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The Technology of Geodesic Dome Design on Cinematography and Interactive Tourist Information Centre Building in Penang

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Abstract: Penang is among one of the states in Malaysia that embrace their cultural heritage and maintain their architectural style from early decade. Its population is extremely diverse in ethnicity, having rich culture, linguistic and religion. The issue of sustainability arose when we have the intention to 'sustain' a culture for tourism purpose but at the same time it contradicted with the process of urbanization and having rapid development of architectural style and recent technology. This research studied on the proposal of upgrading it into a more advance technology yet still maintaining the earlier era of architectural style. In order to keep this heritage, sustain, design approaches may have a combination of two era which is colonial era style with modernism style. Penang virtual and interactive tourist information centre are design to accommodate tourist with an information transferred platform using high technology which is providing a 5D Cinematography and 9D technology. Having a geodesic dome for Penang Virtual and Interactive Tourist Information Centre in the design is a great solution because to build a 5D cinematography can be functional by using a geodesic dome. It also shows that 5D cinematography can be functioning without having columns. Geodesic dome is one of the building elements that can replace column to build a high technology of cinema room. The issue on having large spaces and high ceiling for cinema has been solved. 5D cinematography using an 180° curve screen obviously needs a strong structure which are curve to hold the screen and it is solved by designing the geodesic dome. The issue on sustaining their cultural heritage is also achieved by combining the geodesic dome design with colonial era of architectural style on the building façade.

Keywords: Cultural heritage building, geodesic dome, cinematography, virtual and interactive tourist information centre.

1. Introduction

Penang is a state in Malaysia which is located in northwestern Peninsular. Penang's population is almost 1.78 million as in 2020, (Department of Statistics Malaysia, 2021), while its population density has risen up to 1,684/km2. According to Opalyn Mok (2016), Penang has among the nation's highest population densities and is considered as one of the country's most urbanised states. Penang's heterogeneous population is extremely diverse in ethnicity, having rich culture, language and religion by having Malays, Chinese, and Indians as the three main races and also has Peranakan, Mamak, and others such as Siamese, Eurasian and emigrant communities. Penang is very popular for its heritage character and appeal that attracts tourists particularly in the city of George Town with more than 200 years of urban history (Lim Tiam Chai, 2011). Due to that fact, George Town is indeed a perfect site to be chosen for this research as it has a variety of communities with great cultural diversity by having many races living in there.

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One of the huge decisions in embracing the culture in Penang is that they maintain their architectural style from early decade. According to Tourism Penang (2007), the architectural style of Penang reflects the 171 years of British presence on the island, coalescing with local with the influence by the Chinese, Indian and also having an Islamic influence supporting with other elements to create a unique and distinctive style and characteristic of architecture. The early architectural style in Penang is Colonial Architecture style. Many colonial elements still exist until today which can be seen at Fort Cornwallis, the oldest British structure in Penang. This should be properly sustained as it shall be lost due to the rapid growth of modernism style in architecture. In order to keep this heritage sustain, future design approaches may have a combination of two era which is colonial era style with modernism style.

The combinations of both architectural styles, should be taken into account to be applied into the future design concept considering as a fusion loop way on developing idea. From the early architectural style to modern architectural style is a like loop where with a modern architectural style, designing a high-tech building with high technology which is 5D cinematography and 9D technology for tourist is a good idea. The idea of designing the Penang Virtual and Interactive tourist information centre is a good opportunity to apply both styles.

1.1 Issues and Problem Statement

The existing Penang Tourist Information Centre offered a place for the tourist to get information. Penang has a lot of cultural and heritage information that needs to be shown. The issue of sustainability arose when we have the intention to 'sustain' a culture for tourism purpose but at the same time it contradicted with the process of urbanization and having rapid development of architectural style and recent technology (Lim Tiam Chai, 2011; Mohamad Tajuddin, 2006). This research studied on the proposal of upgrading it into a more advance technology. Penang virtual and interactive tourist information centre are design to accommodate tourist with an information transferred platform using high technology which is providing a 5D Cinematography and 9D technology. Nevertheless, these two high technologies have some issues on functioning especially from the first is their spaces. 5D cinematography has had some issues to be built. In order to design and built a high technology cinema room, a hallway with columnless is required. Large spaces and high ceiling are needed. This 5D cinematography is using an 180^{o} curve screen. Due to that, this building needs a strong structure that is in curve forms to hold the screen. It is preferred that the curve structure can also patch the screen. Curve body for this space are preferred to functioning well.

Focusing on geodesic dome for Penang Virtual and Interactive Tourist Information Centre, it is to build an economical sustainability building. Penang Virtual and Interactive Tourist Information Centre is a high-tech building with a high technology 5D cinematography with 9D technology room. It uses more power to function. Some elements that support to this also solar energy power system also applied. The existing Penang Tourist Information Centre has been using economical architectural elements to cut the cost of the building. Knowing that the virtual and interactive applications in the building shall uses high cost, the building itself should be in the minimum cost to be built. Geodesic dome is the one of the elements that can save the cost of construction because geodesic dome can stand without column. This element is very suitable for 5d cinematography which is the room area need to have less column for the hallway. With a big screen with 180^{o}, column must be less to gives the better feel and intention to the visitors viewing.

