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TRENCHLESS CONSTRUCTION: USES AND POTENTIALS

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Infrastructure projects in the United Arab Emirates (UAE) at federal and local levels have been continuously growing. This includes installation, inspection, repair, and replacement of water mains, sewer, storm water, power, and telecommunication networks. Traditionally, these tasks related to underground utilities involve open trenching construction methods resulting in expensive and disruptive operations, particularly in congested urban areas like Dubai and Abu Dhabi cities. To avoid this serious problem, contractors and local municipalities are using trenchless construction in their infrastructure projects. The development of trenchless methods has gained impetus in the construction industry in UAE due to increasing amounts of investment in underground infrastructures that are new, deteriorating, or under capacity. This paper presents the results of a questionnaire survey of trenchless construction methods used by municipalities and contractors in UAE. The survey provides an indication of current and expected future trends in the application of trenchless construction technologies including types of technologies employed and percentage of projects that employed trenchless technologies. The survey results indicate that trenchless technology is gaining increasing popularity among contractors and municipalities across UAE. The survey results also indicate that trenchless technology is gaining increasing popularity among municipal engineers across UAE. The survey also revealed current and likely future growth in utilizing trenchless construction methods and the average expenditures of municipalities in UAE for new construction and for rehabilitation.

Keywords: Questionnaire survey, Trenchless technology, New construction, Rehabilitation, Underground utilities, Cost.

1 INTRODUCTION

Infrastructure development in the UAE at federal and local levels has been phenomenal in view of the relatively short period since the establishment of the country. Contractors and local municipalities traditionally install and maintain their underground utilities using open-trench construction methods. Such operations may be proven expensive, particularly in congested urban areas. Additional costs are typically incurred by the need to restore the existing finished surfaces including sidewalks and pavements in addition to landscaping. Open cut trenching operations often result in high user (social) costs due to the disruption to traffic and adverse impact on nearby businesses (Zayed and Mahmoud 2013, Ariaratnam 2010). The solution to this problem may be provided by the use of trenchless construction. Trenchless construction is a family of

methods, materials, and equipment used for the installation of new and replacement or rehabilitation of existing underground infrastructure with minimum impact on society and the environment. The benefits of trenchless technology are apparent when compared to the conventional open-cut process (Gokhale and Hastak 2000). Trenchless construction techniques include horizontal directional drilling, pipe jacking, microtunnelling, auger boring, and pipe bursting. Rehabilitation techniques include lining of pipe, pipe scanning and evaluation, and robotic spot repair. The use of trenchless techniques dates back to the 1860s. In the mid-1990s, trenchless technology became the focus of several research efforts.

In busy locations of big cities, the problem of traffic disruptions associated with traditional methods of utility cuts is a major concern. Several attempts were made to explore the importance of using trenchless technology methods to minimize social inconvenience, reduce costs, and improve productivity. Bergeson (2014) investigated the challenges for projects with long drives installed by microtunnelling methods and provided a review for the state-of-the-art in equipment technology. Ariaratnam *et al.* (2014) discussed pipe bursting as a method used for replacement of existing pipelines. It was initially created to replace small diameter gas distribution lines, but has since grown in acceptance as an effective method for replacing pipelines diverse in size and material type with minimal surface disruption (Bennett *et al.* 2011). Also, Zayed and Mahmoud (2013) investigated the potential factors impacting productivity using horizontal directional drilling (HDD).

Other recent research efforts focused on the research gaps and needs for pipeline condition assessment, renovation, and new construction. This includes the use of UV CIPP liner, development of CIPP liner for water mains, development of new trenchless design tools (BOREAID, Plastic Pipe Institute (PPI) BOREAID, PPI-PACE), and application of polymers and polyurea for water main renovation (Rogers 2014). Although many major advances have similarly been made in the area of water pipeline condition assessment and renovation, this area is ripe for growth as existing technologies are still in the early development phase. As commented by Rogers (2014), underground infrastructure will continue to degrade and will fail at an exponentially increasing rate, and we will end up passing on a far greater financial burden to the next generation than if we invest now.

Despite the importance of previous efforts, little has been made to identify the importance of using trenchless technology in UAE as an effective and economic alternative to open cuts. In this research, a questionnaire survey was conducted to explore the use of trenchless construction in the different cities across the UAE. The objective of the survey is to provide an indication of current and likely future trends in the use of trenchless technologies including type and frequency of these technologies used and percentage of projects that employed trenchless technologies. Current and future growth in utilizing trenchless construction methods was then investigated.

