THE STUDY OF SCIENCE AND TECHNOLOGY PARK’S FACILITIES IN ARCHITECTURAL DESIGN

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Abstract: The design of science and technology parks (STPs) is a complex task that requires the engagement of a large number of designers and architects. In designing innovation centers, a detailed analysis of the required facilities is required. STPs are aimed at improving innovations in the country, as well as the possibility of promoting private companies and young professional researchers. So far, a number of STPs have been built in the world, among which one can choose as the most representative and most successful examples. In this paper, the necessary facilities for the design of a STP were explored and the necessary conditions for its construction by analyzing the selected examples. Since their construction is on the rise, it is necessary to analyze the already built ones in order to plan further development and improvement.

Key words: Science Technology Park (STP), Innovation Center, science, start-up, high technology.

1. Introduction

Nowadays, science and technology parks (STPs) become increasingly multidisciplinary, setting a meeting place for science and practice, incubators of new ideas, technology and capital, industry and markets, economic development of a region or a country [1]. They are places with the interplay of knowledge, economy, private and state capital, universities, institutes and state institutions, private enterprises, as well as intellectual and production capacities [2]. This creates a suitable environment for the creation, promotion, education, development, application and commercialization of various technologies, programs and projects.

The model, the form of a STP is an innovative, specific pattern based on the connection of knowledge and practice, a projection that is the result of higher employment, new development technologies, a place where researchers from universities and the industry work together. World experience has shown that STPs are one of the most effective forms in helping and promoting the development of small and medium enterprises [3]. STPs are an integral part of the strategies of economic and social development of cities, regions and countries [4]. Their facilities and presumed activity are complex. The general and strategic goal of developing industrial enterprises in the STP is to introduce economically profitable production with the application of the highest ecological standards.

In this paper, the selected examples of successful STPs are descriptively interpreted and analyzed regarding their functional contents. The main purpose of the study is to focus on researching the required STP facilities as a design guideline for architects. The paper aimed at defining the basic STP functional zones where the facilities for similar purposes can be grouped. Accordingly, the responses to the two research questions are expected: (1) What functional zones can be observed in the STP and (2) what planning methods can be used in designing a STP? The research is based on the analysis of three selected STPs while the research questions are answered in the Discussion and Results section, followed by the concluding considerations.

2. Science and technology parks – definition, types, characteristics

A STP is a connection of free ground, building with equipment and science. It is a planned space which is institutionally rounded, infrastructure equipped, suitable for different
levels of activity, ranging from theoretical and scientific to their modeling to the level of practical application and commercialization. They are usually located near universities, faculties, institutes and research centers. In addition to the administrative staff of various enterprises, there are a number of experts from different fields. They are also places where young experts can improve their knowledge and test their ideas in practice. Furthermore, they include a number of service, commercial and manufacturing activities. In this way, a new environment for work such as a large laboratory is promoted, which usually never becomes available to the majority.

STPs are a type of industrial park. They represent the agglomeration of small and medium-sized enterprises in the field of high technology, connected with educational or research institutions, which provides infrastructure and services for activities gathered in the enterprises, primarily real estate and business premises, facilitates the process of transfer of technology, and is aimed at stimulating the economic development of the region where it is located [5].

Technology park, innovation center, research park, business park and industrial park are different names that are often chosen to make a difference in the marketing and promotion of the aforementioned [6]. Although all these terms can be considered synonyms, they can also vary according to certain characteristics. A technology park is more emphasized on research and production than a science park [1]. As synonyms, there are also the following names: incubators of technology companies, technology transfer centers, expert centers, technical information centers, technopolis or technopol [7].

3. Description and analysis of distinguished STPs

There are several thousands of STPs around the world, of which more than 400 scientific parks, with a tendency of further growth. Despite the fact that they all do similar jobs, it is not possible to find two identical ones. The reason is that they are founded and operate in different sets of conditions and assumptions, which implies different characteristics of the methodological approach in design. In this paper, three most successful innovation centers have been selected: Sina Plaza Building which is the part of STP Zhongguancun in Beijing, Innovation, Science and Technology Building in Florida and Science & Technology Park in Doha, Qatar.