1.2 Background of The Site

The existing Penang Tourist Information Centre are located near the Weld Quay (Pengkalan Weld) road. Weld Quay was named after a Prime Minister of New Zealand, Sir Frederick Aloysius Weld and it is a coastal road along the eastern shoreline in George Town. The Chew Jetty, which is an old Chinese waterfront settlement, is the largest and most active and lively jetty that situated at the end of Gat Lebuh Armenian. The Chews originated from the south-eastern coast of China and were the maritime clan communities in China (Tourism Penang, 2017).

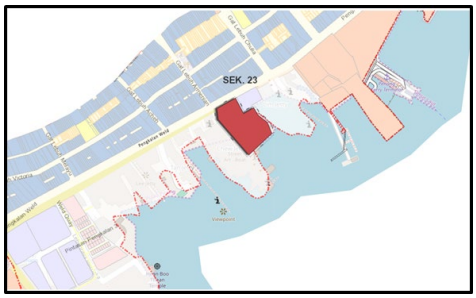


Fig. 1 - The location of the site

1.3 Site Condition

The existing site features mixed-use buildings such as housing, Chinese food restaurant, car workshops, temples and wooden furniture factories. The districts are Timur Laut at the George Town city with section 23. The size is 2.04

acre (8,255.587 sq.m). For the built-up: 4500 sq.m. The topography of the land is flat surface. Land also use for tanah tambak (State land).

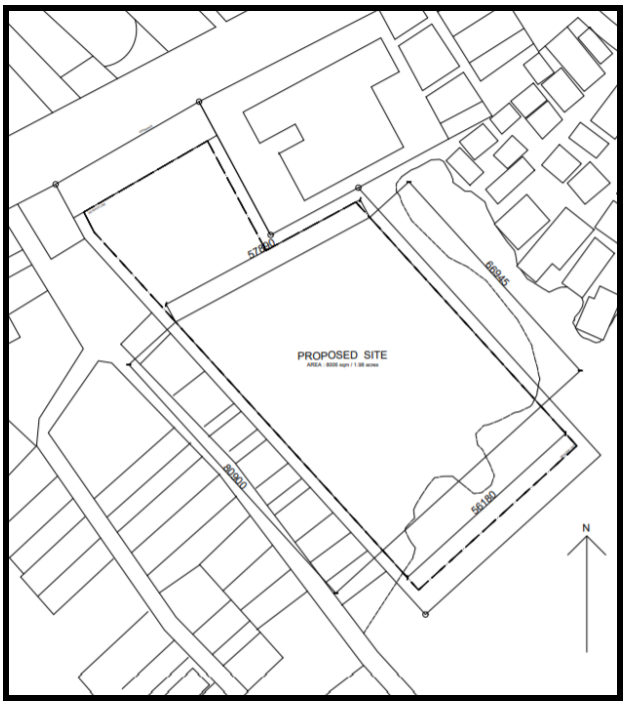


Fig. 2 - The area of the site for information centre

1.4 Research Objective

The objectives of this research is:

1. to comprehend the system of the geodesic dome for building to provide large columnless space
2. to apply geodesic dome for Penang visual and interactive tourist information centre.

2. The Fundamental of Geodesic Dome

Domes are curved structure where one of the main functions is to protect something inside or beneath the domes. Domes may be constructed either in one piece like a shell or if they are made from triangles, they are called as geodesic domes where the geodesic is pronounce as Jee-O-Dess-ikk. The concept of geodesic dome was initially created and developed by an American scientist, engineer and architect Richard Buckminster Fuller somewhere in 1940s where he invented, manufactured and even patented it in 1954. Geodesic domes are hemispherical structures which is a semi sphere-shaped structure consisting of a network like a mesh system of triangles which provide a self-balancing structural framework that uses minimal materials. The word geodesic is Latin and means 'earth dividing'. (Martin Pawley, 1991; Julia Fung, 1980). A geodesic dome is actually like a lattice-shell by having a hemispherical thin-shell structure based on a geodesic polyhedron. The triangular elements of the dome are structurally rigid to distribute the structural stress throughout the structure, making geodesic domes able to withstand very heavy loads for their size. A geometric dome is very interesting because it has the ability to support itself without using any internal or interior column or interior load-bearing walls. (Tamsyn Hood, 2015; Lluvia Baron, 2020). Due to this advantage, geodesic domes is such an appealing structure to be considered into an open space design as it can have huge and wide space without the interruption of columns. Spaces like churches, sports arenas, concert theatres, exhibition halls and any open space hall may consider of having a geodesic dome into the design.

Engineers and architects both have always looking for structural systems that have the capability to support large spans with minimal interference from the internal supports (Amal Sheik & Aneeta Anna Raju, 2019). Geodesic domes are made from separate pieces of ‘material’ arranged in triangles, pentagons and hexagon. The position of the shapes and their sizes is critical and needs mathematics to work it out and it is extremely an efficient form of architectural element as it is the strongest lightweight structures. Dome is made by pieces of stiff material that are joined at the corners to make stable triangle shapes (Lluvia Baron, 2020).

