Prague - Troja
Integrated Daylight Design on Czech Floral Conservatory
by Rafail Afandiyev
Prague - Troja
Integrated Daylight Design on Czech Floral Conservatory

Diploma Thesis Portfolio

Faculty of Architecture, Czech Technical University in Prague
Department of Urban Planning ISIZ
Atelier Hanson - Landscape Architecture Studio

Summer Term 2017-2018

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Diploma Thesis Opponent:
Prague, June 2018
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Thesis Assignment

Czech Technical University in Prague, Faculty of Architecture

2/ ASSIGNMENT of the diploma project

Mgr. program navazující

Name and Surname: Rafał Alandziy
Date of Birth: 27/11/1988
Academic Year / Semester: 2018/summer semester
Department Number / Name: 15/12 Department of Spatial Planning
Diploma Project Tutor: Ing. W. A. Hansen IV, RA LEED AP

Diploma Project Theme:

Integrated Daylighting Design on Czech Floral Conservatory.

Assignment of the Diploma Project:

Description of the project assignment and the expected solution objective:

Life on Earth is possible due to the energy from the Sun. One of the key ingredients of the energy received from the Sun comes to us in the form of light. Both flora and the human species are dependent on light. In addition to an energy source, humans need light to see the world around us; we experience delight in the qualities light offers as it illuminates our world.

This project explores both the qualitative and quantitative attributes of light to the benefit of humans and plants through the development of a conservatory where people can enjoy light and the plants that depend on it as a source of energy. The project site is located in Prague 7, Troja on the upper land owned by the botanical gardens.

Although light is a primary focus of this design assignment, the project shall also be developed as a public facility available to the residents of Prague and the Czech Republic. The conservatory shall support casual visits by the public as well as educational roles in teaching the public, particularly children, about the role of plants in our living environment.

Description of the final result, outputs and elaboration scales:

1. A portfolio describing the detailed development of the proposed conservatory, including all interior and exterior areas. At a minimum the portfolio shall include the following:
   - Analysis of the site and relevant context,
   - Theoretical research on conservatories and daylighting,
   - Development of a facility program,
   - Minimum of six case studies of conservatories at least three in the Czech Republic and at least three worldwide. All case studies should seek exemplary within their context. The case studies shall also include a spectrum of historical periods over the past three hundred years.
   - Graphical description of the proposal development process
   - Photographic documentation of development process in models
   - Complete set of final drawings showing the design proposal.
   - Structural and material drawings that describe the general construction plus typical representative details.
   - All images, quotes, diagrams etc., that are from non-author sources shall be credited at the place of their inclusion in the portfolio.

All drawings in the portfolio shall be at a scale that enables clear and legible information about the context.

1. Posters shall comply with the Faculty of Architecture dimension requirements and shall provide an outline description of all phases of the project and final design proposal. The following is considered the minimum requirements for the poster drawings:
   - Graphic and textual vision statement
   - Critical context and site analysis in the development of the proposal. Analysis of the site and immediate surrounding context shall be represented as three dimensional drawing such as axonometric, isometric, perspective.
   - Illustrative 'bird's eye' representation of the overall design proposal at a scale sufficient for people representing the intended functions to be visible.
   - A minimum of two site and building sections / elevations or section perspectives at a minimum scale of 1:200. These sections shall extend through the entire site area and include the immediate surroundings.
   - A minimum of three building sections / elevations that describe the interior functions, inside / outside relationships, immediate surroundings and include activities of users of the facility. These sections shall be at a minimum scale of 1:200.
   - Elevations drawings at a minimum scale of 1:200 of primary exterior facades including their immediate context.
   - A minimum of three construction sections from foundation to sky at a minimum scale of 1:10.
   - A minimum of two eyeline visualizations of the interior of the facility.
   - A minimum of three eyeline visualizations of the exterior; one of these visualizations must be of the facility from a primary viewing point beyond the limits of the target site.
   - A material and construction diagram of the construction strategy.

9/ List of further agreed-upon parts of the project (model)

Model of the building and relevant surrounding site areas at a minimum scale of 1:200. The model(s) shall be constructed exclusively of biodegradable materials.

Date and Signature of the Student

Date and Signature of the Diploma Project Tutor

Date and Signature of the Dean of FA CTU
Statement

I hereby declare that I developed the submitted thesis independently and that I have faithfully and properly cited all sources used in the thesis project in accordance with the Methodological guideline for ethical training of university thesis.