3.1. Sina Plaza Building, STP Zhongguancun Beijing

Sina Plaza (Fig. 1) is built within the Zhongguancun Science and Technology Park complex, in the Silicon Valley in the northwestern part of Beijing. This area is well connected with the city center by city transport. Due to the limit of the building density coefficient, the edge construction and the limit on the maximum height of buildings built at this location, the object can not exceed 32 m [8]. These requirements condition the application of a certain design methodology. The edge construction of the building has caused the prismatic form of the façade, where there has been impossible to move the construction further from the street. The architecture of the building required a structure that would make the building more elegant. For this reason, the prismatic form of the object was rolling with certain lateral curves that resembled the waves. In this part of the façade, the object seemed to be squeezed from above, from below and from a front side. These interventions emphasized the main entrances to the building, where the canopy, balconies and double heights in some rooms of the building were formed by curving the

Fig. 1. Sina Plaza Building, STP Zhongguancun Beijing, China, architects: Aedas, 2015 [9]
façade, while natural roof lighting is provided on the upper floors. In this way, the object is embedded in the environment, the monotony of the right lines is lost, and the simplicity of the architectural form was retained, while all conditional factors were fulfilled.

The gross area of ground floors is 76,500 m$^2$, while the gross area of basement floors is 48,000 m$^2$ [8]. Due to the great need for office space and common public facilities, the object has 55,000 m$^2$ of open office space, meeting rooms, conference rooms, exhibition rooms, rooms for employees, including rooms for rest and recreation to ensure healthy and an efficient working environment, including a fitness center, wardrobe with showers, restaurants and shops for various purposes, a library, a clinic, and a baby feeding room [9]. The methodological approach of design has enabled the flexibility and functionality of the building. The need for connecting the facilities has caused the design of wide halls and long corridors that were interconnected, both horizontally and vertically. The basic motive for designing the Sina Plaza object was the symbol of infinity "∞" as can be seen in the basics (Fig. 2). This sign motivated architects to project without borders, and a flexible high-tech building was designed. In the design, a suitable modular approach was used, which enabled conversion and customization as needed. Despite the excessive size of the building, the inner parts of building are illuminated by two atriums.

The northern entrance is located in the middle of the building and served as the main entrance for the visitors. The entrance is marked by a massive curved canopy that was created by curving the façade. By entering the hall through the windshield, there is the central indoor atrium with the main vertical communications (Fig. 3), such as elevators, movable and stationary stairs. Due to evacuation, auxiliary vertical communications and auxiliary facilities are located at each of the corners of the building, also connected to the central part of the building. Directly next to the hallway at the northern entrance there are two conference rooms. At this level, there are also a fitness center, rest rooms, recreation facilities and showrooms. On one of the floors, there is a TV studio, a restaurant for staff with 1300 seats and an auditorium with 200 seats.

The design methodology has applied for this object required to build an energy efficient and sustainable building that would include more passive procedures. The development of design led to green construction in line with the philosophy of the large media house, after which the project has received the LEED Platinium certificate of energy efficiency of the building [8]. Optimization and orientation of the building is crucial for minimizing solar overheating as well as increasing the natural ventilation of the building. Illumination of internal communications and halls over the day can significantly reduce the consumption of electricity that can be spent on artificial lighting of these rooms. The double low-emission glass is used to reduce energy consumption for cooling the rooms during the flight while the outer horizontal panels are used as curtains that had the role of reducing the breakdown of the sun’s air inside the building.
3.2. The Innovation, Science and Technology Building in Florida

The building of Innovation, Science and Technology, which occupy the central part of the campus (Fig. 4), is designed by architect Santiago Calatrava. Located on the north side of the central lake it is designed around, the exterior of the 200,000 square feet building is made up of aluminum, aluminum cladding, concrete and glass [10].