2.1 Advantages of Geodesic Dome

There are many advantages of geodesic dome including the strength and construction method where it is stable and easy to construct which is superlative for almost any type of spaces. This is because the equal distribution of weight

throughout the whole structure makes it stable even during natural disasters like an earthquake or other similar hazards. Being in an aerodynamic shape, geodesic dome has the ability to protect itself against strong wind or even storms. The spherical shape of the domes takes less surface area per unit of internal volume, where it has the ability in reducing the interior temperature and heat gain and at the same time enables uniform air flow. The most popular advantages of geodesic domes are it can be very large in size with less surface area, which means less materials are required, therefore reducing the costs. This advantage of having large size is benefit for open space planning without the interruptions od indoor columns. Apart from all that, geodesic domes are also very quick and easy to assemble, which also leads to less labor intensive required. These types of domes are famous for their vast usage in sustainable projects, because the materials required are all environment friendly and the structure itself is very safe and creates healthy interior. In addition, the bowl-shaped interior generates a natural airflow that permits the hot or cool air to flow evenly throughout the dome with the help of return air ducts (Azra Maliha, 2017; Lluvia Baron, 2020).

2.2 Materials of Geodesic Dome

Plenty of materials can be used for geodesic domes and for a simple, portable and mobile structures, materials such as PVC, timber or galvanised steel frames covered with a thin architectural membrane such as PVC polyester or ETFE foil can be used. As for a big, larger and more permanent structures such as sports arenas or stadiums, geodesic domes are more suitable to be constructed with aluminium and steel frames covered with materials such as copper, aluminium, acrylic and plexiglas panels.

Fig. 3 - Material for geodesic dome

2.3 Structure of Geodesic Dome

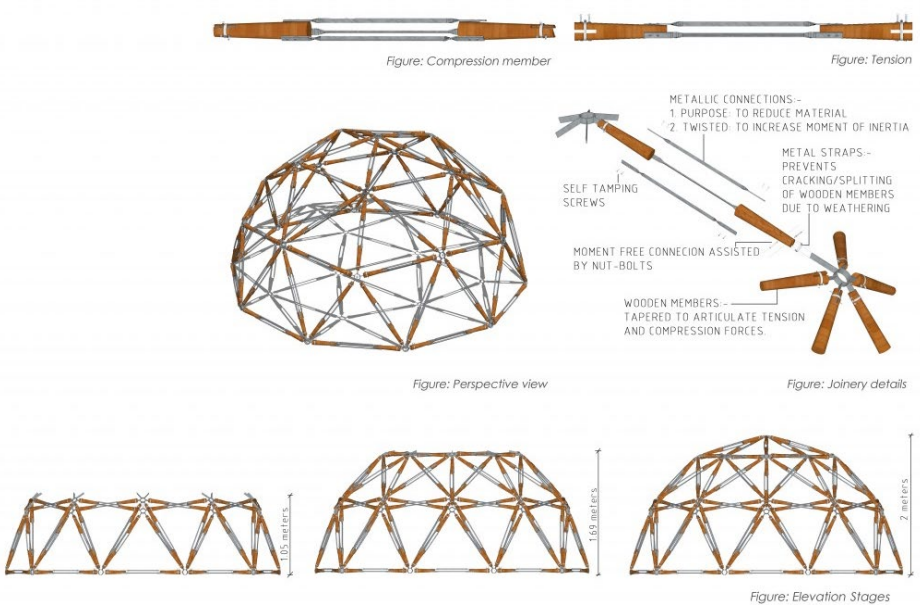


Fig. 4 - Detail structure of geodesic dome

3. Precedent Study

Three buildings with geodesic domes were chosen as the precedent studies which are Geodesic Dome of Dewan Tunku, Komtar, Penang, National Science Centre, Kuala Lumpur, Malaysia and The Tech Interactive, San Jose, California.

3.1 Geodesic Dome (Dewan Tunku), Komtar, Penang

Dewan Tunku in Komtar, Penang is one of the buildings that is using geodesic dome. The Geodesic Dome which is name as Dewan Tunku, is located at the roof top that function as a multi-purpose hall which basically being used for performances, official functions and other events. During the time it was built, it was regarded as a cutting-edge design that makes it very iconic and a first of its kind in Malaysia. The main entrance to this semi-spherical Geodesic Dome is from the roof top at level 5 while it is also accessible from level 4 of Komtar. Tech Dome is a Science Discovery Centre, a public-private partnership linking with the Penang State government that was established to promote and encourage the children, teenagers or even younger adults towards having a greater understanding and interest in science and technology. Having the tagline of Inspiring the Future, it is targeted to be a center that can be a hub to educate people especially the youth about science and technology. Looking at the tagline it is not a surprise that the design is using the geodesic dome.

Fig. 5 - Front view of Dewan Tunku, Komtar, Penang

The Dewan Tunku Geodesic Dome is obviously inspired by Buckminster Fuller Geodesic Dome concept of a semi spherical-shaped or known as hemispherical structure constructed on a pattern of circles called geodesics which intersects to form triangular elements. These triangular elements spread the stress across the entire structure. The architect who designed Komtar is Datuk Seri Lim and his choice of using the Geodesic Dome for Dewan Tunku is based on the design of Buckminster Fuller whom he has a friendship and working business relationship with. (Timothy Tye, 2014;2017).