Prague, 24 May 2018

Rafail Afandiyev

CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF ARCHITECTURE

AUTOR: DIPLOMANT: Rafail Afandiyev
AUTHOR OF THE DIPLOMA WORK / DIPLOMA PROJECT:
Academic Year 2017/2018, Sumner Bernade

TITLE OF THE DIPLOMA WORK / DIPLOMA PROJECT:
Integrating day lighting design on Czech Floral Conservatory

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Integrated Daylighting Design on Czech Floral Conservatory

LANGUAGE OF THE DIPLOMA WORK / DIPLOMA PROJECT:

Diploma Work / Diploma Project
Diploma Work / Diploma Project Supervisor
Diploma Work / Diploma Project Opponent

Henry W. A. Hanson IV, RA MLA LEED AP

Key Words (Czech)
Conservation, Public space, City-Garden relationship, Landscape, Sustainability, Passive climate control techniques, Digigrid system

Annotation (Czech)
Výrazná zlepšení závisí na světlo, které pochází ze slunce. Tento projekt zkouma je kvalitativně tak kvantitativně atraktivní světla ve prospěch lidí a na zákaz zrejí jeho významný vliv.

We know that appropriate light during the day is critical in maintaining key aspects of our overall health. Life on earth is dependent on the light which comes from the sun. This project explores both the qualitative and quantitative attributes of light to the benefit of humans and plants through the development of a conservatory where people can enjoy the day light and the plants that depend on it as an source of energy. Observing Prague climate data and explore the city-gardens relationship, to design integrated daylight design on Prague botanical garden conservatory is the main aim of the thesis project. The project also focus on the inside-outside relationship to find out the common point on conservatory to answer why we conserve the plants which belong to different climate beside of educational and research purpose.

The Author's Declaration
I declare that I have elaborated the submitted diploma work / diploma project independently and that I have stated all the used information sources in coherence with the "Methodological Instruction for Ethical Preparation of University Final Works".

In Prague on ………………………………………… Signature of the Diploma Project Author
Master Thesis Abstract

We know that appropriate light during the day is critical in maintaining key aspects of our overall health. Life on earth is depended on the light which comes from the sun. This project explores both the qualitative and quantitative attributes of light to the benefit of humans and plants through the development of a conservatory where people can enjoy the daylight and the plants that depend on it as a source of energy. Observing Prague climate data and explore the city-garden relationship to design integrated daylight design on Prague botanical garden conservatory is the main aim of the thesis project. The project also focuses on the inside-outside relationship to find out the common point on conservatory to answer why we conserve the plants which belong to different climate beside of educational and research purpose.

The curvilinear conservatory structures have been designed with sustainable as a starting point, with every consideration such as different climatic conditions given to passive climate control techniques. A computer-controlled shading system have been integrated into the fabric of the building to efficiently maintain the climate within.
Description of the project

Life on earth is possible due to the energy from the sun. One of the key ingredients of the energy received from the sun comes to us in the form of light. Both flora and the human species are dependent on light. In addition to an energy source, humans need light to see the world around us; we experience delight in the qualities light offers as it illuminates our world.

This project explores both the qualitative and quantitative attributes of light to the benefit of humans and plants through the development of a conservatory where people can enjoy light and the plants that depend on it as a source of energy. The project site is located in Prague 7 Troja on the upper land owned by the Botanical gardens.

Although light is a primary focus of this design assignment the project shall also be developed as a public facility available to the residents of Prague and the Czech Republic. The conservatory shall support casual visits by the public as well as educational role in teaching the public particularly children, about the role of plants in our living environment.
Theoretical research on conservatories and daylighting
Daylight

Daylight is the natural light of the day, the mix of all direct and indirect sunlight. This includes direct sunlight diffuse sky radiation, and both of these reflected by the Earth and objects on earth. Generally reflected sunlight by objects in outdoor isn’t thought about daylight. However, daylight excludes moonlight, despite it being indirect sunlight. Daytime is the period of time each day when daylight actualize. The reason daylight occurs because Earth rotates and either side on which the Sun shines is considered daylight. (Christoph Reinhart, 2014). Daylight has been a key factor influencing whole life on earth since universe had beginning. All living organisms have internal rhythms that control cellular functions and physiological processes. These natural rhythmic cycles act as a type of clock that orders when and how our bodies do almost everything — need food, get thirsty, create energy, stay alert, fall asleep, control mood, sustain body temperature and more. Prior to the invention of artificial light, which placed light a ‘switch’ away humans stayed awake during the period when the sun was up and slept when it set. (Light Rhythms, 2009, in experiencelife.com)
Illuminance