The innovation building functions as the primary object of the campus. This facility contains university classrooms, laboratories, offices, meeting rooms and amphitheater for major events. The methodological approach of designing the rooms is in the form of a tract, using a gallery type of design, where all rooms are organized around a central part, making longitudinal communication in the middle (Fig. 5). Upstairs, the corridor has faculty and administrative offices on the outside, to the inside, some small conference and study rooms, as well as the functional and architectural heart of the building: a multipurpose library and study space with a soaring ceiling that is known as the “Commons” [10]. The offices and meeting rooms are arranged around a large meeting space under the vaulted skylight. Around the entire building site is a terrace that comes across bridges that bend to the lake.

The building's interiors are made of aluminum, aluminum cladding, concrete and glass (Fig. 6), while the building has pergolas made of lightweight aluminum grids that wrap the exterior, and they are also visible in the interior. Pergolas not only add character but also reduce the solar load of the building by 30%. It also has an operational roof, made of two sets of 46 aluminum parts that use the power of hydraulic pistons to move in relation to the sun, which can be equipped with solar panels [11]. Aluminum moving parts, in case of sunscreen protection, can be lowered or lifted (Fig. 4). An operational roof, which is exposed to direct sunlight, helps the skylight of common space to be in shade and to increase daylight in the space. This ability to trigger operative roof makes the facade more dynamic.
Dominant from all sides of the campus, the futuristic building has become a familiar feature in the local community and has already appeared in the advertising campaign of a large carmaker. In designing the main campus plan, Calatrava made the largest part of the unique topography of the central part of Florida. Lake Campus serves as the main object for rainwater retention and as a reservoir of irrigation water. The campus is connected by a series of pedestrian paths and promenades, as well as a route that circles the lake with surrounded forests and greenery.

Calatrava for the first time commissioned to design the foundation stone for the new campus of the University, after which it was established that the existing space was not able to accommodate a larger number of students. Situated on the northernmost corner of the campus, the novelty of innovation, science and technology buildings is positioned to serve as an icon of the central point of the University as a lighthouse for further development throughout the region. It is also expected to help increase the profile of the Florida High Tech Corridor as an incubator and an economic motor for the state.

3.3. Qatar Science and Technology Park

STP Qatar (Fig. 7), built in 2007, is located about 20 km from Doha International Airport. The main vision of the park is to be an internationally recognized center for applied research, innovation and entrepreneurship. It aims at providing a strong and productive platform for technology-driven research, with the rise of enterprises in Qatar and their commercialization. It focuses on four main topics, including energy, the environment, health, information and communication technologies. STP Qatar is on a safe path, with constant improvement, to become the regional node of technological innovation, which will help research its tenants.

Infrastructure connection with various educational institutions is established directly over the highway, thus fulfilling one of the conditions of the site that is planned for the construction of science and technology parks. The urban plan includes the area of 123 Ha, while the buildings of 115000 m² are divided into three parts, among which there are new teaching hospitals and congress center interconnected with warm connections [12]. The incubation center (Fig. 8), which includes administrative and business facilities, is arranged at 12000 m², while the transfer information laboratories (Fig. 9) are located on an area of 20000 m² [13]. The methodology of project design at this location requires accountability for functionality, construction and aesthetics. Site conditions are not demanding, borderline construction is not applied, but the object is set freely in relation to the plot, with the main entrance being set up so that it has a direct connection with the main road connecting this part of the city to the center, without having to take into account the index construction as well as the height of the building.