Fig. 6 - Hall of Dewan Tunku

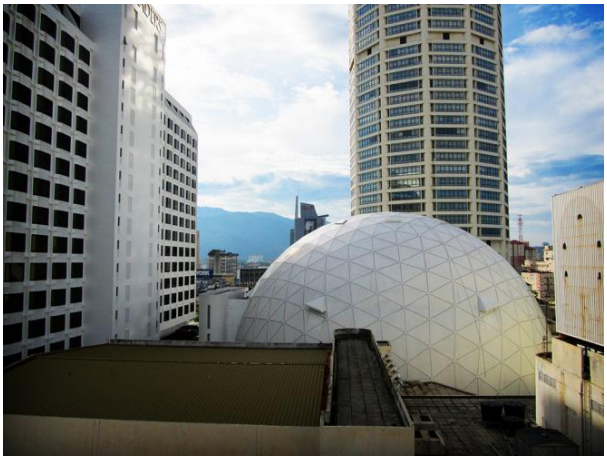



Fig. 7 and 8 - Perspective views of Dewan Tunku

3.2 National Science Centre, Kuala Lumpur, Malaysia

Pusat Sains Negara or National Science Centre which located in Kuala Lumpur is another building that is using geodesic dome in Malaysia. The function of this building is as the science centre and similar to Dewan Tunku, it also has intentions to promote and encourage the children and young adults towards having a greater understanding and interest in science and technology. The building bears a resemblance to a truncated cone capped with a geodesic dome. Among the themes featured in the exhibition galleries are future world, environmental odyssey, thinking machines and pathways to discovery. Looking at the themes, it is also not a surprise that the design is using the geodesic dome.

Established in 1996, this National Science Centre is a crowd puller and because it shaped like a futuristic wide dome, it is divided into several sections, displaying range of scientific knowledge.

Also known as the Pusat Sains Negara, Malaysia's first overhead freshwater aquarium, filled with more than 30 different species of local freshwater fish, are built along the way to the main exhibition area. The most interesting part of the National Science Centre is undoubtedly the hall where you can watch a science show beamed straight into the interior of the main dome without interfering by any indoor column (Pusat Sains Negara, 2020).

Fig. 9 - Structure of Dome of National Science Centre

Pusat Sains Negara or National Science Centre accommodates variety of exhibitions to encourage, stimulate and motivate the visitors to be excited and interested in Science and Technology. Due to this, the design geodesic dome is obviously a right choice for the building where it resembles the science of technology in architecture and structure.

Fig. 10 - Perspective of National Science Centre

3.3 The Tech Interactive

Another building with a geodesic dome is The Tech Interactive (previously The Tech Museum of Innovation), commonly known as The Tech is a science and technology centre in San Jose, California, in Silicon Valley. Having approximately similar function as previous buildings explained above which are also on science and technology, it is also not a surprise that it's using geodesic dome. It is situated adjacent to the Plaza de César Chávez in San Jose. The Tech Interactive's architecture is the work of Ricardo Legorreta, a Mexican architect. The facade has a very distinctive color choice of mango and azure. It has three floors, each with its own significance where the ground floor has the main entrance and other spaces includes café and store that is being named as The Tech Cafe and The Tech Store, a theater named as the IMAX Dome Theater, and a recreational area that is reserved for special events. Four major theme galleries consist of Communication, Exploration, Innovation, and Life Tech fill both floors of first floor and second floor to achieve the goal of inspiring future generations with science and also exploring and experiencing applied technologies. (Sal Pizarro, 2018).

Fig. 11 - The Tech Interactive in azure color while the IMAX Cinema in is the geodesic dome in blue

This IMAX dome theater made its debut in 1998, because although it is being built in 1998 it is successively chasing on technology that was so 20th century. The Tech made huge achievement by having new digital laser projection system, along with a new sound system and "seamless" screen at the Hackworth IMAX Dome Theater. There is an inherent superiority to the image that can get from actual film, especially the 70mm variety that IMAX and other large-screen venues use. Nevertheless, film has some flaws too as it tends to break, gets cloudy and dirty where it

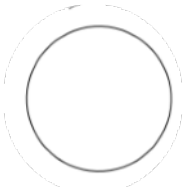
degrades along the way. Furthermore, it takes a lot of space to store those huge reels and eventually more and more filmmakers are avoiding using film which whittling down the Tech's potential IMAX offerings. The Tech Interactive shows is the place the whole point should be to have the newest technology available (Sal Pizarro, 2018).

Fig. 12 - Interior of IMAX cinema of The Tech Interactive

From the three precedent studies done, concerning on the strength and weaknesses, the design shall be proposed on having the geodesic dome for the 5D cinematography considering it shall use the180^{o} curve screen and the design development is as follows.

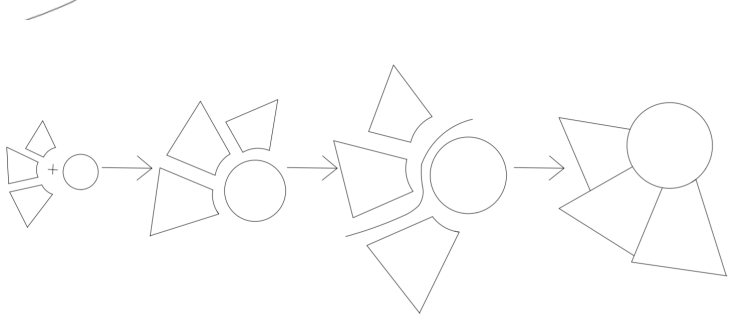
4. Design Development

The design generated from design concept which is fusion loop by combining organic form with geometry form to get the form building using fusion technique. It is representing a combination of two era in architectural styles.



The circle as the main center of building which is the main attraction tourist and followed by three triangles.

The line is as connection of three geometry form to the organic form circle. The combination of all this form can get one form for this building.



