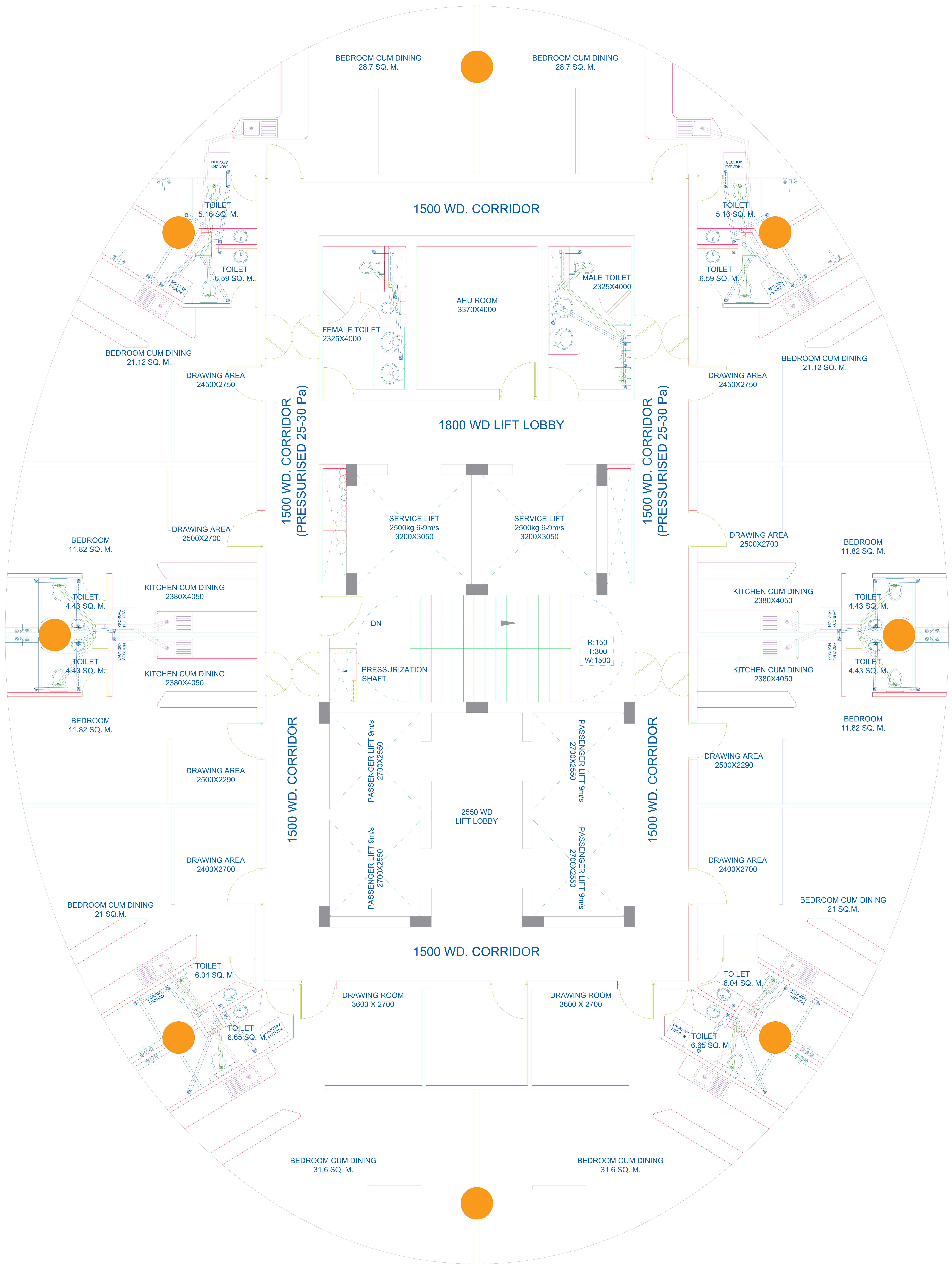
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LEVELS- SERVICED APARTMENT 730M^2 FLOOR PLATE) (TOWER A)