Fig. 7. Qatar Science and Technology Park, architects: Woods Bagot, 2007 [12]

Fig. 8. The base of typical floor plan and the cross section of incubation center [13]
The design of the architectural form relies on Islamic cultural references, with the wavy form of the main entrance gate representing the free surface of the sand dunes. This element is 34 m high and has a sculptural quality that strongly contravenes flat horizontal lines [12]. The function of a wavy roof covering is also in connecting separate objects and covering the central atrium area. Due to the warm microclimate, the building is covered with modern two-layer facades, while the entire complex is located inside the green areas that characterize freshness and comfort. Structural assembly is a steel spatial lattice that provides stability to the building, whereby the object is fresh and light.

The characteristic of Islamic architecture is the focus on the interior. In this example, the outer and inner look of the object is shown (Fig. 10), whereby the glass portals allow their connection. The main holly space, which is connected to the main entrance, extends through all the floors, which enhances comfort, visibility and pleasant ambience. On the roof of the holly space are placed glass panels that allow natural lighting.

4. Discussion and results

STPs are complex structural compositions that play a role in the improvement of civilization. The improvement of the university is best achieved through the construction of STPs, as it enables easier linking of science, research, achievements with production, that is, publication and commercialization of new discoveries of young scientists. In order to obtain a good solution, prior to designing, it is necessary to start with the analysis of all the natural and artificial impact factors that are related to the location, because its position is conditioned by the entire design process. The methodology of STP design at locations far from universities and faculties would require different conditions, much more office space for professors, in some cases even a larger number of hotel rooms.

By investigating published works, studies and projects, as well as analyzing the descriptive examples, characteristic common content can be observed. Of the total required content for the design of the STP, it is necessary to include four basic types of content, production block, education block, block of public contents and an administrative block. In the case of the need for accommodation of foreign researchers for inclusion in STP projects, it is necessary to foresee the hotel, which means the fifth type of content.

The production unit includes scientific and research units, among which laboratories of various purposes: mechanical, chemical, biological, software development, microelectronics,
work with dangerous substances that must not be exposed to direct sunlight, presentation of the presentations, project bureau, various workshops. In addition to laboratories, accompanying premises are also needed: warehouses, depots, utility rooms, offices and technical facilities.

The educational block contains classrooms for individual and group work, rooms for seminars, reading room, library, media, internet cafe, periodicals, lectures, creative workshops, exercise and painting spaces, music room, space for the possibility of using electronic journals, classroom, bookshop, photocopy house, planetarium with accompanying thematic rooms and a block with offices for the preparation of lecturers.

The block of public content is most attractive, it aims at gathering a large number of people for the organization of various interesting content. Within the STP, art and science-technology museums, exhibition spaces for permanent and temporary settings can be envisaged, accompanying content with exhibition space and museum, maintenance, security, video equipment monitoring, warehouse, sanitary facilities and multipurpose hall, coffee shop, cafe bar, shops of various contents, bank, post office, information center, accompanying premises with information center, logistics support, computer maintenance, office, baby feeding room, service for maintenance and sale of computers.

Within the administrative block, a position should be envisaged for the director, the secretary, the office of the manager of the technology park, the offices for employees in the administration, the meeting room with the potential users of the technology park, the archives of administration, the club for employees, the rest and relaxation rooms and a mini kitchen.

Depending on the capacity of the STP, the necessary accommodation should be provided. The hotel can contain single or multiple rooms, suites, coffee bar, kitchen with accompanying amenities including wardrobes for employees, sanitary facilities, lounge and staffing, office, bar, drinks and food stores, restaurant with accompanying facilities wardrobe and sanitary, exchange office, sale of newspapers, shops of various purposes, swimming pool with accompanying rooms, dressing rooms, wardrobe, showers and sanitary facilities, spa, massage and pool facilities, fitness center. There should also be room for employees who serve guests at the hotel. Therefore, on each floor where guest rooms are located, a floor office, which includes a sanitary knot for maids, a kitchenette with an elevator connected to the kitchen, a bed linen with an elevator that connects all the floors, of which there is a dirty and clean laundry, laundry, drying and ironing. Within the hotel, there is a need for administration, the place for the administrator, the secretary, the economist and the manager.

