Special aspects of exterior design of elements of stationary and mobile observation constructions

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Abstract. The article systematizes scientific, informational, regulatory and reference literature on the research topic. Construction schemes of stationary, mobile and transportable Ferris wheels are considered, and their common and distinctive features and peculiarities are outlined. Designs of the world’s highest Ferris wheels are illustrated, the history of their creation, types, design and functional features are described. Special aspects of construction of amusement towers as objects of the short-term panoramic observation of the area are specified. The functional purpose of metal observation constructions used in the entertainment industry is discussed. The development of the tourist industry of cities with active sightseeing attractions is analyzed. Conclusions of the scientific research are drawn and prospects for the development of observation constructions as amusement facilities and landmarks of the urban environment are described.

1. Introduction
The Ferris wheel is one of the undisputedly popular attractions in any amusement park. This amusement invaded all entertainment areas for the first time more than a hundred years ago, and nowadays it is difficult to imagine any large amusement park without it. The Ferris wheel always attracted the attention of visitors and tourists of large cities, where these tourist attractions became iconic. The Ferris wheel is very impressive, because the feeling of flying above the ground is additionally accompanied by the extreme sensations of rising high. In a short period of time, upon a rapid change of the height, visitors can observe panoramas of the area.

Amusement towers also perform the sightseeing function. These towers are entertainment facilities that have a secondary function of a short-term panoramic observation of the area. They are divided into observation towers and free-fall towers, and their height is usually over 40 meters. These towers to some extent act as substitutes for Ferris wheels. They are less metal-intensive and more compact. Most of them are focused on emotions and impressions of visitors from falling from the height in order to experience the adrenaline rush and extreme thrills. Racks of such high-rise spatial constructions fixed on a rigid base or basic platform work as a console.

In addition to the classic Ferris wheel, the similar functions are performed by modern panoramic observation facilities, including outdoor elevators with glass platforms, open platforms, terraces and balconies, amusement and observation complexes, escalators, mechanically movable constructions. These objects are very interesting in terms of design, and their value reaches tens of millions of dollars in view of the technical and engineering complexity of their manufacture with the use of concrete, steel and glass.

Today, metal observation constructions, historical monumental complexes, supports of telecommunication towers, meteorological constructions, supporting constructions for factory exhaust pipes, frames of monuments perform additional functions of observation of the territory. They are additionally included into the entertainment and tourism industry of the city where they are located.

Observation towers and Ferris wheels are one of the main highlights of amusement parks, so that is why their architectural expressiveness and design are important. Along with the safety of objects,
manufacturers of such constructions are paying more and more attention to the aesthetics and creativity of their products.

2. **Analysis of recent publications on the subject**

Over the last ten years, only few publications in scientific journals have been devoted to the analysis of the construction and design of Ferris wheels. Most of the publications are contained in periodicals, which have more informative nature. Articles in popular science journals cover individual objects, the history of their creation and operation. By the example of Singapore Flyer, researcher Erica X. Y. Yap, accentuates that Ferris wheels should be considered as popular urban forms for tourists (Yap, 2012). Researchers M. Lohvyn and I. Lytovchenko touch upon the issue of change of the urbanization level that is closely related to the development of tourism. They note that cities concentrate a large number of historical and cultural objects and educational objects, including Ferris wheels that attract tourists from other countries (Lohvyn & Lytovchenko, 2017). Vira D. Kovtun considers the Ferris wheel as a component of the amusement park environment, identifies the basic concepts and technical characteristics and gives examples of their practical implementation (Kovtun, 2010). S. Bilyk and M. But developed an algorithm for finding of a rational location of supporting struts for cantilever steel Ferris wheel (Bilyk & But, 2018).