Illuminance is the amount of light that falls on an object around us, measured in footcandles or flux. It is a material property of the surface or object. Illuminance is important in architecture as it is what gives form its perceptible qualities to the human eye and gives sense of space. It allows us to navigate through space, also perform tasks in space. Illuminance plays a large role in our emotional response in architecture. Illuminance was formerly often called brightness, but this leads to confusion with other uses of the word. 'Brightness' should never be used for quantitative description, but only for nonquantitative references to physiological sensations and perceptions of light. (http://www.ledke.com/what-is-illuminance-definition/) There is a scale of illuminance which can also be used to create hierarchy in space, through changeable lighting levels.

Luminance

Luminance is the amount of light reflected from a surface. It is measured in foot-lambert or candela per square meter, and is dependent upon the material color and surface texture. Luminance plays an important role in material selection in architecture, as the color of surfaces can have a large effect on how light is distributed around the space. (academia.edu) Here surfaces become secondary light sources and they can reflect light. It is like how a full moon reflects the sun’s light onto the earth.

Color and Temperature

The color and temperature of light is closely linked to our perceptions of time and space. Cool, blue light is associated with sunrise and morning sun, while warm light is associated with evening sun and sunset. Our circadian rhythms are governed by a daily cycle of light and dark whose nuanced colors evolve with the passing of time. We can estimate the time of day and year based on the color of light, and the position of the sun. Use of artificial light in architecture can be used to alter our perceptions of time, and to create different moods.

Density

Lighting density controls the activity of space. The arrangement of lighting can be used to aid in circulation, direct the eye to a specific place, or create a spatial hierarchy. The placement of light sources can be grouped into three typologies: linear, random, and organized pattern. Linear organization creates a single linear light from one or multiple light sources. Up close, individual lights can be seen on an LED strip, but from far away, the light is seen as one continuous strip of light. In random organization, the placement of lights follows no logical pattern, while in an organized pattern, some form of geometric logic is followed. On a larger scale, lighting density relates to development and economic prosperity. The largest amounts of light pollution can be found in cities, which are highly developed and wealthy.
Qualitative and Quantitative Daylight Aspects

Daylight has been an important design factor since the beginning of architectural practice, though qualitative concerns, such as atmosphere and effect, have largely influential quantitative considerations such as functional and thermal optimization. This inequality has only widened as architectural and engineering disciplines become increasingly specialized, such that architects are entirely responsible for qualitative design aspects while engineers are responsible for quantitative matters. However, depending on the context of the project, daylight quality and quantity may have different weights. Therefore, the purpose of this body of work was to initiate the design of a Floral Conservatory, design which account for and encourage overlap between qualitative and quantitative factors throughout the design process.

Light quantity also depend on light intensity, is the total amount of light supplied to the plant, which is then used for photosynthesis, up to a point the high light quantity the more energy a plant can sequester in photosynthesis. Light quality refers to the wavelengths of light supplied (i.e. color of light), for example red light has wavelengths between about 630-700 nm, farred light is 705-740 nm, blue light is at 400-450 nm, and ultraviolet A is 315-400 nm. Plants can respond to different colors of light by changing their growth form – a high fraction of far-red light (from incandescent lamps or as shaded by other plants) causes plants to stretch excessively. High fraction of blue light (such as from fluorescent or metal halide lights) can cause shorter plants (Neil Mattson, 2014). How to measure light quantity. Humans and plants see light differently. Humans see green light most easily (peak at 550 nm) and it takes a comparatively small amount of light for us to see well. For photosynthesis, plants use light between 400-700 nm, and the more light and more. Because of this, ways of measuring light for humans (example foot candles) are not appropriate for plants.

![Light as perceived by humans and Light as perceived by plants for photosynthesis](http://www.greenhouse.com/mf/240/30508/0_lightlight.pdf)
Conservatory

A conservatory is an architectural space having mainly of transparent material or tarpaulin roofing used as a sunroom for plants in which require regulated climatic conditions are grown. A more scientific description is “a covered structure that protects the plants from extensive external climate conditions and diseases, creates optimal growth microenvironment, and offers a flexible solution for sustainable and efficient year-round cultivation” (Shamhiri Ramina, Kalantari 2018). Mostly conservatories confused with greenhouses. If one wants to look at the definition of a conservatory, probably it will state that it is a greenhouse. Both are transparent rooms in which vegetation can be grown. But just as a violin and a fiddle are the similar instruments, and they have exactly same shape. But when they are played makes all the difference. With the same way, some conservatories are used that distinguishes it from greenhouses designed exclusively for the growing of plants. While some greenhouses suggest design structures that set them apart from the purely useful, they usually are not considered to be living spaces so do not offer the comforts we suppose from the environments in which we live.