The complexity of the facilities required for the design of science and technology parks requires the application of the design methodology through several gradual phases. In the beginning, it is necessary to choose the location near to existing universities, student dorms and faculties. Then connect the necessary blocks of facilities to the existing institutions, providing them with access roads. Roughly define entry positions for different block facilities, which means that each block should have at least one entrance. The same facilities can be connected vertically or horizontally. Only after a rough analysis of the facilities, taking into account the necessary areas and dimensions, a detailed project development is followed. It is strictly necessary to take into account the functional connection of the content. Production should be connected with warehouses and economic entrance, as well as with exhibition areas. In order to achieve a better architectural solution, the form and function should be taken into account in parallel, as it is illustrated by the analyzed examples.

5. Conclusion

The methodology of designing facilitates the path from the idea to its realization. It helps architects to direct their good ideas to the goal, while rejecting worse, enabling the synthesis of logical analyzes and creative thoughts. The methodology of designing in architecture and urban planning starts from the analysis of types and models, the elaboration of the concept of organization, the definition of architectural and urban solutions, in order to finally enable the presentation
of this solution. Designing technology parks requires a studious analysis of the required facilities and their good synthesis, or interconnection as a whole.

By analyzing the characteristics of the design methodology that is used in the elaboration of the analyzed examples in the work, it has been shown that the project design methodology greatly influences the development of the project as well as the overall solution. The characteristics of the location itself, urban factors, construction rules regulated by law, climatic conditions, sociological and economic needs, dictate design conditions by which the design method itself is chosen.

The design of STPs in the world is more developed than in Serbia. Technological, scientific, biopark, and all related institutions are integral to the strategies of economic and social development, primarily of the cities in which they are located, and then the region and the state. Scientific parks act as a separation core and significantly contribute to the development of enterprise, city, economy and society as a whole. Development and investments in the construction of STPs in Serbia would significantly improve society, education and science. In order to build quality parks, professional architecture engineers are needed, who have previously studied well the characteristics of the methodology of designing facilities of this type. Long-term practice in the world has shown that science parks are one of the most effective forms for the promotion of small and medium-sized enterprises, a start-up company. There are a number of reasons why the importance of such a complex is reflected: effective use and improvement of the innovation potential of a state, support for young and creative people in the formation of companies, promotion of industrial innovations, introduction of profitable production, application of the highest standards and creation of strong connections between private investors, public authorities and universities. Only some of the positive impacts of these institutions are mentioned. Observed in general, science and technology parks are the needs of all developing cities, and especially developed ones, because only by generating top-level knowledge and transforming them into new technologies, one can achieve the competitive advantage of one region and the nation as a whole. Therefore, the design of these facilities is of great importance for mankind. This study aims to help further research and development of conceptual solutions to science-technology parks.

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ИССЛЕДОВАНИЕ ОБЪЕКТОВ НАУЧНО-ТЕХНИЧЕСКОГО ПАРКА В АРХИТЕКТУРНОМ ПРОЕКТИРОВАНИИ

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Аннотация: Проектирование научно-технологических парков (НТП) – сложная задача, требующая привлечения большого количества дизайнеров и архитекторов. При проектировании инновационных центров требуется детальный анализ необходимых объектов. НТП нацелены на совершенствование инноваций в стране, а также на возможность продвижения частных компаний и молодых профессиональных исследователей. До сих пор в мире было создано множество НТП, среди которых можно выбрать наиболее репрезентативные и успешные примеры. В данной работе на основе анализа отобранных примеров исследованы необходимые объекты для проектирования НТП и необходимые условия для его строительства. Поскольку их строительство находится на подъеме, необходимо проанализировать уже построенные НТП, чтобы спланировать дальнейшее развитие и совершенствование.

Ключевые слова: научно-технический парк (НТП), инновационный центр, наука, стартап, высокие технологии.

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