Researchers Jason Krolicki, Brandon Sullivan and Michael Willford described the story of the Vegas High Roller, which in 2014 became the highest Ferris wheel in the world. It is a giant Ferris wheel that is well integrated into the surrounding environment and that became a world-level tourist attraction. The researchers carried out a detailed analysis of potential threats for the construction, as well as developed recommendations for ensuring the smooth operation and safety of transportation of passengers. They made calculations for the design of the Ferris wheel in seismic situations, under conditions of the strong wind load and extreme temperatures (Krolicki, Sullivan & Willford, 2013). A group of researchers – Andrew Allsop, Pat Dallard and Brendon McNiven – drew attention to the design of the Ferris wheel in Singapore, which became the highest one in the world in 2007-2014 (Allsop, Dallard & McNiven, 2018). Authors of Vegas High Roller: Giant Observation Wheel Design, Jason Krolicki, Brandon Sullivan and Michael Willford, describe the design, composition and safety of the High Roller in Las Vegas, its power and passenger capacity (Krolicki, Sullivan & Willford, 2013). For this object, they made additional calculations of the comfort of conditions of stay of visitors inside cabins under different wind loads (Almufti, Willford, Ferguson, Allsop and Krolicki, 2013).

The monograph by O.Popova, I.Kondratenko, A.Rashchepkina highlights the main design aspects of modern amusement towers. The authors analyze constructive solutions for their main parts – platforms, columns, and nodes with account for the technological equipment and current engineering developments on this topic (Popov, Kondratenko & Rashchepkin, 2009). Authors of the scientific research Multi-Level Viewing Points in the Urban Structure of a City V. Kuzmych and Yu. Petrovska formed a compositional observation scheme using the example of a Ferris wheel, where a viewer observes a change in the level of height above the ground within a short period of time (Kuzmych & Petrovska, 2020).

3. **Research Methods**

The article systematizes scientific, informational, regulatory and reference materials on the research topic. Construction schemes of stationary and mobile foundationless Ferris wheels are analyzed. Based on the structural analysis, the differences between mobile, transportable and stationary Ferris wheels are highlighted. Designs of the world’s highest Ferris wheels, history of their creation, types, design, functional features and significance for development of the tourist sphere of cities are illustrated. By the method of generalization, conclusions of the scientific research are drawn and prospects for the development of observation facilities as entertainment attractions and urban landmarks are outlined.
4. The Ferris wheel as an object of tourist interest

Urbanization plays a special part in terms of influencing on and stimulating various types of tourism activities. Tourist cities are a new form of urbanization that results from the development of functions related to the provision of tourist and recreational services and are a product of industrialization of the society. Large metropolitan cities with the significant historical and cultural potential, in particular unique points of interest, additionally contribute to the growth of the international tourism (Lohvyn & Lytovchenko, 2017). The Ferris wheel is the most popular attraction in any city, both for residents and for tourists, and entertains them with observation effects. It is a mechanized attraction where visitors move with help of different types of energy. Every city in the world wishes to have an iconic landmark that would distinguish it from others by an interesting design or construction. That is why this attraction is often the most significant and the most popular object in a city. These attractions are often located in the central part of the city or in nearby areas for the purpose of providing a better overview of its historical and architectural part.

These objects are becoming the most visited by weekend tourists. The central part of historic cities is the most interesting and attractive from the point of view of people flows, therefore the location of observation facilities in the historical part improves the attendance of cities. If the central part of a city is included in the list of UNESCO World Heritage Sites, then, in accordance with UNESCO requirements, it is prohibited to build any stationary objects or buildings over 20-30 meters high in the historical parts of such cities.

5. Ferris wheels as urban landmarks

The world’s largest Ferris wheels include the Ain Dubai (United Arab Emirates, 250 meters), High Roller (Las Vegas, Nevada, 167.6 meters), Singapore Flyer (165 meters), Star of Nanchang (Nanchang, Jiangxi, 160 meters) and London Eye (London, 135 meters). All these objects are unique, have their own history, design, construction, and each of them exceeded the height of its predecessor. The last of them, Ain Dubai, reached 250 meters in height in five years of construction. Its opening is scheduled for 2021 and it will be the largest Ferris wheel in the world. In 2017, the Bailang River Bridge Ferris Wheel in China became the largest centerless Ferris wheel in the world that does not rotate axially, but reaches a height of 145 meters exceeding the world-famous London Eye by 10 meters (Figure 1) (Trejos, 2014) (Nair, 2019) (Martin, 2017).

