Questions to be responded to by the firm submitting the application

Why do you think this project should receive an award? How does it demonstrate:

- innovation, quality, and professional excellence
- transparency and integrity in the management and project implementation
- sustainability and respect for the environment

It is accepted that submarine tunnel is within engineering area of great difficult construction and high risk. As the longest and the first submarine tunnel project in China, Qingdao Jiaozhou Bay tunnel project is a milestone in the development of China’s tunnel, also it has an important influence on world tunnel area. This project took feasibility study in 1993, started to construct in 2007, and opened to traffic in June, 2011 that took 18 years. During the project argumentation and construction, many technical problems had been solved, such as the prevention of water gushing and control of water seepage, engineering risk management, anti-disaster operation and rescue etc. It has gained five national invention patents, 8 utility model patents and 12 national and provincial awards.

1. The long submarine tunnel is involved in many difficulties and complex challenges.

1) Jiaozhou Bay tunnel goes through the sea area which has a very complex hydrogeology condition, more than 22 kinds of the rocks and ever-changing rock mass structure. Tunnels that are partly under the sea pass through 4 groups 14 fault zones, most of which are Mesozoic and Cenozoic brittle fracture and they have high water permeability. During the construction, the accidents such as collapse and water gushing are easy to happen. Hard construction and high risk may seriously threaten tunnel structure, the safety of constructors and facilities. How to find, ascertain and rush through the adverse geological sites often dominates the success of this project.

2) Submarine tunnel adopts the V-type longitudinal gradient. Underground water will be unlimitedly supplied by seawater. During construction and project operation, it needs machine to drain away water. The key point is how to proactively control tunnel displacement, keep tunnel drainage system free from obstacles and reduce drainage cost.

3) How to build the safety guarantee system of constructing shallow tunnel with large cross-section.
4) The extra-long tunnel has a complicated ventilation and safety system, also it has a high technical requirement. It's important that how to reasonably locate the facilities to achieve the safety of economy management.

2. **Overcome technical difficulties and make technological innovations reach both domestic and international leading level.**

1) The key technologies of rapid construction through the bad geological section.

The advanced detecting and accurate positioning technologies have been developed. Digital detecting water by pilot hole has been developed, by which water-bearing structure and stratum can be identified for further determination of the accurate location, physico-mechanical properties, water abundance and its connectivity with seawater in the bad geologic sections. Jiaozhou Bay tunnel has accurately detected the fault line and 28 water exits where the water yield of the biggest single well is 496L/min, which reduced the risk of water gushing. No collapse and water gushing appear during the construction.

The technology of non-stopping wall grouting of fractured rock mass has been developed and it's available to drill grouting one-time. The process is infuse superfine cement paste to unite the rock mass and form the sealing batholite then continue to infuse superfine single grout to form waterproof curtain. Pre-grouting took the informational grouting machine setting system to carry out the grout parallel operation, which improved the efficiency of grouting and the speed of constructing and made it possible to rapidly grout the fractured zone to cut off water under the complicated condition.

2) Theories and methods of active control of tunnel waterproof and drainage system

Based on geological conditions, the hierarchy methods of tunnel flowing yield have been established, which referred the active control of drainage design. Besides, the dynamic relationship between reinforcement criterion of stratum and displacement was established. It can adapt to the requirements of the displacement control to adjust reinforcement criterion of adjacent rock stratum and initial supporting parameters. The reasonable thickness of reinforcing is thus determined in fracture zone of Jiaozhou Bay tunnel ring (main tunnel is 5m, and service tunnel is 3m). The effect of water plugging has been improved and the displacement has been controlled within 0.2m/d•m. The water pressure of second lining is
approximately zero. In addition, the maintainable waterproof and drainage system has been developed, which improved the reliability of drainage system.