N

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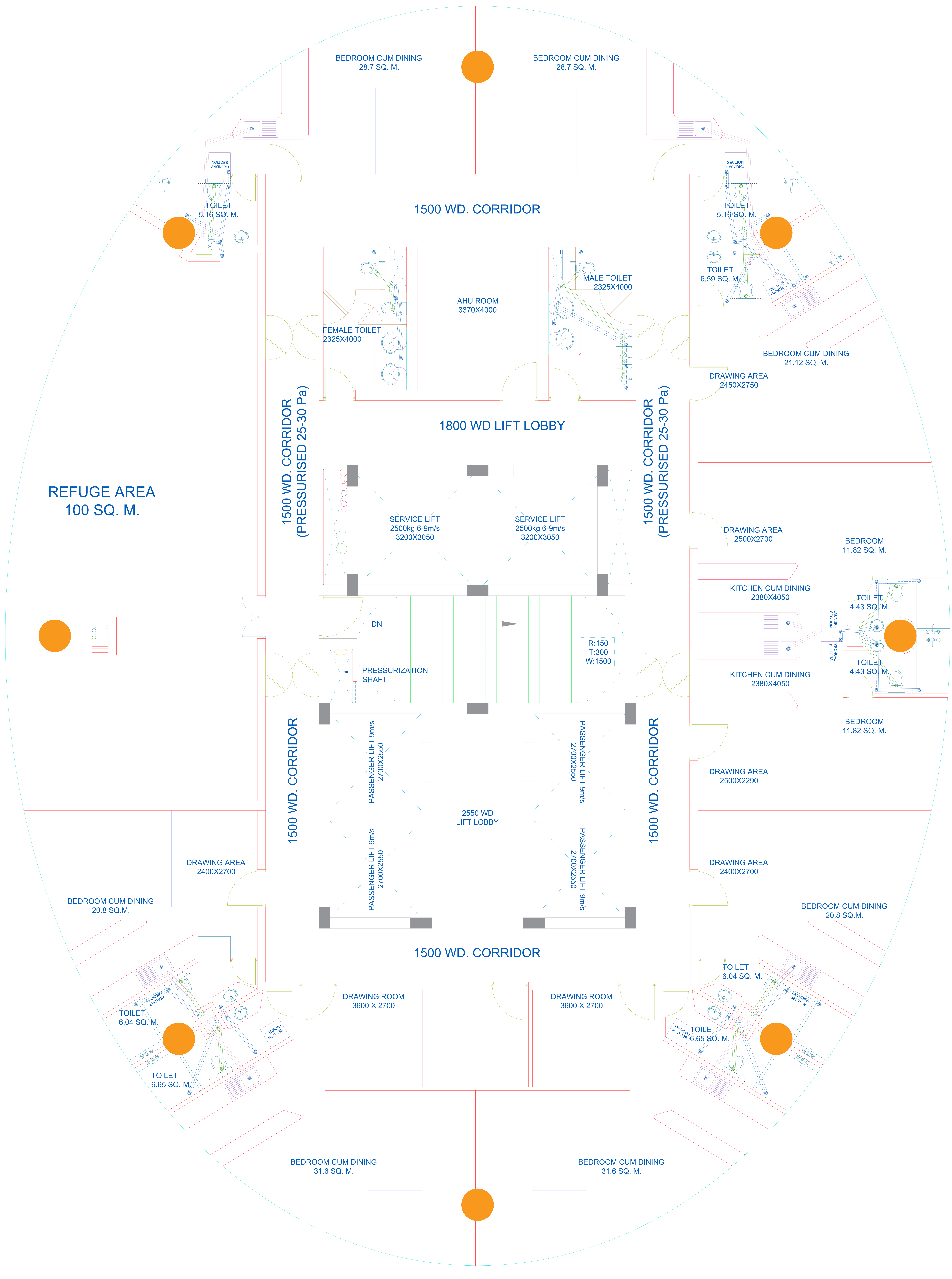
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LEVELS-38) (PLAN SHOWING TOWER A)