![Figure 1](image_url)  
**Figure 1.** Ratio of the height of the largest Ferris wheels in the world (Author's scheme).

The London Eye, one of the symbols of London, is located on the banks of the River Thames and was built in 1999. It is a giant cantilever Ferris wheel resting on two supports that are attached to the foundation on the bank of the river and inclined at the angle of 65 degrees from the horizontal line. The whole structure is held by support cables attached to the foundation on the opposite side of the river. The Ferris wheel is 120 meters in diameter and is connected with its centre by 64 cables that
work like a bicycle wheel. The wheel is equipped with 32 cabins for passengers. One rotation cycle takes about 30 minutes. In 2006, the decorative digital LED lighting system was installed to make the wheel more attractive in the urban environment (Lewis, 2018).

In 2006, a new Ferris wheel – Star of Nanchang – was opened in the Chinese city of Nanchang, the capital of Jiangxi Province, which surpassed its predecessor, the London Eye, by 160 meters (Ming, Zhou & Song, 2018). This giant Ferris wheel was considered to be the largest one in the world until 2008, but the Singapore Flyer at Downtown Core, Singapore set a new world record of 165 meters. The Singapore Flyer has 28 cabins with dimensions of 4 by 7 meters, mounted on a rotating wheel structure, providing passengers with a continuous view of the panorama. They are equipped with the air conditioning system and protection from direct sunlight. Initially, the wheel rotated counterclockwise, but later on its movement direction was changed. The Singapore Flyer includes the station building located at the base of the wheel, which serves as a place of passenger boarding, as well as provides retail services – in particular, the station has shops, restaurants and a wellness center inside (Allsop, Dallard & McNiven, 2018).

6. Structural elements of stationary Ferris wheels

The Ferris wheel belongs to entertainment attractions that create a festive mood for all visitors. Its design provides for the spatial movement in a circle in one plane (gradual ascent, staying at the calculated height for a certain time and gradual descent in an arc). Every time, authors of such constructions aim to improve the wheel by increasing its functionality, safety, entertainment ability and comfort. The structural elements of the wheel and its supports are improved; they are getting equipped with stations and boarding platforms, and observation cabins are getting additionally equipped with devices for air conditioning, rest and relaxation. In their calculations, engineers take into account the components of wind and snow load, seismicity of the location, icing load, various types of mechanical loads and numerous additional factors ensuring the safe operation of the construction (Arkhipov & Arkhipova, 2008).

The bearing frame of the Ferris wheel contains a base in the form of a rigid metal structure with at least one mounted support and a rotating part of the wheel, which in its turn consists of an outer ring, spoke ropes, suspensions, drums, motor drive, support part and frame. Spoke ropes are flexible ropes that provide for the spatial rigidity of the outer ring and are equipped with fastening units. Suspensions that fix cabins for passengers are installed under the bridge. They are attached to the outer ring and have a counterweight system in each cabin. In the automatic mode, they maintain the horizontality of the cabin within the limits of the permissible deviation (not more than 3-5 degrees). The cabin is made in the form of a spatial rod-like frame of tubes in the shape of ellipsoids. Its exterior part is glazed with toughened glass and equipped with at least two doors, comfort appliances (air conditioning, food heaters, additional lighting, etc.) (Arkhipov & Arkhipova, 2008).

The mobile attraction is equipped with devices for transportation and multiple-time quick assembly (disassembly). The attraction is transportable and installed on a specially prepared site or foundation, the construction of which allows disassembly, transportation and assembly at other place of operation. The stationary attraction is designed for one-time installation at the site of operation (Law of Ukraine, 2006).