3) The safety guarantee system of constructing shallow submarine tunnel with large cross-section

It’s necessary to make high precision prospecting and analyze the engineering influence. The characteristics and distribution of the bad geological sections can be recognized effectively through the comprehensive application of the magnetic observations, multichannel seismic exploration, multi-beam water depth detection and side scan technology, which broke through the technology of detection in complicated sea area. Based on the total classification of rock mass quality and the research of the parameter, the risk analysis methods of the rock mass quality’s variation was put forward, which made the tunnel design become more scientific and practical. To reduce the risk of collapse and water gushing will be the major principle of confirming the coating thickness of the minimum rock. The fault zones are the main sites where collapse and water gushing often happen and the fault zones are used to analyze and confirm the minimum thickness of the main bisect with engineering analogy method, elastic-plastic numerical simulation analysis and simulation test. It reduced the risk of tunnel instability and the sea water crush by using the largest water depth of 42m and minimum coating 25m as the burial depth.

The life cycle security technology and strategy design is adopted to optimize structure section and the blasting technique to strictly control the damage of surrounding rock. The development of antiseptic anchor stock, C35 high-performance wet shotcrete and C50 second lining form concrete and adoption of good grouting material improved the ability of anti-seawater corrosion.

According to the systematic risk assessment, the establishment of risk control measure and the research of remote intelligent management platform of construction security risk set the risk control forward, which laid the foundation for the emergency rescue, ensured the safety during the construction and created the management model of large-complex engineering.

4) The intelligent safe operation system of long tunnel and measures of anti-disaster and
Through establishing the tunnel ventilation physical model with high range of 1:10, it needs to simulate the ventilation effect of tunnel and check the rationality of the theoretical arithmetic and design. The operational concept of the air-flow organization and air-blower units also has been put forward. According to the operation characteristics of the tunnel, the strategy plans of normal traffic, heavy traffic, traffic accident and fire hazard, automatic control program should be made to ensure the safe and economic operation of the tunnel.

3. **Ideas of transparency, integrity and fairness are implemented**

Early demonstration data should be passed through the websites to the public and solicit opinions from all sides. The program decision hearing of Qingdao-Huangdao bridge and tunnel schemes was held and the public opinions were debriefed.

FIDIC contract management, risk management and sustainable development concept have all been adopted in the overall process of Qingdao Jiaozhou Bay Tunnel project. Specifically, an integrity management mechanism has been established by introducing FIDIC Integrity Management System and integrating FIDIC ideas such as social responsibility, quality service, objectivity and fairness, integrity, combating corruption, and ethical competitive edge. Also by applying FIDIC project management method, six management systems (excellent performance management, quality management, environment management, occupational health and safety management, integrity management, and social responsibility management) have been blended so that the actual consulting work of the project has reflected the power of integrity, excellence, teamwork, and commitment. After completion, the project passed national and local level audits, and no breach of consulting engineers’ codes of conduct has been reported.

4. **Respect the environment and serve for the urban sustainable development**

1) The C35 high-performance wet shotcreting, C50 second lining form concrete, and double-mixture of silicon powder and fly ash are processed into coarse aggregate, which decreased the industrial residue, saved about 95000 tons cement and reduced 38200 tons CO2. Furthermore, it ensured the structure durability.

2) The whole tunnels displace about 4000m$^3$/d per day and the main tunnel displace
design standard and actual displacement of the same kind tunnel and will save the cost by more than 500 million RMB.

3) From Qingdao to Huangdao, it needed 1.5 hours crossing the bayside highway or 40 minutes by ferry. Since the opening of the Jiaozhou Bay tunnel, it needs only 5 minutes, which shortens the round-trip time. The cumulative vehicles were 29.56 million (23900 per day) and the passing people are 180 million up to the late November, 2014. The people returning to both sides are 4 times as before, which achieved the urban spatial expansion in Qingdao and provided the new power for the economic development on both sides.

What services did the member firm provide to the project? Please describe briefly.

In 1993, China Railway Tunnel Survey & Design Institute Co.Ltd began to perform the feasibility study of this project. In May, 2005, the feasibility report was completed (gained the first prize of national excellent engineering consulting achievement issued by China Engineering Consulting Association). In April, 2008, the project research and engineering design were completed. During the process of design, technical innovation was connected tightly with design and most of the advanced techniques including detecting water by pilot hole, the design theory and methods of active control of tunnel waterproof, endurance concrete, antiseptic anchor stock, maintainable drainage system, and rapid grouting were firstly adopted and gained good effect.

Please use additional pages as needed. Maximum 5 pages per project.