SERVICED APARTMENT

N

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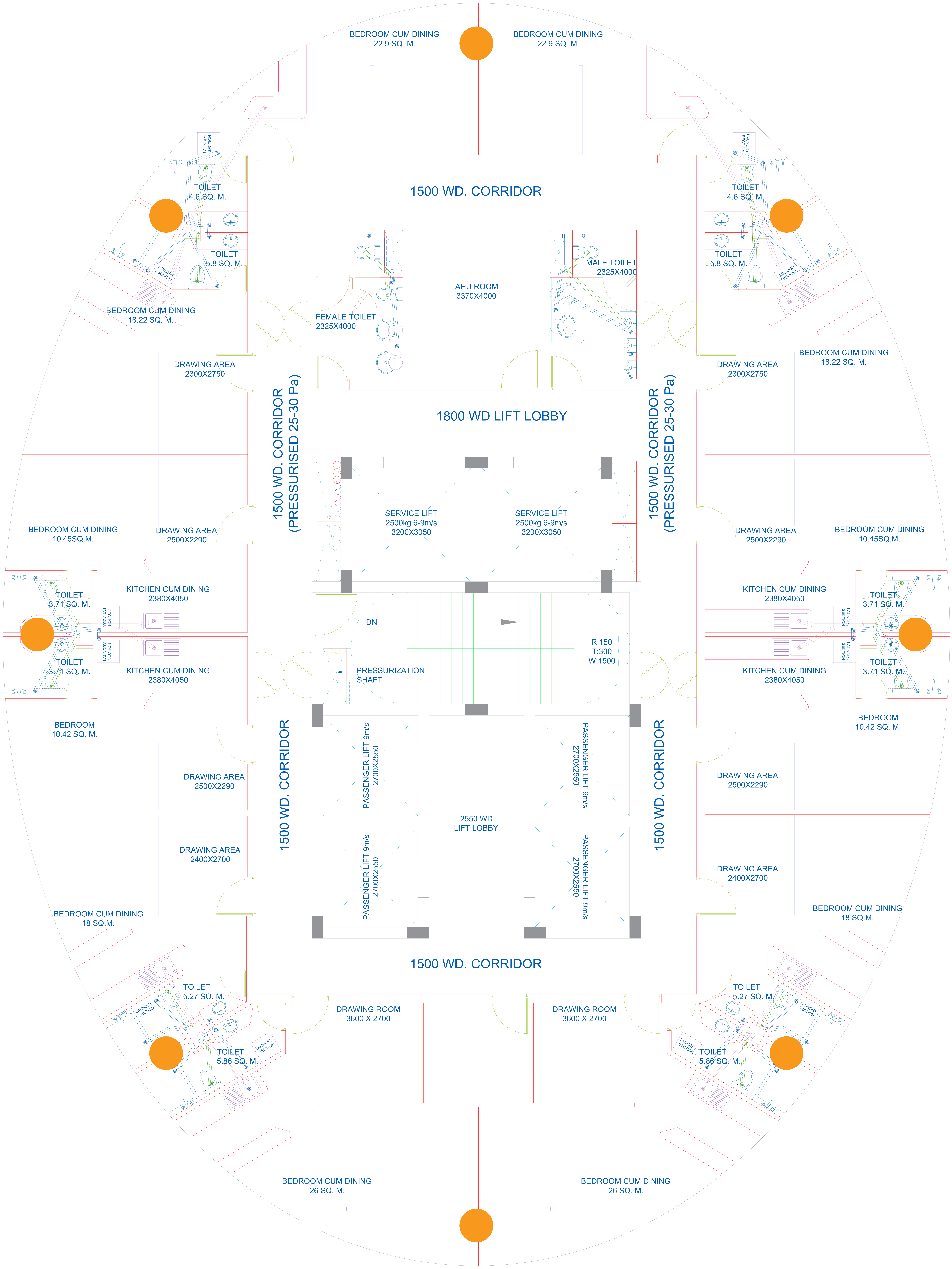
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U

SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LEVELS- SERVICED APARTMENT 680M^2 FLOOR PLATE) (TOWER A)