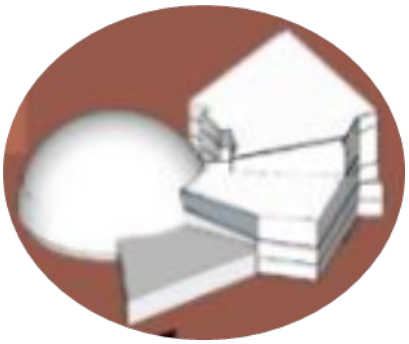


Fig. 13 - Design development

4.1 Site Analysis

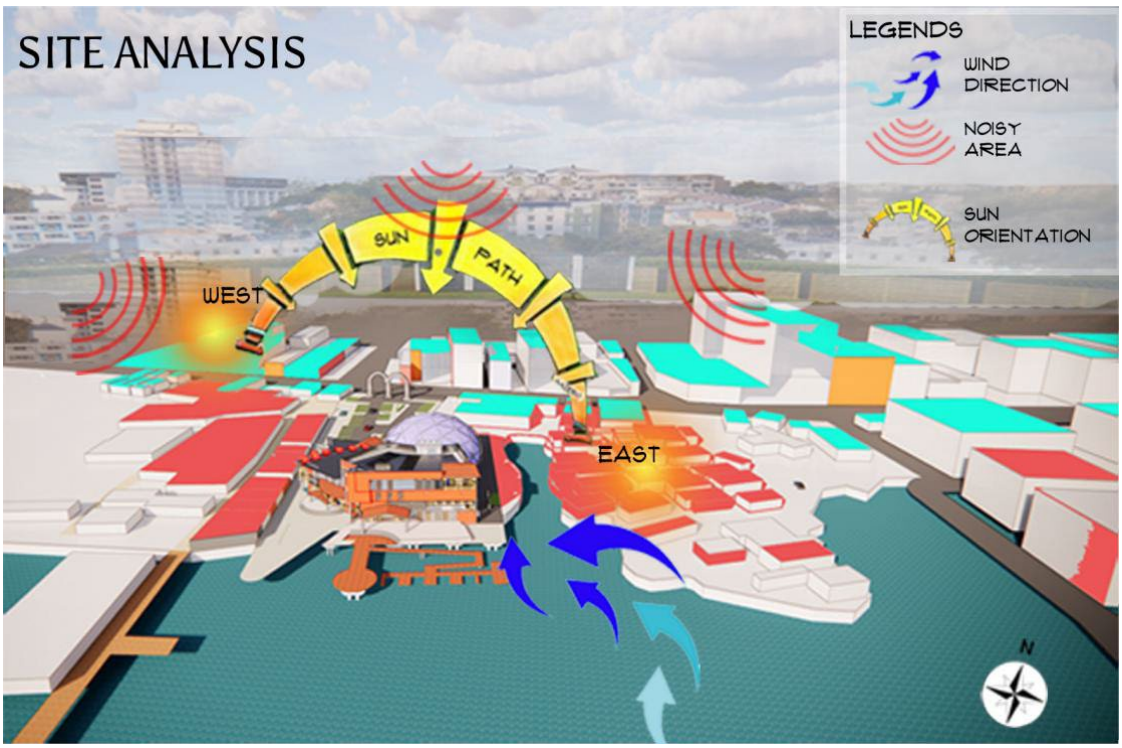


Fig. 14 - Sun path with wind direction and noisy area

From the site analysis, wind directions are mostly come from the sea it's not been blocked by any building. Noise also comes from the front of the site because the buildings are mostly at the front.

Fig. 15 - Sea level

From the sea level, low tide of the sea is 0.5 meter while, high tide is 12 meters. For the height of the buildings surrounding the site, the maximum height is approximately 15 meters.

