Xi’an Metro Line 2

LOCATION:
Xi’an, China

SUBMITTING FIRM:
China Railway First Survey & Design Institute Group Co., Ltd.

FIDIC MEMBER:
China National Association of Engineering Consultants (CNAEC)
Extending from south to north for 20.62 km and connecting 17 stations, Xi’an Metro Line 2 is the world’s first metro line which has been built in loess region, with a number of worldwide challenges successfully addressed which include ground fissure, heritage conservation, geological condition conservation and conservation of cultural features as an ancient city. The project has been awarded four invention patents, 14 utility model patents, and won six national, provincial and ministerial-level awards. It has taken 17 years for the completion of the project with consultancy having been carried out since 1994, construction started in 2007 and the project put into operation in September 2011.

1. Featuring engineering arduousness and complexity, the project has addressed a number of formidable challenges and made several worldwide breakthroughs

1) The first brand new and biggest challenge is how to ensure safe metro passing in ground fissure.

Xi’an is well known for its unique geological disaster—ground fissure which in the past 20 years has caused enormous damage of up to 161.9 billion RMB. Out of the 14 ground fissures that have been found in Xi’an, Metro line 2 runs through 12. The ground fissures are zonally distributed between loess ridges and valleys with an average distance of about 1 km, featuring three-dimensional deformation with the design deformation of ground fissures to be 500 mm per hundred years. To build a metro line in ground fissure is
unprecedented in the world’s history of metro construction.

2) The second challenge is how to achieve harmony between metro construction and heritage conservation.

As the capital of thirteen ancient Chinese dynasties with a history of more than 1100 years, Xi’an is renowned as one of the world’s four ancient civilizations’ capitals, the other three being Athens, Rome and Cairo. Xi’an reflects historical glory of China with the relics of Zhou, Qin, Han and Tang dynasties and carries the cultural heritage and spirit of Chinese people with the ancient city wall. To achieve harmonious coexistence between metro construction and heritage conservation has always been a formidable task both home and abroad.

3) The third challenge lies in the construction which at the same time should protect cultural relics.

Metro Line 2 runs through several national key cultural relics – the North City Wall, the South Gate Wall and the Bell Tower. Construction settlement and operation vibration cause shouldn’t cause any damage to the Bell Tower and the City Wall, which poses a serious challenge to the construction. Yet no success stories in this regard can be drawn worldwide.

4) The collapsibility of loess in Xi’an poses another key challenge to the project.

5) How to reflect the rich cultural flavor of Han and Tang dynasties pose a serious architectural challenge.

The most striking feature of Xi’an is its characteristics as an ancient city. Whenever people think of Xi’an, the Terracotta Warriors, the Bell Tower, Huaqing Pool, the ancient city walls and many other relics and places of interest will come to mind immediately. Therefore, metro construction should blend the modernity of technology into historical culture and features of Xi’an.
2. Conquering technical difficulties, the project has achieved leading research results

Thanks to unremitting efforts of the consultants for nearly 18 years, the project has successfully overcome four major technical difficulties and realized the ambition of building a modern metro running from the south to the north of Xi'an. A number of remarkable technology innovations were achieved.

1) Safe structure and smooth operation are both achieved in ground fissure segments. A series of measures were taken, including partial reinforcement, reserved headroom, segment processing, flexible joints, waterproof processing after structure processing, and adjustable frame plate. These measures successfully addressed the key challenge posed by ground fissure and achieved the goals of safe structure, smooth operation and zero seepage. The comprehensive building technology has reached the international leading level.

2) Exemplary heritage conservation techniques have been applied in the project. A comprehensive technical heritage conservation package has been worked out, including technical plans, research methods and construction management. A series of measures were adopted, such as deepening and diversion, shield first, stratum strengthening and insulation, enclosed bracing under the gate wall and vibration reduction by seamless track. These measures resulted in an increase of 80.57 million RMB investment, which however is worthy in terms of cultural heritage conservation and protection. The realization of harmony between metro construction and cultural relic conservation has guiding significance for subsequent construction projects. The heritage conservation technology has reached China's leading level.

3) Remarkable tunnel construction technology in loess area has been developed. A unique set of design and construction methods of shallow depth excavation has been applied, with a technical guide and professional standards worked out. Shield technology in the loess area was invented. By taking measures of deepening and diversion, precipitation in
advance for soil fixation, foundation treatment and governance, and pipeline risk elimination, the project has promoted advancement of metro construction technology in loess area. The tunnel construction technology has reached China's leading level.

4) The logo design, choice of station names and design of station cultural walls

embodied a new style of antiquity and the unique cultural characteristics of the ancient capital. The metro logo – the city wall crest – fully represents the ancient city culture. Combining the artistic style of Moscow metro stations with modern craft in Beijing and Guangzhou metro stations, Xi'an metro stations are filled with ancient city atmosphere and artistic flavor. The stylish entrances are painted in primary colors of black and white with drawings of squared patterns and roseofinch, reflecting regional style and modern flavor. Each station is literally home to a diversified collection of scenes: ancient post offices, sports, Tang dynasty, the Qinling Mountains, Qin style dancing and singing, and so on. By connecting 17 unique stations, an underground art gallery was invented.

3. The concept of transparency and integrity has been fully reflected in the overall process of the project

FIDIC contract management, risk management and sustainable development concept have all been adopted in the overall process of Xi'an Metro Line 2 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. Reflecting on the past and looking into the future, Xi'an Metro Line 2 opens a new era

In the construction phase, the project provided over 60,000 jobs both directly and indirectly. In the operation phase, 1,600 jobs were provided directly. There was no death report during construction.

The operation of Xi'an Metro Line 2 marks the start of metro era. By breaking the unprecedented record of building metro in collapsible loess areas and ground fissure areas, achieving harmony between metro construction and heritage conservation, the project has attained good social benefits. A "Rail Transit Economic Belt" has come into being as a result, which has promoted the rapid economic development of Xi'an. Besides, by the end of 2013, Xi'an has reduced the accumulated pollutant emission of 50.936 tons, bringing about environmental benefits of about 1.35 billion RMB.

The successful application of heritage conservation techniques under the Bell Tower, the North Gate Wall and the South Gate Wall has met the requirements of settlement and vibration control for ancient buildings.

The environment of Metro Line 2 has been widely commended by the public and professionals. Taking the metro is like a cultural tour. Its unique cultural atmosphere corresponds with the local history, forming the completeness of decoration artistry and cultural connotations.

Xi'an Metro Line 2 is recognized as an example of the best combination of cultural heritage, urban construction and economic development. With the implementation of the strategy of Guanzhong-Tianshui Economic Zone Development Planning, Xi'an is accelerating its paces of building itself into an international metropolis. This, in turn, puts forward higher
requirements for metro construction: by 2018, altogether six metro lines will be completed and put into operation. Obviously, the carrying capacity of urban development will be further strengthened. Metro construction will speed up the building of international metropolis and will make the ancient capital shine even brighter with both charm and speed.