N

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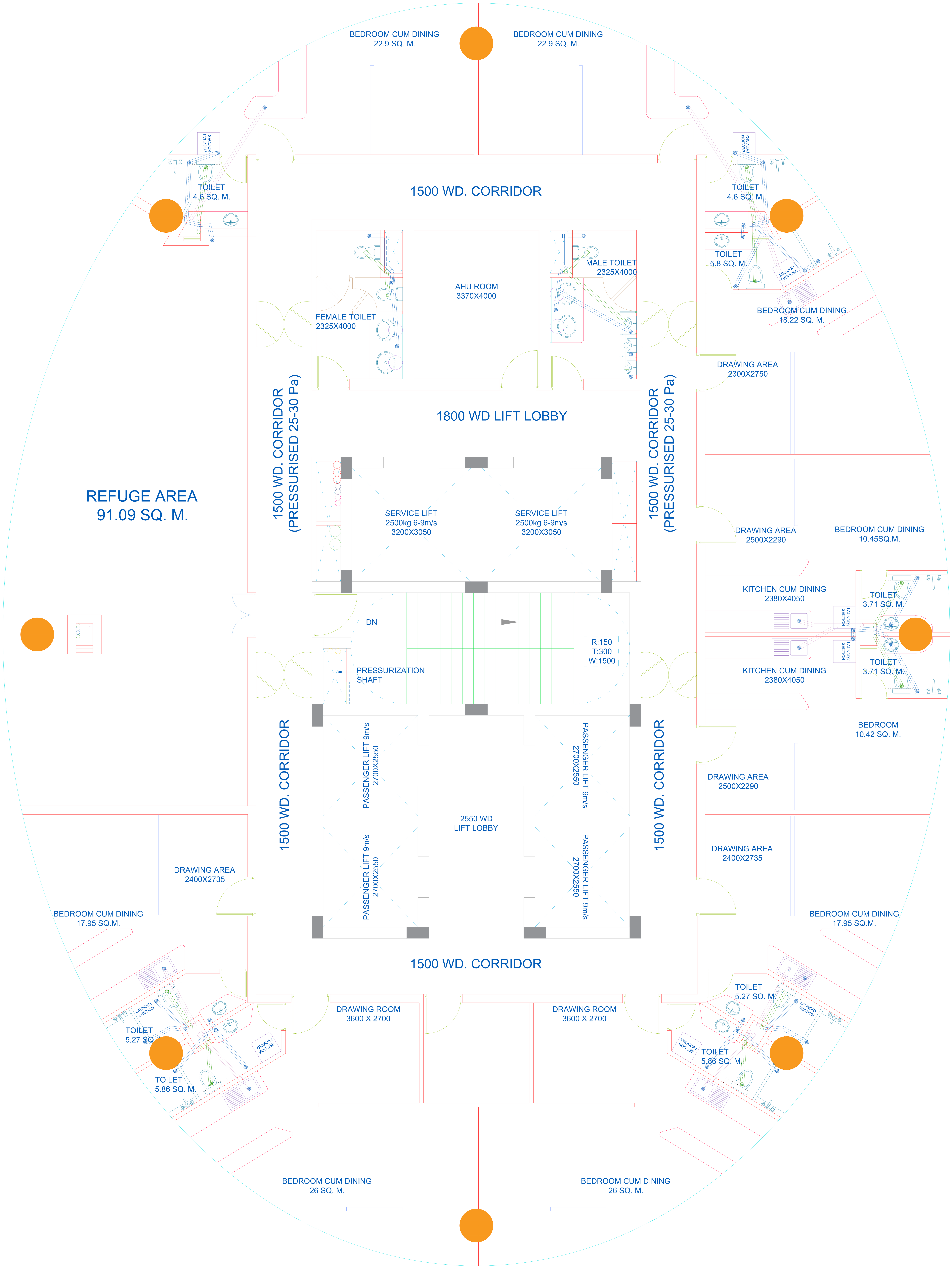
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U
SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

REFUGE FLOOR (LEVELS-42) (PLAN SHOWING TOWER A)

SERVICED APARTMENT

N

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5th YEAR 10th SEM.
B.ARCH 2019-20
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SCALE: N.T.S.

SECTION AT P-P'

THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

PLUMBING LAYOUT FLOOR 50 AND S. POOL

N

NOT TO SCALE

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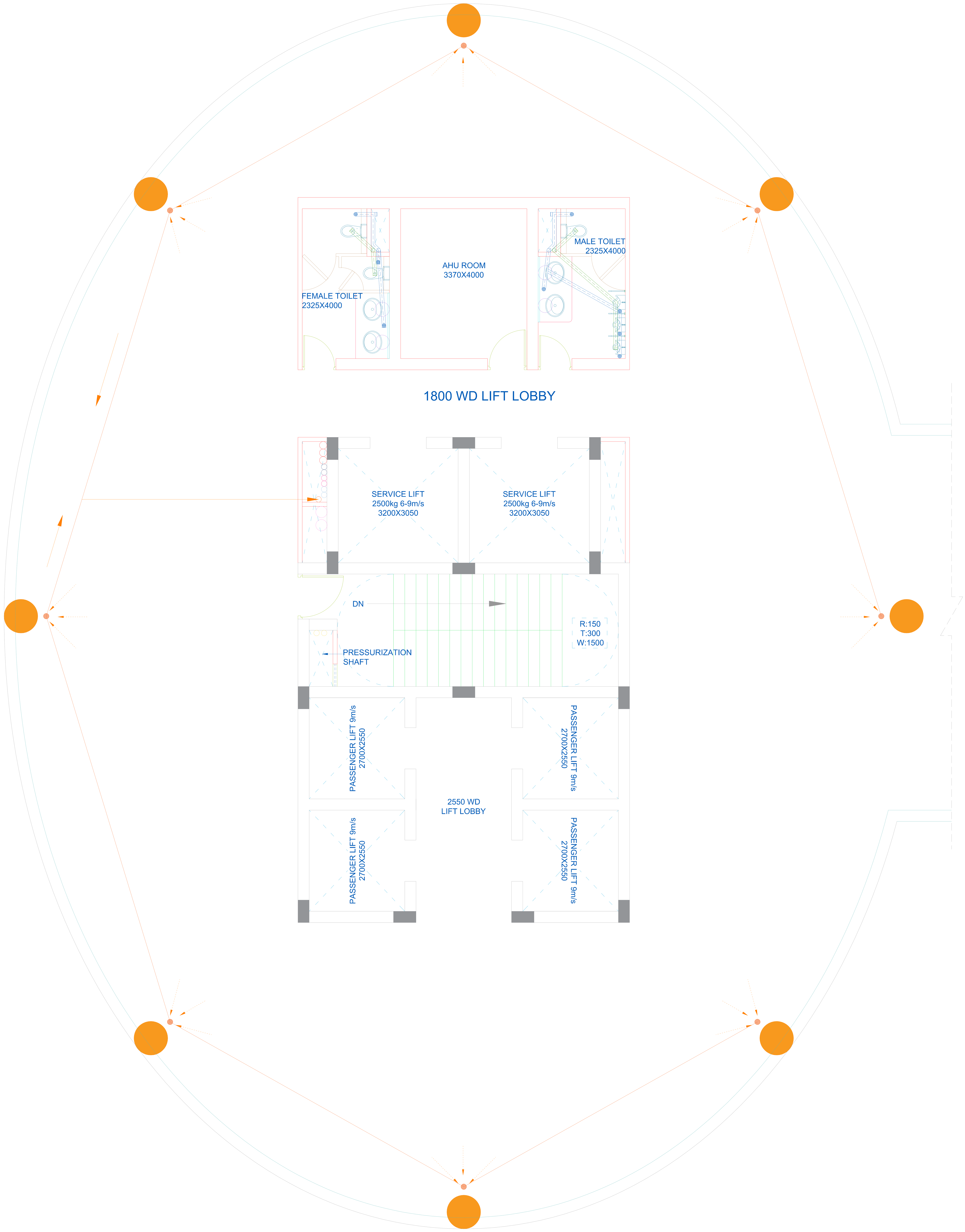