A conservatory on the other hand is suitable not only for growing plants, but also have the chance for a countless of activities. It can be extra sitting room, study room, even wedding salon. So generally, in Botanical gardens, conservatory have used for exhibition of plants which are belonged different climatic zone. Conservatories originated in the 16th century when rich landlords wanted to cultivate citrus fruits such as lemons and oranges that available their dinner tables brought by sellers from the Mediterranean regions. Public conservatories became popular in the early 19th century which was the golden age of botanic conservatories, mainly in England. “English conservatories were the product of English love of gardening and new technology in glass and heating technology” (Antrim & Morrice 2008). Many of the glorious public conservatories, built of iron and glass, are the product of this century. Kew Gardens in London is a perfect case of a large greenhouse used for growing rare vegetation.
Site Analysis
Prague

Prague, capital city of the Czech Republic, is divided by the Vltava River. Nicknamed "the City of a Hundred Spires," it is known for its Old Town Square, the heart of its historic core, with colorful baroque buildings. Gothic churches and the medieval Astronomical Clock which gives an animated hourly show. Completedit in 1410, pedestrian Charles Bridge is lined with statues of Catholic saints. Prague is full of historic monuments, lively squares, and winding lanes of cobblestone. In a city with such rich cultural heritage, Prague also features a variety of parks and gardens, some formal, sculpted Baroque gardens, some smaller secret gardens and even some large wild parks.

Area: 490 km²
Population: 1,294,125
Coordinates: 50°05'N 14°25'E

Site
Praha Troja

Area: 53 ha
Population: 19772
Density: 372/ha

On the banks of the Vltava, leafy Troja is a peaceful residential suburb with several high profile attractions. The baroque Troja Castle houses 19th century Czech paintings and hosts wine festivals and concerts in its manicured gardens, while Prague Zoo is home to elephants and Komodo dragons. The Hillside Botanical Gardens offer sweeping views, and a tropical greenhouse and a wine shop at St. Gertrude’s Vineyard.
Accessibility

- **Line A**: Nemocnice Motol-Depo Hostivař
- **Line B**: Zličín-Černý Most
- **Line C**: Letňany-Háje

**Muzeum** is a Prague Metro station providing the interchange between Lines A and C, and serving the National Museum. It is located at the top end of Wenceslas Square.

**Můstek** is another interchange point between Lines A and B. Each line has a separate set of platforms which are connected by a series of corridors.

**Florenc**, providing the interchange between Lines B and C. It serves the city center bus station.

**Bus Stations**

It takes 20 min from the city center to the upper part of the Botanical Garden by using No5. It is possible to take the Můstek from the station Nádraží Holešovice to the stop Zoologická zahrada. From there, you can board bus No46 or No62 from Kobylisy to the Muzeum.

One of the biggest challenges of accessibility to the project area is the current layout. It’s is set on four parallel lines that have 500 km of tracks. They cover a large area of Prague and are used by some 200 million people a year.

**Nádraží Holešovice** is a Prague Metro station on Line C serving the Botanical Garden. Můstek is another station on Line C that serves the city center bus station.

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**Prague-Troja** Integrated Daylighting Design on Czech Floral Conservatory Diploma Thesis Report
Prague Botanical Garden

The botanical garden spreads over the Troja area, its surface area being approx. 80 ha in a very rugged terrain, elevated 199 to 296 metres above sea level. The present-day botanical garden in this area was planned and established in 1968. The garden was then realized according to the visionary project of academic architects Josef Špaček and Jiří Švarc and by Jiří Heger. Building the garden was a long-term project, due to its difficulties. Until 1992 the garden was not generally accessible, and the initial exposition was opened on a surface area of 3 ha. It is arranged as a park with collections of small bulbous plants, perennial, annual flowers, and herbaceous plants, moss plants, saxifrage, and hydrophilic plants, with a greenhouse and hydrophilic plants, and a department of botany with domestic and foreign coniferous species. Today's area, which is open for public in the season from May to August, apart from the initial exposition, can also serve as a Japanese garden with original kinds of Japanese plants. A geographical exposition of plants from Europe and the Mediterranean with a collection of rare species There is a unique flood-scarred hall in the garden. [http://www.botaniska.cz]