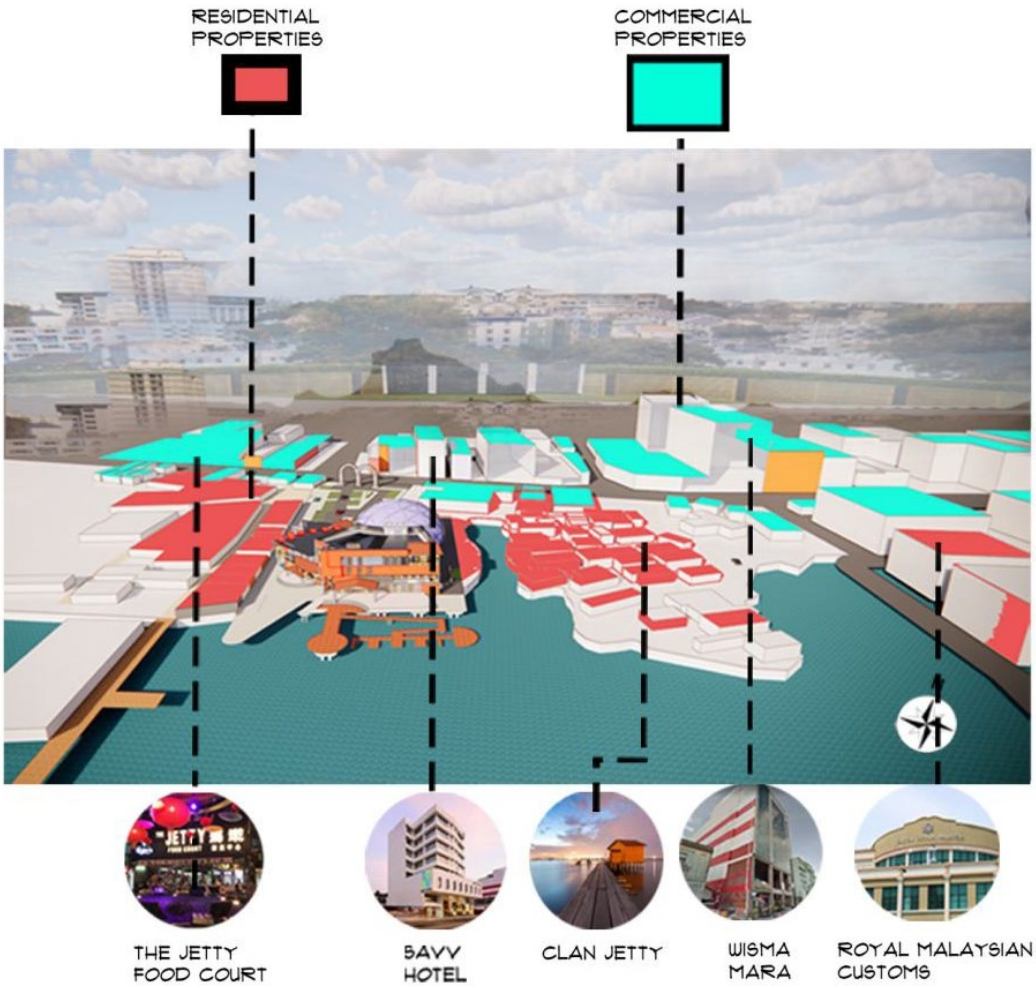


Fig. 16 - Zoning and site surrounding

From the zoning diagramme shown above, the red colour indicates the residential properties. Parallel to the site which is along the seaside are the residential properties. The cyan colour indicates zoning for commercial properties where mostly commercial properties are located infront of the site.

4.2 Geodesic Dome Functioning

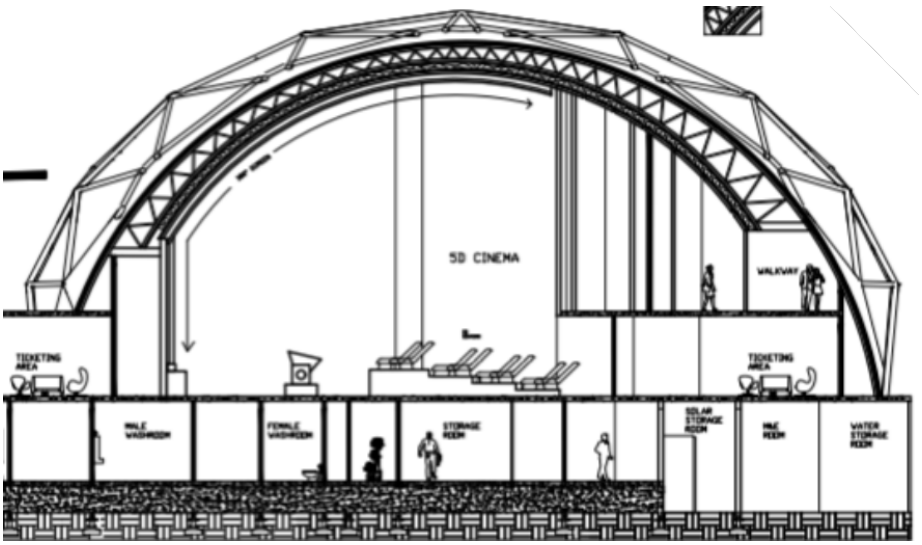


Fig. 17 - Sectional Plan with 5D cinematography spotted

Instead of 5D Cinematography, the geodesic dome also covers other space including services rooms of the 5D cinematography itself and also services room for the whole building such as M&E room at the ground floor, solar storage, AHU room and etc.

180^{o} screen is hold by the structure of the dome itself which can withstand the screen strongly. As shown by sectional plan above, it does not have any column inside the 5D cinematography. Columns are only built around the 5D cinematography to separate 5D cinematography to other space.

