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Comparative analysis of horizontal directional drilling pipeline practices in China vs. United States

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ABSTRACT

Horizontal Directional Drilling (HDD) has played a critical role in infrastructure development by providing an economical, practical and environmentally responsible way to install new, buried pipeline systems. The versatility of HDD enables installations in various strata including mountainous terrains, extensive farmland and crossings of water bodies. China and the U.S. currently are leaders in pipeline installations due to numerous major energy projects. This paper examines those practices being used in China in order to compare those to standard practices in the U.S. in order to gain insight into similarities and differences. Notable differences including Field data was collected on several HDD pipeline projects in both China and the U.S. Differences and similarities in site considerations, manpower and labor conditions, and equipment usage were studied. It was found that extensive geotechnical investigations are performed prior to design and construction of HDD pipeline projects in China and the U.S. In the U.S., designs are most often based on meeting minimum design parameters, while in China, analysis is taken one step further and includes advanced simulation models and graphing of all installation stages. Labor sourcing in China somewhat more complicated compared to the U.S. It is a common practice to employ significantly more workers than actually required. This is a standard practice that is recognized on a national level in order to employ more people from China's 1.3 billion population. Working hours in China are twenty-four hours per day, seven days per week broken into two twelve-hour shifts per day. In the U.S., wages are typically paid to workers on a weekly basis. Many HDD pipeline projects have work hours of 12 h per day, five to six days per week with overtime paid at a rate of 1.5–2 times base hourly rate for each hour over 40 per week. Much can be learned by understanding the differences and similarities between Chinese and U.S. HDD pipeline contractors.

1. Introduction

As a developing nation, China is currently faced with the challenge of providing safe, reliable and adequate energy resources to the county's growing urban areas as well as to its expanding rural populations. To meet this demand, the country has initiated massive construction projects to expand its national energy infrastructure, particularly in the form of natural gas pipelines. The most notable of these projects is the West-East Gas Pipeline Project. This project supplies clean and efficient natural gas to nearly sixty million users located in the densely populated Yangtze River Delta.

Rapid adoption and advancement in large diameter natural gas pipeline installations has resulted in numerous successful pipeline projects including a series of recently executed record-breaking HDD installations (Li et al., 2017). It is expected that records will continue to be broken as large-scale pipeline installations continue and competition between China National Petroleum Corporation (CNPC), Sinopec (China Petroleum and Chemical Corporation), and China National Offshore Oil Corporation increase. Thus, China's role as the global leader in large-scale horizontal directional drilling will not only continue, but should grow in the foreseeable future.

It is expected that there will be a plethora of opportunities for Chinese HDD contractors to continue to test the limits of the HDD technology through equipment advancement, record setting executions, and number of crossings attempted. Chinese manufacturers of maxi-rig equipment will continue to test the boundaries of how "large" future drill rigs can be produced. HDD contractors will attempt crossings that are larger and further than ever before attempted. The Chinese government will continue to fund large-scale pipeline construction projects and continue to tighten energy efficiency requirements for all parties. The country's network for natural gas pipelines in 2015 reached 64,000 km and is expected to reach 163,000 km by 2025, a 9.8 percent

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annual increase (Xin, 2017).

Understanding the role that Chinese HDD contractors have played in the advancement of HDD is of great value to the global pipeline community. However, little is known about actual construction practices Chinese contractors are utilizing. While Chinese academic and industry leaders have investigated various theoretical aspects of HDD design, little technical information has been published in the area of large-scale HDD execution in China with regards to tangible execution methods. In addition, first hand witness of pipeline projects by foreign experts in China is virtually non-existent.

The main objective of this paper is to examine those practices being used in China in order to compare those to standard practices in the U.S. in order to gain insight into similarities and differences. There are benefits for better understanding of Chinese advancements for large-scale HDD installations. In developed areas, such as the U.S., studying Chinese execution may allow for new ideas to help to improve long established methods. These factors combined further solidify China's role as the global leader in trenchless technology methods and provide the opportunity for Chinese HDD contractors to contribute to the world's knowledge for best practices of the HDD method.

2. Research methodology

In order to develop a clear understanding of the Chinese HDD pipeline installation practices, field data was collected from several large water crossing installations in China. In depth interviews with site personnel were conducted to obtaining first-hand perspectives of procedures. Particular areas of interest were site considerations, manpower and labor conditions, and equipment usage.

Qualitative analysis from six comparable large-scale HDD crossings was conducted. Three projects in China and three in the United States were evaluated. The Chinese projects studied included: (1) Yangtze River Crossing, Jiangyin City, Jiangsu Province; (2) Weihe River Crossing, Weinan, Shanxi Province; and (3) Qin River Crossing, Zhengzhou, Henan Province. The U.S. projects included: (1) Lake Houston Crossing, Houston, Texas; (2) Sabine River Crossing, Liberty, Texas; and (3) Walnut Grove Crossing, Walnut Grove, California. Specific information on these projects is presented in Table 1. The case study analysis was invaluable in better understanding site practices and the value of project management, especially for the Chinese projects.