THE 50 TWINS SKY

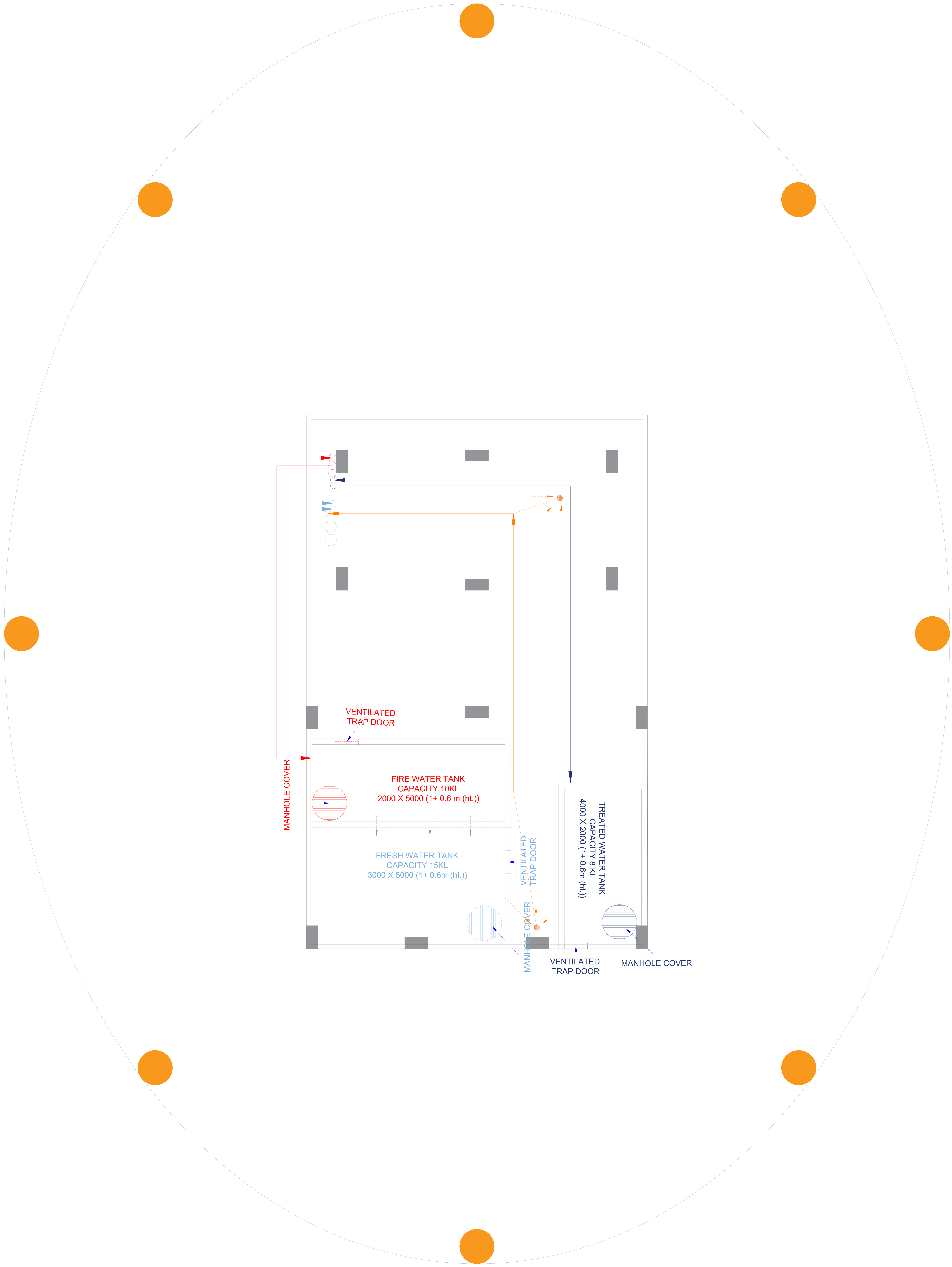
COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LEVELS- TERRACE)
(TOWER A)
USE- R W H

N

RISHABH SINGH
5th YEAR 10th SEM.
B.ARCH 2019-20
B.B.D.U

SCALE: N.T.S.