2 THE QUESTIONNAIRE SURVEY

A total of 105 surveys were distributed to municipalities, contractors, and engineering firms across the UAE. Responses were received from 8 municipalities, 36 contractors, and 20 engineering firms in the country in the cities of Abu Dhabi, Dubai, Sharjah, Al Ain, Ajman, Al Fujairah, Ra'as Al Khaima, and Omm Al Quwain. Estimated

population sizes in 2013 of the 8 cities range from around 65,000 to over 2 million. A total of 64 responses were received representing a response rate of 61%. The majority of the responses were from Abu Dhabi and Dubai followed by Sharjah and Al-Ain.

3 DATA ANALYSIS

The UAE is expected to spend over $300 billion by 2030 on infrastructure development as the construction sector bounces back after the economic downturn in 2008. The UAE's construction sector gained momentum in 2013. Last year, Dubai won the bid to host Expo 2020, a six-month global exhibition that is expected to attract 25 million visitors. Expo-related infrastructure development and operations will cost around 32.39 billion dirhams. Under Dubai's 2020 vision announced last year, the number of visitors in the emirate is expected to double from 10 million in 2012 to 20 million by 2020. In order to accommodate 20 million visitors, the number of hotels in Dubai is expected to double (Gulf News, June 2014).

According to the survey respondents, the statistical analysis implies that, in general, municipalities are spending a greater portion of their annual budget on new infrastructure than on rehabilitation. To compare the budgets for new and rehabilitation construction to the population of the city, municipalities were grouped into three categories: (1) small-size (under 150,000 in population); (2) medium-size (between 150,000 and 500,000); and (3) large-size (over 500,000). These categories were chosen on the rationale that municipalities with populations over 500,000 typically consist of congested urban areas with large underground infrastructure. Municipalities in this category include Abu Dhabi, Dubai, Sharjah, and Al-Ain. The municipalities in the 150,000–500,000 category include Fujairah, Ajman, and Raas Al-Khaimah. Only Omm Al-Quwain has a population under 150,000. This municipality have a smaller, less developed underground infrastructure and no dense downtown area. Surveyed respondents were then asked to provide information about their organization's annual utility infrastructure budget for new construction and for rehabilitation projects. Based on the responses received, it was found that, in big cities like Abu Dhabi, most new construction and rehabilitation projects fall under the "$25 million and above" category while in relatively small cities like Al-Ain, the majority of projects fall in the "under $500,000" category. Medium size cities fall under the "$2.5 million to under $5 million" category.

4 UTILIZATION OF TRENCHLESS CONSTRUCTION IN UAE

The distribution of the utilization of various trenchless methods is shown in Figure 1, which present the percentage of respondents that have used each technology. The horizontal directional drilling was determined to be the most widely used method with 40.6% of the respondents indicating having used this method followed by the lining of pipe method with a 34.4% response rate. Pipe jacking was third (26.6%) followed by pipe bursting (21.9%). Among the new trenchless construction methods, robotic spot repair is the least utilized technology (9.4%).

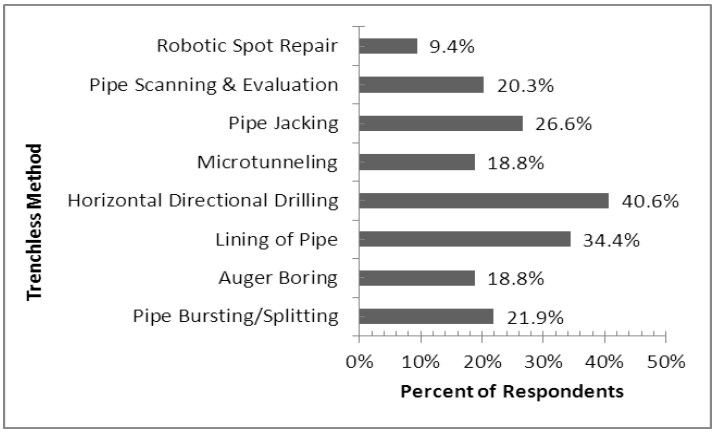

Figure 1. Utilization of trenchless technologies by respondents.

A comparison between the current results and the results obtained by Zaneldin (2007) is summarized in Table 1. Table 1 also shows the rank of each trenchless technology method in terms of its frequency of use. From this comparison, it was noticed that the auger boring is not popular any more while the horizontal directional drilling gained more popularity. Also, some contractors started using the robotic spot repair method which was not used at all in 2005.

Table 1. A comparison between the current results and the results of 2005.