St. Claire's Vineyard
Spans 3 hectares. Our vineyard is the second largest in Prague and is classified as a 'national heritage'. It was established in the 11th century in the time of the reign of Henry II. With a vineyard once in four times of Charles IV. In 1991 the vineyard was acquired by St. Claire's church and later opened to the public. It is a vineyard with the same name, and it is open for public. It is a vineyard with a unique historical feature. It is a vineyard with a unique historical feature.

http://www.botaniska.cz

Greenhouse Exhibition

Pivoňková Meadow

North American

Wetland

Mediterranean

Ornamental Gardens

Japanese Gardens

St Claire's Vineyard

North American Meadow

http://www.botaniska.cz
Greenhouse for shade plant conservation

Greenhouse for important collections of cacti and other succulent plants

Cacti and other succulent plant Conservatory

Wetland with moisture loving shrubs and perennials
Small Greenhouses for perennials and shrubs

Aligned raised beds for plants.

Pražská Meadová

Wetland with Carex rostrata and acorus calamus
Average temperatures

The red lines indicate the maximum temperature of an average day for every month for Prague. Dashed red and blue lines show the average of the hottest day and coldest night of each month of the last 10 years.

Precipitation amounts

The precipitation diagram for Prague shows in how many days per month certain precipitation amounts are reached.

Cloudy, sunny, and precipitation days

The graph indicates the monthly number of sunny, partly cloudy, overcast and precipitation days. Days with less than 20% cloud cover are considered sunny; with 20-40% cloud cover as partly cloudy and with more than 80% as overcast.

Wind speed

The diagram for Prague shows the days per month during which the wind reaches a certain speed.
Sun Direction Monthly in Prague

<table>
<thead>
<tr>
<th>Climate Variable</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Max Temperature °C (°F)</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>13</td>
<td>18</td>
<td>25</td>
<td>23</td>
<td>23</td>
<td>19</td>
<td>13</td>
<td>6</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Average Temperature °C (°F)</td>
<td>-2</td>
<td>-1</td>
<td>3</td>
<td>13</td>
<td>16</td>
<td>17</td>
<td>17</td>
<td>13</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Average Min Temperature °C (°F)</td>
<td>-5</td>
<td>-4</td>
<td>-1</td>
<td>2</td>
<td>7</td>
<td>16</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>4</td>
<td>0</td>
<td>-3</td>
<td>3</td>
</tr>
<tr>
<td>Average Precipitation mm (in)</td>
<td>24</td>
<td>23</td>
<td>28</td>
<td>26</td>
<td>77</td>
<td>73</td>
<td>66</td>
<td>70</td>
<td>40</td>
<td>31</td>
<td>32</td>
<td>25</td>
<td>526</td>
</tr>
<tr>
<td>Number of Wet Days (probability of rain on a day %)</td>
<td>13%</td>
<td>12%</td>
<td>12 %</td>
<td>13 %</td>
<td>13 %</td>
<td>13 %</td>
<td>13 %</td>
<td>10 %</td>
<td>13 %</td>
<td>12 %</td>
<td>13%</td>
<td>12%</td>
<td>150%</td>
</tr>
<tr>
<td>Average Sunlight Hours/ Day</td>
<td>1h 46'</td>
<td>3h 02'</td>
<td>4h 56'</td>
<td>6h 18'</td>
<td>7h 48'</td>
<td>8h 49'</td>
<td>8h 32'</td>
<td>7h 54'</td>
<td>6h 22'</td>
<td>3h 46'</td>
<td>1h 46'</td>
<td>1h 21'</td>
<td>5h 12'</td>
</tr>
<tr>
<td>Average Daylight Hours/ Day</td>
<td>8h 35'</td>
<td>10h 09'</td>
<td>11h 49'</td>
<td>13h 42'</td>
<td>15h 25'</td>
<td>16h 19'</td>
<td>15h 34'</td>
<td>14h 26'</td>
<td>13h 12'</td>
<td>10h 30'</td>
<td>8h 59'</td>
<td>8h 03'</td>
<td>12h 00'</td>
</tr>
<tr>
<td>Percentage of Sunny (Cloudy) Daylight Hours</td>
<td>21 (79)</td>
<td>31 (57)</td>
<td>43 (82)</td>
<td>47 (53)</td>
<td>61 (49)</td>
<td>55 (45)</td>
<td>55 (44)</td>
<td>52 (43)</td>
<td>36 (63)</td>
<td>32 (50)</td>
<td>20 (80)</td>
<td>17 (83)</td>
<td>43 (57)</td>
</tr>
<tr>
<td>Sun altitude at solar noon on the 21st day (°C)</td>
<td>20</td>
<td>29.4</td>
<td>40.2</td>
<td>51.8</td>
<td>60.1</td>
<td>63.3</td>
<td>60.3</td>
<td>52</td>
<td>40.5</td>
<td>29.1</td>
<td>19.9</td>
<td>16.5</td>
<td>40.2</td>
</tr>
</tbody>
</table>