Table 1
Case study project parameters.

Yangtze river crossing project parameters	
Crossing length/Max depth	3294 m (10,807ft)/43 m (98ft)
Drill soil angle (Entry)/(Exit)	10 degrees/8 degrees
Pipe outer diameter	(P1) 457 mm (10 in), (P2 & P3) 711 mm (28 in)
Pipe material/End use	(P1, P2, & P3) L485 LSAW steel pipe/natural gas
Weihe river crossing project parameters	
Crossing length/Max depth	2948 m (9688ft)/32 m (105ft)
Drill soil angle (Entry)/(Exit)	10 degrees/8 degrees
Pipe outer diameter	(P1) 159 mm (6.25in), (P2) 273 mm (10.75in)
Pipe material/End use	L450M PSL2 Steel Pipe/Coal
Qin river crossing project parameters	
Crossing length	1840 m (6038 ft)
Drill soil angle (Entry)/(Exit)	10 degrees/8 degrees
Pipe outer diameter	(P1 & P2) 1012 mm (40″)
Pipe material/End use	(P1 & P2) Steel pipe/Water
Lake houston crossing project parameters	
Crossing length	3344 m (10,971 ft)
Drill soil angle (Entry)/(Exit)	12 degrees/12 degrees
Pipe outer diameter	(P1) 159 mm (6.25 in)
Pipe material/End use	API-5L-ERW X-52 Steel/Natural gas
Sabine river crossing project parameters	
Crossing length/Max Depth	3374 m (11,065ft)/28 m (92ft)
Drill soil angle (Entry)/(Exit)	12 degrees/12 degrees
Pipe outer diameter	(P1) 305 mm (12 in)
Pipe material/End use	Steel/Natural gas
Walnut grove crossing project parameters	
Crossing length	1779 m (5835 ft)
Drill soil angle (Entry)/(Exit)	12 degrees/12 degrees
Pipe outer diameter	(P1) 610 mm (24 in), (P2 & P3) 273 mm (10.75 in)
Pipe material/End use	(P1) Steel Casing, (P2 & P3) HDPE Carrier/Water

3. Comparative analysis

Factors inherent to HDD projects were analyzed and compared to gain a perspective of the similarities and differences between Chinese and U.S. projects. All aspects of the HDD process from initial design to final inspection were studied. In addition to onsite observations and interviews, the "Horizontal Directional Drilling Best Practices" (Bennett and Ariaratnam, 2017) as well as sample specifications from both U.S. and China were used as a framework for this comparison.

3.1. HDD application and process

The typical HDD contractor in the U.S. furnishes all supervision, labor, equipment, materials and supplies to perform the work necessary to install pipe by HDD in accordance with the project drawings, specifications, and contract documents. In most cases, those documents are prepared by a third party being either the owner, local authority over the project, or a designated design engineer. In some cases, the contractor is contracted to provide both design and construction services under design-build contracts. This is similar in China; however, the owner and engineer are often subsidiaries of the same parent agency as the case with CNPC and other State Owned Enterprises. This relationship is not typical for HDD projects in the U.S.

In the U.S., an HDD contractor does not typically proceed with work until the owner (or owner's representative) approves the supervisor, personnel, subcontractors, vendors, drilling plan and schedule. This information is generally provided during the bid process. This is especially true for projects utilizing alternative project delivery methods where company qualification is just as, if not more, important that actual bid price.

In both China and the U.S., all parties are still required to comply with all requirements of permits obtained by the owner for construction of the pipeline facilities and drilling operations. In the U.S., for example, the HDD contractor is required to identify water sources and obtain any required permits for water withdrawal. This is not the case in China. Additionally, U.S. contractors are typically responsible for all work necessary for withdrawing and transporting water to the jobsite including all costs associated with water usage. Subsequently, the U.S. contractors are impacted due to high costs for both acquisition and hauling of water result.

In the U.S., it is common for the owner to require the HDD contractor to monitor water bodies and ground surface for drilling fluid release or surface settlement along the full length of the drill corridor at all times during drilling operations. This was not witnessed to be the case on any of the jobsites visited in China. In addition, the U.S. HDD contractor typically monitors facilities and other sensitive areas within 150 m (500 L.F.) of the drill path for possible drilling fluid migration and release. Inspections are performed daily, or more often if fluid migration is detected. Sometimes, when working next to highways, streams or sensitive natural areas, a full time monitoring crew may be required if specified in the contract. These costs are also the responsibility of the HDD contractor and are included at the time of bidding. Drilling mud leakage into water bodies in China is prohibited by environmental regulations; therefore, it is a major concern during HDD projects.

In the U.S., the HDD contractor typically submits a drilling schedule for owner approval. The schedule is typically job specific and complies with the schedule specified in the contract documents. This plan typically addresses continuity of supervision, quality management, and