Chapter 7
Green Architecture

7.1 Lusail Stadium in Qatar

Promoting innovation and technological progress is an important way to address economic and environmental challenges. In accordance with the requirements of Qatar Global Sustainability Assessment System (GSAS), the Lusail Stadium project in Qatar was built with various green designs, green technologies, and energy-saving materials to highlight innovation while preventing environmental pollution and risks; the design improves the efficiency of utilizing resource and energy. At present, the design phase of the project has satisfied the standards of the GSAS five-star rating, and the construction management phase is also being implemented in an orderly manner with the standards of the GSAS five-star rating as the goals.

7.1.1 Background

The 22nd FIFA World Cup will be held in Qatar in 2022. This will be the first World Cup to be held in a Middle Eastern country and the second World Cup held in Asia. The 2022 World Cup will also be the first time that the winter World Cup in the northern hemisphere, and Qatar will be the first World Cup hosted country that has never competed at the World Cup finals. This event is thus of great significance for and has profound influence on Qatar and the Middle East. Qatar has invested heavily to build a new city, "Lusail," a "green city" about 15 km to the north of the capital city Doha. Bordering the Persian Gulf in the east, Lusail City covers an area of 38km^2 and contains a series of sports stadiums and supporting facilities.

In order to host the World Cup of a high quality and achieve the national goal of becoming an example for quality life and sustainable lifestyle by 2030, Qatar required that all stadium construction projects in Lusail should meet the four-star rating standards of GSAS, Qatar's green construction rating system, in both the design

BRI International Green Development Coalition, *The Belt and Road Initiative Green Development Case Studies Report 2020*,
https://doi.org/10.1007/978-981-16-3188-7_7

and construction phases. The GSAS system adopts a lifecycle approach to evaluate the sustainability performance of buildings and their environment, aiming to meet the project needs while minimizing the ecological impact and resource consumption of construction projects. In 2016, International Federation of Association Football (FIFA) officially adopted the GSAS system as the green building evaluation system for the 2022 World Cup stadiums in Qatar.

Located in the heart of Lusail, Lusail Stadium will be the main stadium for the 2022 World Cup in Qatar. It will host the final, the closing ceremony, and other major events and ceremonies and will be preserved as a landmark sports building and a World Cup heritage in Qatar. Therefore, the design, construction, operation, and overall management of the Lusail Stadium not only had to overcome various technical challenges to complete the design and construction of the stadium of high quality, but also had to meet the strict requirements of the GSAS standards.

7.1.2 Project Overview

In November 2016, China Railway Construction Corporation (CRCC) and Qatar contractor HBK Contracting (HBK) won the bid as a joint venture and were awarded the main contract to build the Lusail Stadium project in Qatar. The total contract value of the project is QAR 2.8 billion (approximately USD 767 million).

With a gross floor area of 180,000 m^2, the Lusail Stadium is bowl-shaped, with a diameter of 312 m, a height of 74 m on the east and west sides and 58 m on the north and south sides, and a capacity of 92,000 seats, making it the second largest professional football stadium in the world that meets the standards of FIFA. The Lusail Stadium is also the largest membrane-structure building in the world, with the roof incorporating 56,000 m^2 membrane, and it is one of the World Cup stadiums that has a roof with the fish-belly-shaped cable net being one of the world's largest by span and overhanging distance (Fig. 7.1).

The construction of the project commenced in November 2016. As of October 2020, the main steel structure has been completed and the whole project has been running smoothly. According to the assessment by the relevant authorities in Qatar, the design phase of the project has reached the GSAS five-star rating standards, and the construction management phase is also progressing towards the standards (Fig. 7.2).

7.1.3 Establishment of a Strict Environmental Management System to Implement the Project

Qatar has high standards in environmental protection. In the construction and management of the project, it refers to and implements the relevant environmental

Fig. 7.1 The Lusail stadium

Fig. 7.2 The construction of the cable net roof

management systems and standards of the western developed countries in consideration of the local circumstances, creating an environmental management style that incorporates characteristics of the Middle East and other sources. In the Lusail Stadium project, the main contractor is required to establish and implement the Environmental Management System (Q22M-APW-CMN-PMC-HSE-0362) specified by the owner of the World Cup project, and to strictly comply with the *Qatar Environment Protection Law*, *Qatar Air Quality Standards*, *Qatar Irrigation Water Standards and Sea Drainage Standards*, and *Qatar Construction Specifications 2014*. Furthermore, the design and construction are carried out in accordance with the GSAS

four-star rating standards, Dutch soil and groundwater quality standards, and relevant British standards.