Prague located at 50°06'N, 14°15'E, and altitude is 365 m. Prague has a marine west coast climate that is mild with no dry season or warm summers. Heavy precipitation happens during mild winters which are dominated by mid-latitude cyclones. According to the Holdridge life zones system of bioclimatic classification Prague is situated in or near the cool temperate steppe biome.
Case Studies
Fata Montana Conservatory

Fata Morgana Tropical Greenhouse is one of the selected case study of my diploma project. Main reason of selection is location that located outside the outdoor exhibition areas of the Botanical Gardens on the sunny southern slope of the Tyniec Hillside which is almost same location with my project site. Another argument is that division in the greenhouse is designed in three separate parts, with different temperatures and humidity, in which the visitor gradually adapts with tropical and partly semi-tropical climatic zones.

Chateau Lednice Conservatory

Chateau Lednice Conservatory is another case-study conservatory that located in Czech land with its historic glory which can be considered as one of its time periods in architectural history. Chateau Lednice is the first fully functional greenhouse on the planet continent. Its unique design and architecture are about the conservatory is that it was built without diagonal support, and it has sunlight against the wind. The curvilinear glass and iron structure can withstand the wind without being supported by any other structure.

Phipps Conservatory

During the case study about worldwide conservatories, Phipps Conservatory in Pittsburgh, is worthy attention in terms of its design purpose and the facilities, house elaborate gardens within the fourteen rooms conservatory itself and on the adjoining ground. Phipps conservatory and Botanical Gardens of a variety of ornamentals to support the formal and informal education groups provide workshop with services and opportunities that align with state standards, mushroom the curriculum and laboratory and evolve in inspiring young minds. At Phipps, research and discovery are essential tools to evolve the interconnections between people, plants, health, planet, and beauty.

Oman Botanic Garden

From the case-studying perspective, along with facilities of Oman Botanic Garden here, many alternatives such as interpretive styles for exterior and interior exhibition, research facilities include laboratories, library, information and education facilities with classroom seminar rooms and accommodation. Overall, the garden consists of the following key components: nursery, visitor center, research center, study center, outdoor living gardens, northern mountain Bione, southern mountain, Bione, and mountain reservation. Environmental education is at the heart of the garden and one of its key functions.

Gardens by the Bay

Gardens by the Bay is one of the largest contemporary conservatories in terms of its structure and landscape representation. Supertrees are like trees that dominate the garden’s landscape with heights that range between 25 meters and 50 meters. They are vertical gardens that perform an multitude of functions, which include planting, shading and working as environmental engines for the gardens. Gardens by the Bay is a part of a strategy by the Singapore government to transform Singapore from a Garden City to a City in Garden. The stated aim is to raise the quality of life by enhancing greenery and flora in the city.

Castle Prague Orangery

One of the examples of high-tech architecture in the Czech Republic located in one of the most exposed locations. The project is made of the construction of the orangery in the Prague Castle Royal Gardens, the history of which can be traced back to the 17th century. The structure consists of bar silo arches 4.5m in diameter supported by system of diagonal pipes made of stainless steel. The pipes create wide arches attached to each other mechanically by one single screw. Brackets, consisting of flat metal strips support laminated glass panels held in place by clamps. The brackets are connected to the lower part of the joint.
Phipps Conservatory

The gardens were founded in 1937 byuel and real estate magnate Henry Phipps as a gift to the city of Pittsburgh. Its purpose is to educate and entertain the people of Pittsburgh with formal gardens (Boskoff, Ehrlich, 2014) and various species of exotic plants. Currently, the facility houses elaborate gardens within the fourteen-room conservatory itself and on the adjoining grounds. In addition to its primary role as an exhibit, the sophisticated glass and metalwork of the Lord & Burnham conservatories offers an interesting example of Victorian greenhouse architecture.