Trenchless Technology Method	**Now**		**Year 2005**	
	Response Rate	**Rank**	**Response Rate**	**Rank**
Horizontal directional drilling	40.6%	1	34.1%	4
Lining of pipe	34.4%	2	54.5%	1
Pipe jacking	26.6%	3	40.9%	3
Pipe bursting/Splitting	21.9%	4	27.3%	5
Pipe scanning and evaluation	20.3%	5	22.7%	6
Microtunneling	18.8%	6	18.2%	7
Auger boring	18.8%	6	45.5%	2
Robotic spot repair	9.4%	8	0	8

The limited number of contractors who have the capacity to perform works using the robotic spot repair method may account for the lower utilization of this method. To evaluate the growth of the use of trenchless construction in UAE, its use today and five years ago was compared. From the survey results, 23.7% of the respondents indicated that they used trenchless technologies on 10% or more of their new construction projects five years ago. Today this has increased to approximately 38.9%. This percentage was 27% in the year 2005, as reported by Zaneldin (2007). Similarly, around 29.7% of the respondents indicated that they used trenchless technology for rehabilitation projects on 10% or more of their projects 5 years ago. Today, this figure has risen to 36.7% as compared with the 34% in 2005. The survey therefore indicates that there has been a significant increase over the past 5 years in the utilization of trenchless methods in UAE.

The survey also collected data on the lengths of pipes installed or rehabilitated using different trenchless construction methods during the year 2013 to provide a better understanding of the volume of trenchless construction in UAE (Figure 2). The survey indicated that of all the trenchless construction methods listed, over 27.6% of the total length of pipes installed or rehabilitated was completed using horizontal directional drilling, followed by lining of pipe (26%). Pipe jacking came third with 15.2%. The other trenchless methods accounted for the remaining 31.2% of the total length installed. The large proportion of the pipes installed may be because of the familiarity and simplicity of the horizontal directional drilling and lining of pipe methods.

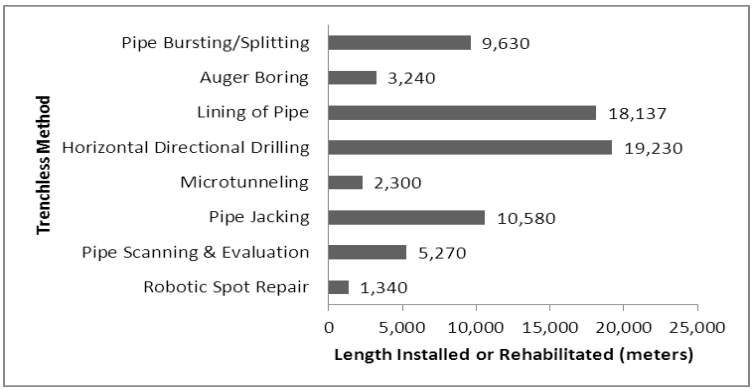

Figure 2. Lengths of pipes installed or rehabilitated in 2013.

5 POTENTIAL FOR FUTURE GROWTH IN TRENCHLESS TECHNOLOGY

The use of trenchless technologies in new construction and rehabilitation projects is expected to increase as more contractors and municipalities become familiar with their applications and aware of their advantages. To provide a realistic idea about the most future growth of trenchless technologies, municipalities, contractors, and engineering firms were asked to rank the technologies that they felt had the most potential for future growth in a scale from 1 to 5 (1 being very promising and 5 being not promising). A weight in a scale from 0 to 4 was given for each of the five possible ranking numbers with a weight of 0 for "not promising (rank = 5), 1 when the rank is 4, 2 when the rank is 3, 3 when the rank is 2, and 4 when the rank is 1. No weight was given when no response was provided. Data received from respondents were analysed and an importance index percentage was then calculated. The results indicate that "horizontal directional drilling" method has the highest potential for future growth in new construction. The "pipe jacking" method was ranked second and the "robotic spot repair" was ranked last.

6 CONCLUSIONS

From the survey, it appears that research is required in the development of specifications and guidelines for design, contractor selection, and management of

trenchless projects in the UAE. The growth in trenchless construction methods in the UAE has been inspired by the many benefits of this technology. Trenchless technologies allow for the completion of complex underground infrastructure projects in congested urban areas in a safe, economical manner with minimal disruption to surface traffic, nearby businesses, or environmentally sensitive areas. In this study, it was found that around 89% of the respondents indicated that they had utilized at least one method of trenchless construction. Over the past 5 years, the utilization of trenchless methods for new construction and rehabilitation has experienced a growth of more than 64% and 24%, respectively. In conclusion, 40.6% of the respondents had utilized horizontal directional drilling method in the past. Also, horizontal directional drilling method is the most utilized trenchless technology accounting for 27.6% of the total length of pipe rehabilitated or constructed during the year 2013. Trenchless technology methods that are expected to experience the greatest future growth are horizontal directional drilling, pipe jacking, and lining of pipe for new construction and lining of pipe for rehabilitation. According to respondents, the "robotic spot repair" method is expected to experience the least future growth among all other trenchless technologies for both new construction and rehabilitation.

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