THE 50 TWINS SKY

COMMERCIAL TWIN TOWERS, DELHI

FLOOR (LEVELS- MUMTY)
(TOWER A)
USE- WATER SUPPLY

N

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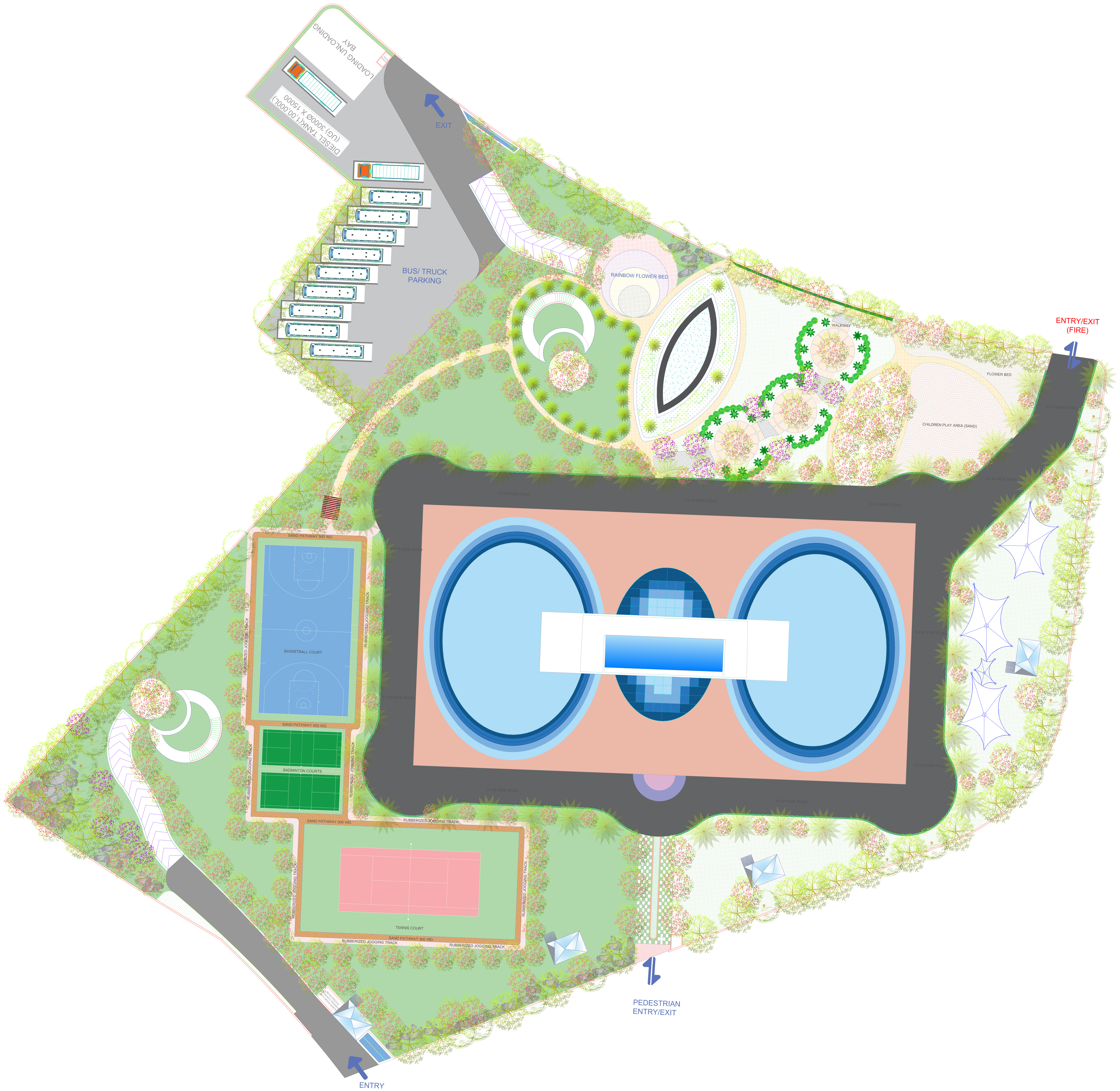
B.B.D.U

SCALE: N.T.S.



LEGENDS

GRASS (LVL ±00)	
ROAD (LVL +75)	
TERRACOTTA TILES (LVL +150)	
SAND (LVL ±00)	
RUBBERIZED TRACK (LVL +50)	
SANDSTONE PAVERS & GRASS (LVL +150)	
PVDF TENSILE MEMBER TENT	

VEGETATION LEGEND

	MANGO TREE	MANGIFERA INDICA	32
	ASHOKA	SARACA ASOCA	57
	DWARF FEATHER PALM	PTYCHOSPERMA MACARTHURI	81
	FIRANGIPANI	PLUMERIA	176
	BOUGAINVILLEA	BOUGAINVILLEA	15
	COMMON DAISY	BELLIS PERENNIS	57
	SNAKE PLANT	DRACAENA TRIFASCIATA	24

THE 50 TWINS SKY
COMMERCIAL TWIN TOWERS, DELHI

SITE & LANDSCAPING PLAN

N

NOT TO SCALE

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