Phipps is one of the greenest facilities in the world. The entire portion of the Phipps conservatory received LEED certification. Its greenhouse production facility has received Platinum certification, the first and only greenhouse to be so certified. Moreover, the Center for Sustainable Landscapes designed to be environmentally sustainable produces all of its own energy.

Location: Pittsburgh, Pennsylvania
Built: 1993
Architect: Lord & Burnham

Oman Botanic Garden

Oman Botanic Garden is located in Muscat in the Sultanate of Oman. The garden currently under development, is an exciting, dynamic and green breathing project. The garden will reenact the cultivation, study and conservation of Oman’s rich native flora with creative large scale native habitat displays and amenity planting under the overarching theme of plant conservation environmental education and authentic existence.

The garden will bring the plants and habitats, and plant-related traditions of Oman to life through displays, exhibitions, events, and activities to engage a wide range of visitors. Oman’s climate is hot and dry with an annual rainfall of less than 50mm. This therefore means maintaining an adequate supply of water for agricultural and domestic use is Oman’s most pressing environmental problem. Occasional droughts contribute to the shortage in the nation’s water supply and this will impact strongly on the future management of the Oman Botanic Garden.

Location: Muscat, Oman
Built: under construction
Architect: Grimshaw Architects

https://www.phippsconservatory.org
https://www.omanbotanicgarden.com/p/omangarden.html
https://www.phippsconservatory.org/plan/phippsconservatory

https://www.omanbotanicgarden.com/faq
https://en.wikipedia.org/wiki/Muscat
Fata Montana Conservatory

The tropical greenhouse of Fata Morgana, which is under the administration of the Botanical Garden of Brno, is located on the southern slope of the Třeboňský Jezera. The large structure has massive granite piers and is embedded in a wall of granite. 

Access to the garden is relatively difficult for pedestrians; hence the location of the greenhouse on the side. The glass panoramic windows provide unobstructed views of the surrounding landscape, with a view of the sun and the sky. The arrangement of the plants is possible to achieve by using the elevated platform inside the building. The greenhouse is equipped with a system for climate control and the ventilation of the glass roof.

Location: Prague, Czech Republic
Built: 2002
Architect: Zdeněk Day

Château Lednice Conservatory

The conservatory at the Château Lednice is the southernmost example of a garden. It is located in the Czech Republic and was constructed by the Duke of Lednice in 1638. The conservatory was designed by the architect Giovanni Maria Talenti. The conservatory is a large, rectangular structure with a glass roof and is surrounded by a garden. The conservatory is used for displaying exotic plants and is a popular tourist attraction.

Location: Lednice, Czech Republic
Built: 1638
Architect: Giovanni Maria Talenti
Castle Prague Orangery

The orangery of Prague Castle situated in the Belvedere Garden. The orangery is used for growing exotic plants, especially citrus on the south side of the Belvedere garden, on the edge of the moat. There is an old story behind which the first orangery was built in the middle of the 19th century. Under the protection of His Highness, the orangery served until the beginning of the First World War. After that, they were no longer cared for and went into disuse until the late 1940s. But the place for the cultivation of plants was discovered again. A simple glasshouse was built, which house citrus plants and tree species that would be grown in the orangery. The old orangery was then restored and finally converted into the present day. It is a beautiful example of the use of historical functions. The orangery was designed by a local architect. The leading concept was to ensure that the orangery would be a place where people could come and enjoy the beauty of nature. The orangery is also a place where people can relax and unwind.

Location: Prague, Czech Republic
Built: 1906
Architect: Václav Jirků

Gardens by the Bay

Located in Marina Bay, Gardens by the Bay is a key project in delivering the Singapore Government's vision of transforming Singapore into a City in a Garden. At a total of 60 hectares, the Gardens by the Bay project comprises three distinct waterfront gardens - Bay South, Bay East and Bay Central. The commission to design the 34 hectare Bay South garden was won in 2006 by a team led by Grant Associates and including Wilkinson Eyre Architects. Rather than a garden, it is a tropical greenhouse, with a total of 101,000 plants and trees. The gardens are designed to create a link between the city and the sea, and to highlight the beauty of nature in Singapore. The gardens are also a place where people can come and relax, with a wide range of activities available, including guided tours and workshops.

Location: Singapore
Built: 2012
Architect: Wilkinson Eyre Architects
Development of Program Facilities
Providing visitors to a location with information on the areas attraction, lodging, maps and other items relevant to botanical garden detailed information on events. Located near the entrance of visitor center to welcome visitors. Certain information desk can cover approximately 15 m².