Attractions of the rotating-and-observation type must endure maximum loads (weights of own structures, moving parts, attraction with visitors, wind and snow, as well as dynamic, vibrating, shock, emergency, temperature, seismic and other loads that occur in the process of installation and operation. Attractions must retain the specified properties in case of a repeated assembly, disassembly and transportation. Constructions of rotating attractions must be suitable for static loads for out-of-operation conditions and in the process of operation with full and partial loading. The calculations for one-sided loading are made for cases when seats are occupied by 1/4 or 3/4 of the perimeter of the attraction. Rotating attractions must be stable under conditions of one-sided loading of seats by 1/6 of the perimeter of the attraction. Driven or non-driven rotating devices must be adjusted so that they cannot exceed the maximum permissible speed (Law of Ukraine, 2006).
7. Structural elements of mobile Ferris wheels
The Ferris wheel can be transportable, mobile or stationary, have a height from 5 meters to 200 meters, have different types of cabins and seats, various configurations and complexity levels of the model, various sizes and equipment. The transportable attraction up to 55 meters high does not require any foundation. A mobile amusement park is one or more mobile or transportable attractions that are located at the place of installation for no more than a half of the season of operation in the present area (Law of Ukraine, 2006).

It is an interesting fact that the largest mobile Ferris wheel in Europe, Mirador Princess, reaches a height of 70 meters and weighs 600 tons. 42 cabins for transportation of passengers are mounted on it. This Ferris wheel was installed in 2015 in the port of Malaga in Spain. First of all, the foundation was mounted, the supporting structures were assembled and later on the wheel was fixed. Simultaneously raising all the supports to the calculated height, the engineers fixed the wheel at the target level and mounted cabins for passengers. To strengthen the foundation, bored piles were installed under the foundation of the construction. The wheel operated in 2015-2019, and was dismantled in view of termination of the lease agreement (Chaplow, 2019).

There are two approaches to the installation of support platforms of amusement towers with a shaft serving as a guide surface for sliding equipment. The amusement tower (free-fall tower) carries out an advancing movement of boarding places by vertical guides. Most of manufacturers use platforms in the form of a rigid flat truss that lies freely on thoroughly leveled ground or rests on it via supports with the possibility to adjust the height. The platforms of modern amusement towers are made according to the following design scheme: the shaft is arranged on a powerful frame structure connected to the platform of six or eight beams joined in the center by a rigid core to increase the resistance to overturning (Popov, Kondratenko & Rashchepkin, 2009).

Amusement towers with no foundation still remain interesting and profitable elements of the entertainment industry. These structures must be as light, rigid and reliable as possible. At the same time, manufacturers of such attractions must reduce the cost, the main component of which is the material consumption (Archipov, 2008). The construction of such buildings consists of a shaft and a support platform. The elevator car with passengers moves along the shaft of the attraction tower, so in contrast to the classic telecommunication towers these constructions must have a high accuracy of guiding elements, which role is often performed by the main supporting racks (Popov, Kondratenko & Rashchepkin, 2009). In the process of mounting, the attraction must be leveled, have a stable position, generate uniform pressure on the ground and be firmly fixed. The site’s ground must reliably withstand the calculated load of the attraction specified in the installation instruction (Law of Ukraine, 2006).

In January 2021, the world’s largest amusement tower with a height of 140 meters was opened in Bollywood Amusement Park in Dubai. SkyFlyer is a giant swing that set a new world record. 421 ton of steel were used to manufacture the Skyflyer’s structure. The console has a mounted rotating structure, which consists of 12 beams with 12 sets of double seats that rotate around the tower, rise and spin at a height to the accompaniment of light and music (Cairns, 2021).

8. Transformation of the shape of Ferris wheels
The classic Ferris wheel has always been the object of imitation in terms of its form, function, orientation, and content. Half a century ago, designers and engineers began to work actively in order to change, add and transform the shape of this sightseeing object, thus creating new forms of amusement facilities, which were also in demand in the tourism industry.