(1) **Commissioning a Third-Party Environmental Consulting Organization to Establish an Environmental Management System and Strictly Implementing It**

The joint venture commissioned KEO, a local third-party environmental consulting firm, to provide comprehensive technical support and services for the environmental management of the project. With KEO's support, a Construction Environmental Management Plan (CEMP) (SC-C01-CAG-HBC-PLN-EN-00014) was developed as the basic environmental policy for the project, covering environmental control policies, environmental control index, environmental management plans, environmental inspections and audits, etc. The CEMP was used as the basis for the establishment of the project's specific environmental management system, which was then strictly applied to the control and management of project site. The CEMP was firstly approved by the project engineers and the owner before being submitted to the Ministry of Municipality and Environment (MME) for approval.

(2) **Environmental Pollution Prevention Measures and Environmental Monitoring Management**

In accordance with the CEMP, the Lusail Stadium project focused on strict monitoring of environmental indicators such as noise, air quality (especially dust), soil, groundwater quality, and waste disposal. During the construction, the main pollution risks on site included potential soil and groundwater contamination, and the main focus of risk control was fuel or chemical spills.

To this end, the project has set up a special oil storage warehouse, which was managed in strict accordance with the warehouse management regulations and chemical management guide and was inspected regularly; oil trays were set up for the generator and other areas of the construction site to prevent soil contamination caused by oil; when the construction involves painting, a special shed would be set up for proper protection and the ground would be covered with protective films to prevent soil pollution caused by chemicals; routine environmental inspections were conducted to deal with any violations in a timely manner and provide training and environmental protection education to the relevant construction teams. At the same time, the project established contact with local environmental protection laboratories through a professional third-party environmental protection agency; the laboratory provided technical support and services, such as testing and analysis of soil samples and water samples.

In addition to the risk management measures above, the project office also adopted the following environmental monitoring measures.

- Carrying out standardized environmental protection control: Since the start of the project, a total of 38 monthly environmental protection reports have been developed to keep detailed records of environmental protection control during the project construction.

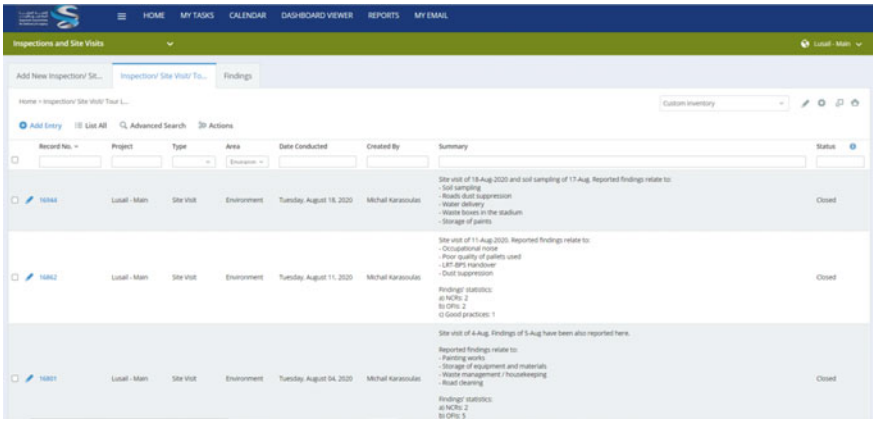

Fig. 7.3 Using information technology in environmental inspection and disposal

- Building a professional environmental management team: Relying on the technical support provided by a professional third-party organization, the project office has set up a special environmental protection department responsible for the daily work of the project, and has equipped with mechanical equipment such as sprinklers, sweepers, crates, and forklifts that can be used at any time.
- Developing the environmental protection control system: A daily inspection system has been established to provide timely guidance and solution for problems; the weekly on-site inspections and regular meetings with owners have been organized to engage all parties to settle any environmental issue; the environmental audit plans have been strictly implemented.
- Strengthening the environmental protection education: Emphasis has been placed on environmental protection training and education, and special educational activities have been conducted to address typical on-site problems.
- Using information technologies in environmental inspections: Relying on the project's Intelex's EHS Management Software, information technologies are utilized in the whole process of environmental protection inspection, disposal, approval, and settlement.
- Ensuring the standardization of environmental information: The environmental protection department of the project has drawn and analyzed the environmental control information on a monthly basis to form a detailed monthly report, so the environmental control efforts could be traced (Figs. 7.3, 7.4, 7.5 and 7.6).