Store primarily selling souvenirs relating Prague Botanical Garden, also books on botany, horticulture, botanical art, photography, handmade collections relating Czech culture. Gift Shop carries a variety of botanically themed items. Gift Shop will cover approximately 20-25 m².

Providing exhibition concerned with preservation, education and demonstration of specific items relevant to Czech flora and fauna to attract visitors interests and curiosity. Hall will cover approximately 50-60 m².

To host special activities such as performing art, conducting cultural events, professing lectures and carrying out various presentations and seminars. As it could be used for all occasions. Auditorium will cover approximately 180-200 m².

A set of days to day activities that relate to financial planning, record keeping, billing personal, physical distribution and logistic within the Botanical Garden. Organizing all events and activities relevant education, presentation and maintenance of gardens; having responsibilities of ensuring that administration activities within gardens are efficient, by providing structure toward employees throughout the activities. Contains one director office with its secretary room, three offices for employees, meeting room and small kitchen for daily hydrate and relax.

To provide experienced based education that increasing understanding, appreciation and conservation of plants and natural world, and inspire people of all ages, backgrounds and abilities to think and act in sustainable way. Center of diversity of programs and experiences for visitors to explore the wonders of nature and present variety of topics including plant adaptation, seeds, rainforest ecology, trees, pollution and other nature related topics.

The Education Center enables the Prague Botanical Garden to significantly expand programs for early childhood education and to train a wide audience of early childhood caregivers and educators in the theory and practice of nature play.

The center will include three multi use classrooms with semi open offices. The center will have library with many books on themes of botany, nature study, gardening, conservation, floral and landscape design, botanical illustration and more.

From cultural standpoint, garden cafe largely will serve as a center of social interaction while drinking their beverages. Semi-open garden cafe also will serve to visitors with local pastry and beer with spectacular views across the Prague Botanical Garden. Cafe will cover approximately 60-80 m².
Design Project
The concept of design is creating wall which separate city and botanical park as an inside outside spaces, to define program facilities according to their function and relation with city and garden. Direction of wall have been oriented according to the sun path to enable to get sufficient daylight for conservatories. The wall also formulates the circulation of visitors which has different purposes such as educative, garden visit, or administrative. Structure of conservatory has been designed with sustainability as a start point, with every consideration given to passive climate control techniques.
Separation wall figuratively divide city and park in term of outside-inside relationship. Existing axes emphasize the gate here from inside to outside.

Bending separation wall according to define space on the outside and inside.

Bended separation wall allow me to ramp along the wall for new pedestrian circulation that visitor can enjoy while circulating from inside to outside.

Wall also define the program facility on both sides according to its functionality and relationship of the city and park.

The position of the wall has been adjusted according to the sun path which conservatory and garden cafe allocated south side of the wall to get more daylight.

The conservatory has direct access to the existing garden landscape that tropical rainforest, desert garden and Czech flora garden consist of the conservatory which each of them has connectivity to understand how landscape forms influence ecological function.
Axonometric Plan
Diagrid Detail

The geometry of the single module plays a major role in the external axial force distribution, as well as in concentric force and bending rigidity to the conservatory structure. In normal diagrid structure, concentric load and high diagrid angles support is enough but in this case of eccentric and diagrid angles are small that require beams support all eccentric load.

a. Insulated Glass Unit
b. Steel Window Connector
c. Facade Structure/Steel 100mm Diameter

http://www.desk.com/wordpress/code/grasshopper-code
http://blog.suderveer.blogspot.cz
https://blog.desk.com/wordpress/g نفسه-definitions/diagrid-structure
The Conservatory is a semi-circular diagrid model in wrought steel and glass. One of the main advantages of this system is more space and more daylight. The diagrid is a framework of diagonal intersecting metal tubes that is used in the construction of buildings and roofs. It requires less structural steel than a conventional steel frame.

Welding the steel members together with the connection nodes

Attaching the steel window frames to steel members

Single Connection

Multiple Connection
Shading System

The curvilinear conservatory structures have been designed with sustainability as a starting point, with every consideration given to passive climate control techniques. A computer-controlled shading system has been integrated into the fabric of the building to efficiently maintain the climate within.

Deployable shade concealed in tube

Steel arch

Channel rail for building maintenance unit

Fabricated arm extension

Overall representation of shading system on conservatory
Bibliography


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