Two Ferris wheels, made to order by Waagner-Biro’s, were installed in 1976 in amusement parks in America. The Giant Wheel is a double Ferris wheel that operated in 1973-2004 in the family theme park Hershey Park located in Hershey, Pennsylvania. Its total structure weighed over 135 tons and was fixed in a concrete slab. The structure included a shaft where a transverse beam was attached with rotating wheels at both ends that had twelve spokes. The cantilever-type bracket was supported in the middle by a high vertical support. Round cabins, which could accommodate eight passengers, were
attached to each of 12 spokes. The wheels rotated clockwise (Michelson, 2016). A triple version of the Ferris wheels under the name Sky Whirl was developed in 1976. Each wheel rotated around one of three ends of the support brackets. The plane of rotation was not horizontal, so in the process of rotation of the support frame each wheel ascended and descended. When descending, one wheel occupied a horizontal position at the ground level, while other wheels remained raised and continued to rotate in an almost vertical plane at a considerable height. The attraction operated until 2000, and then it was closed and dismantled (Michelson, 2018).

One of the most unusual Ferris wheels in the world is located in Japan. This wheel is one of the main attractions of Tokyo Dome City entertainment complex. The Big O is a huge “empty” wheel, without a core and spokes that is mounted only on the side supports. Extreme and more impressive sensations of visitors are additionally provided by the roller coaster passing through the center of the Ferris wheel with its cabins racing along at a speed of 150 kilometers per hour (Big O, 2016).

Modern constructions also try to imitate the shapes and functions of classic Ferris wheels. SkyView Globen is an interesting project that aims to simulate an object of observation. The equipment is mounted on a large spherical structure of the dome of the complex for holding concerts and sports competitions. Outside the dome, completely transparent glass balls move on special rails and lift passengers to a height of 130 meters, allowing to explore the surrounding urban landscapes of Stockholm (Andersson Sören, 2020). Another Ferris wheel is mounted on a skyscraper in the Georgian city of Batumi. At the top of the building, the construction is built into the facade at the level of the 30th floor (100 meters above the ground level), and has eight capsules for observation of the area (Skrypnyk, 2018). The world’s highest horizontal Ferris wheel is located on the Canton Tower in Guangzhou, China. Since the tower affords beautiful views of the big modern city, the authors took advantage of this potential and installed an observation deck at its height. Transparent Bubble Tram cabins go at an angle in a circle along the edge of the roof at the height of 400 meters above the ground. This unusual attraction consists of 16 round passenger cabins with large panoramic windows (Bubble Tram, 2020).

9. Conclusions
The Ferris wheel is an indisputable example of the classic sightseeing attraction being an attribute of any amusement park or an element of the urban environment. It is a large, vertically mounted round rotating metal structure with passenger cabins attached to its edge. The classic Ferris wheel is already over 100 years old, but today its design remains an example of stability, imitation and transformation of form. Many followers imitate its main function – a panoramic view of the surrounding area. Designers and engineers searched for new engineering forms of expression of this object, and created new attractive forms as a result of development and transformation of the form, which are interesting for and popular among tourists. The main function of the Ferris wheel is getting a bird’s-eye view of the city, historical and cultural monuments, and unique landscapes. If it is not possible to mount such object in the city center, it immediately gives an impetus to new ideas and design of new forms. New amusement and observation facilities are installed on facades of high-rise buildings, including outdoor elevators with glass platforms, open platforms, terraces, escalators, mechanically moving objects made of glass, concrete and metal. Old TV towers, historical monumental complexes, and engineering structures also began to perform the observation function, getting additional opportunities for operation and reconstruction. Additional panoramic windows and balconies are arranged at the highest points of high-rise buildings, thus inducing tourists to visit these buildings.

For over a hundred years, the world’s major cities have been competing for the largest and most original Ferris wheel, installing them in the most interesting places, making them higher than before, giving them different shapes and designs, changing the shape of passenger cabins and providing with different functions for comfortable panoramic view. Its form and functions are still popular today, and the Ferris wheel continues to remain an object of great significance in the urban environment.
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