7.1.4 Implementation of the Green Building

GSAS is a green building rating system originated from Qatar and designated by FIFA as the rating system for the 2022 World Cup stadiums. It is also widely used in Qatar and the Middle East. The GSAS system assesses the sustainability of a construction

Daily Environmental Site Inspection Checklist

Shift time 6 AM to 5 PM ☐ 5 PM to 4 AM ☐ Date

S. No	Item (please mark yes or no in respective area column)	Stadium	Laydown	Worker Accom.	Crusher, Screener & Stockpiles	Site Env. Inspector Remarks	Inspector Response
1	Is there any visible dust cloud?					If yes, what are the actions taken?	
1.1	Is there any black smoke from the operating machinery/ vehicles?					If yes, what are the actions taken?	
2.1	Are the waste signages placed at each skip?					If no, what are the actions taken?	
2.1	Is there effective waste segregation inside the skips?					If no, what are the actions taken?	
2.2	Are skips covered?					If no, what are the actions taken?	
2.3	Is there any overflowing skip?					If yes, what are the actions taken?	
3	Is there any oil spill in this area? (trace/drop					If yes, what are the actions taken?	
3.1	Are the spill kits readily available nearer to working zone ?					If no, what are the actions taken?	
3.2	Are the spill kits clean i.e. no traces or accumulation of waste?					If no, what are the actions taken?	
4	Is there any leakages from the tanks (holding, fuel, water etc.) ?					If yes, what are the actions taken?	
5	Is there any abnormal/ excessive noise/ vibration noticed from any operating machinery/ vehicles					If yes, what are the actions taken?	
6	Are the A/Cs, Exhausts in chemical store are working?					If no, what are the actions taken?	
7	Are there unattended chemicals without drip trays?					If yes, what are the actions taken?	
8	Is the site fence secured					If no, what are the actions taken	

Site Environmental Inspector Notes	
Best practices noticed	
Discussed with (in the event of any non-conformances)	

Environmental Inspector	Environmental Engineer

Fig. 7.4 Daily on-site inspections

Fig. 7.5 Noise testing around the stadium

Fig. 7.6 Dust testing around the stadium

project during the three phases of its lifecycle: design, construction management, and operation. The GSAS assessment framework sets eight evaluation indicators including urban connectivity, site, energy, water, materials, indoor/outdoor environment, cultural and economic values, and management and operations, focusing on challenges such as air pollution, land abuse and pollution, loss of fossil fuel, water consumption and pollution, material loss, human health and comfort, and climate change in the building environment. The GSAS certification has different levels for different phases of the project. There are 6 stars for the design phase (GSAS-DB), 5 stars for the construction phase (GSAS-CM) and 5 stars for the operation phase (GSAS-OP).

Qatar requires the Lusail Stadium project to meet four-star rating standards in terms of design, construction, and delivery. On the basis of close cooperation between all parties, the project fully tapped on the main advantages of technologies, equipment, and businesses from China. The design and construction of the project were audited, directed, and approved using the BIM model. In the construction process, SPTM was used for steel structure transport, hollow plunger jacks for steel structure V-column and junk ring hoisting, and 3D laser scanning for precision control. The radial cables of the roof are made of high-vanadium spiral cables, the circumferential cables are made of high-vanadium enclosed cables, and the clamps of the circumferential cables are made of G10MnMoV6-3 cast steel. The exterior curtain wall is made of hyperboloid hollowed-out aluminum slab curtain wall. The green design of the project highlighted the combination of building functionality and energy-saving and took into account the cultural characteristics of Qatar. The efficient and precise construction enhanced the efficiency of energy and materials usage. The materials used in the building were in compliance with green standards, which can effectively save energy and reduce emissions. The environmental protection measures and risk prevention measures during the construction greatly reduced the environmental impacts and risks of the project.

At present, the total score of the design phase of the Lusail Stadium project is 2.133 (out of 3), which has reached the GSAS-DB five-star rating standards. The project is being executed in strict accordance with the highest standards during the construction phase and strives to maintain the four-star rating and increase to a five-star rating, which will make the Lusail Stadium project an example of GSAS five-star architecture.