5. Design Outcome

5.1 Floor Plan

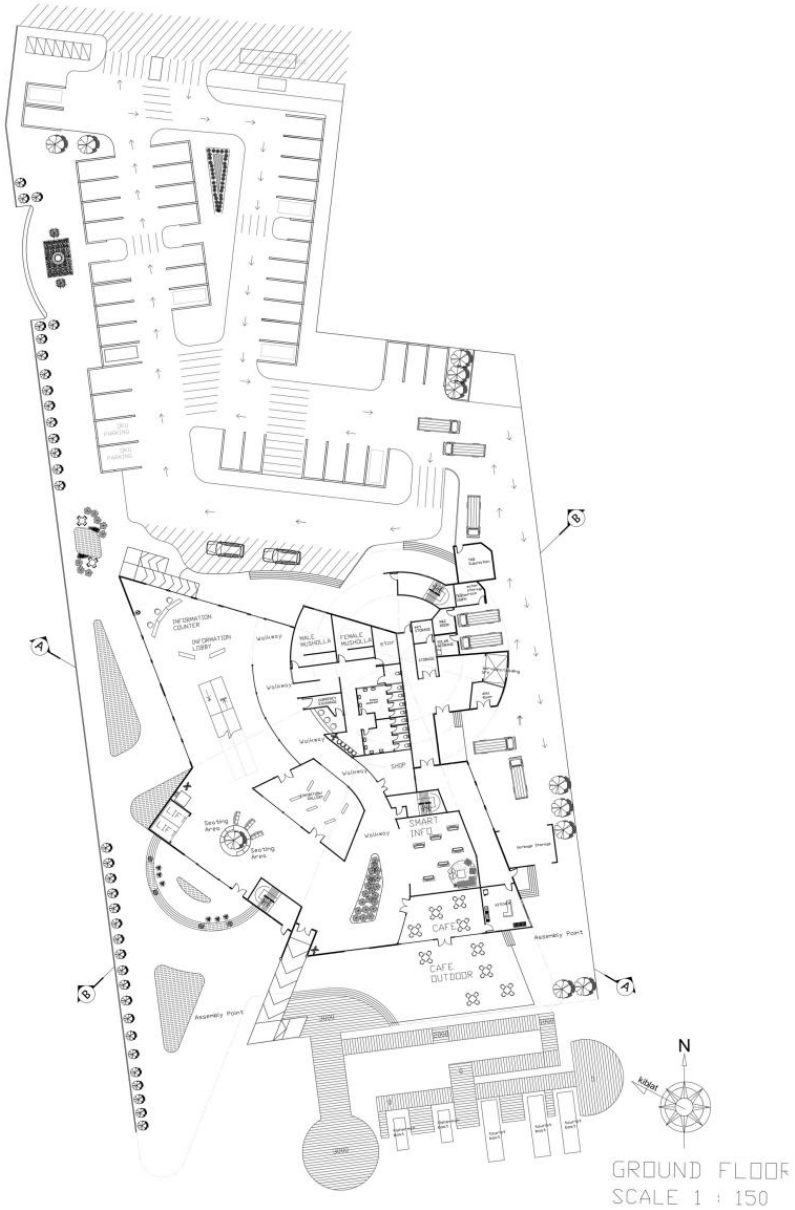


Fig. 18 - Layout for ground floor

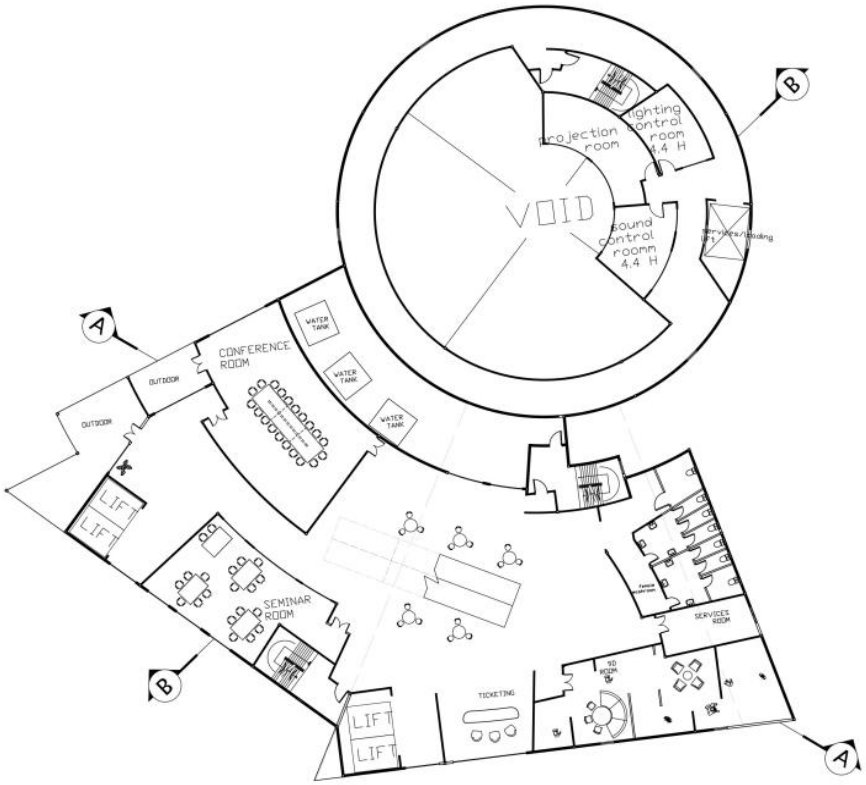


Fig. 19 - Layout for first floor

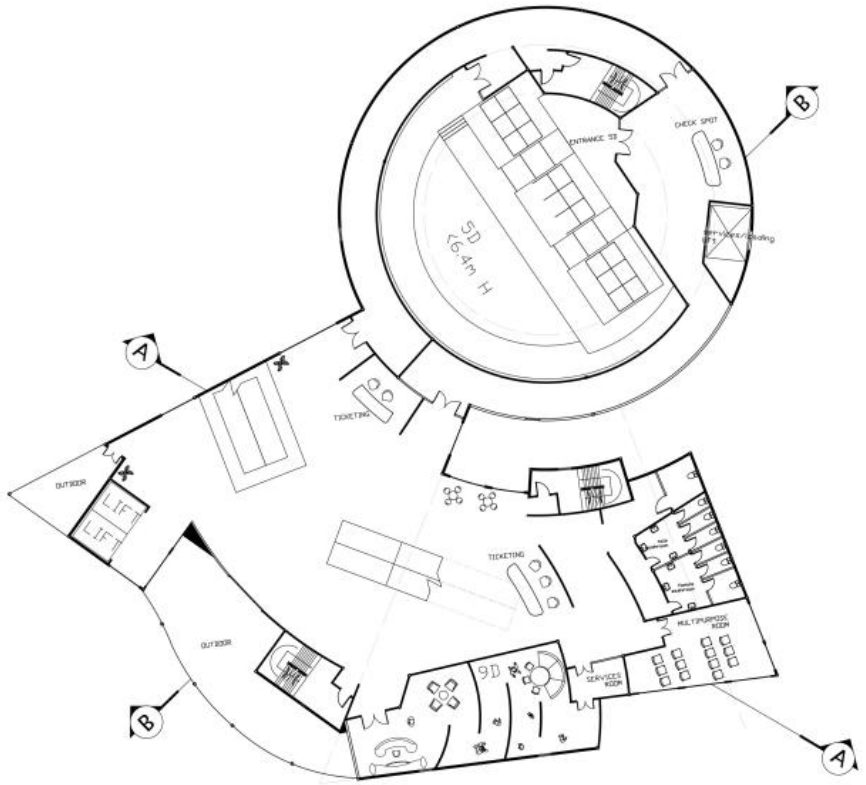


Fig. 20 - Layout for second floor

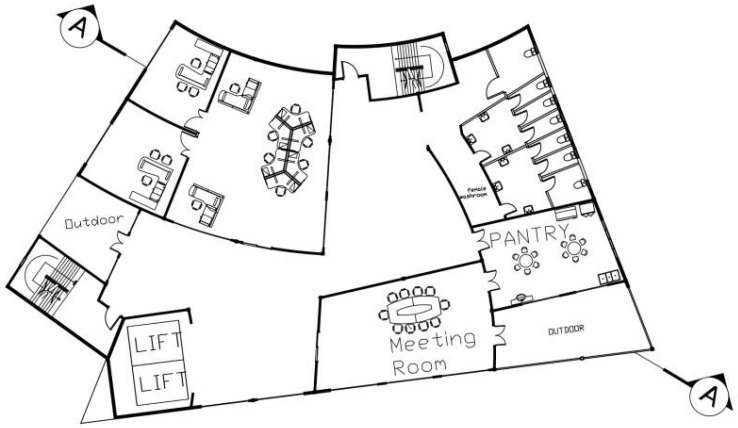


Fig. 21 - Layout for third floor

5.2 Sectional Elevations

Fig. 22 - Layout for section A-A

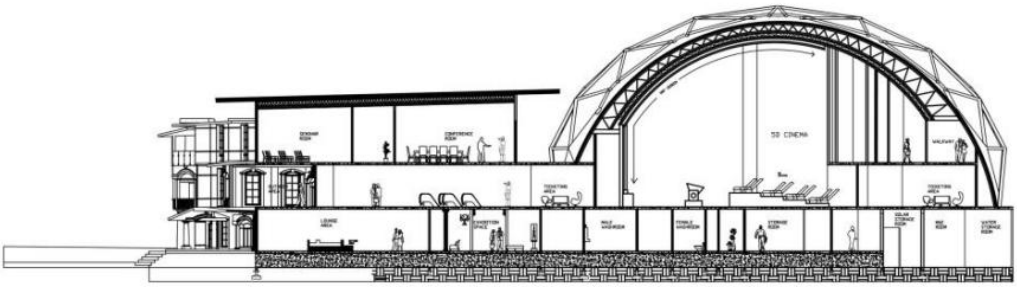


Fig. 23 - Layout for section B-B

5.3 Elevations and Perspective

Fig. 24 - Front elevation

Fig. 25 - Right elevation

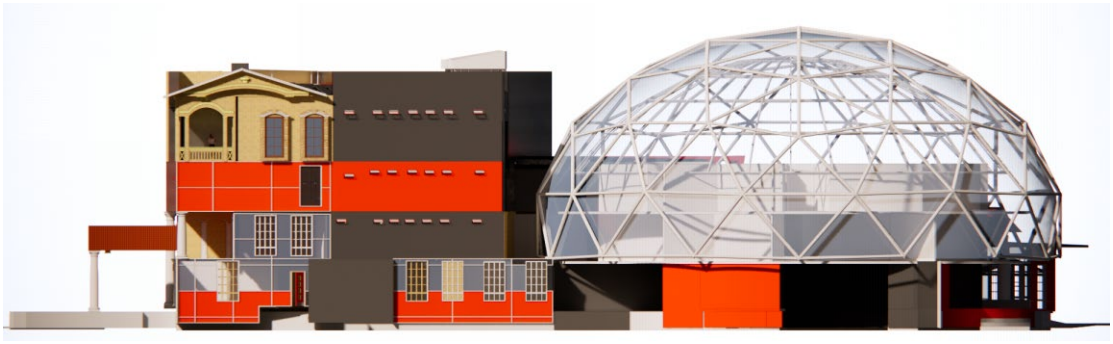


Fig. 25 - Left elevation

Fig. 26 - Rear elevation

Fig. 26 - Rear elevation

6. Conclusion

In conclusion, having a geodesic dome for Penang Virtual and Interactive Tourist Information Centre in the design is a great solution because to build a 5D cinematography can be functional by using a geodesic dome. It also shows that 5D cinematography can be functioning without having columns. Geodesic dome is one of the building elements that can replace column to build a high technology of cinema room. The issue on having large spaces and high ceiling for cinema has been solved. 5D cinematography using an 180^{o} curve screen obviously needs a strong structure which are curve to hold the screen and it is solved by designing the geodesic dome. The issue on sustaining their cultural heritage is also achieved by combining the geodesic dome design with colonial era of architectural style on the building façade.

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