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Infrastructure System Recommendations for Narrow and Steep Streets in Istanbul

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ABSTRACT

In Istanbul, with the establishment of clamshell concrete channels, refurbishment of water, electricity, natural gas and telephone infrastructure is expected to be much easier. Therefore, to combine the infrastructure services and managing from a single center, precast clamshell concrete channels (utility tunnels) shall be considered in priority. However, considering geographic and land use structure of the Istanbul, narrow and steep hilly streets come to mind immediately. These channels, also known as Utility Tunnel, should be designed as one or several people can work inside comfortably. Moreover this scale reinforced concrete tunnel is not possible to be fitted under a narrow and steep street or the pavement. Instead, this type of alternative infrastructure systems such as trenchless technology in the streets, can serve as a connection to the host system. In summary, Utility Tunnels have to be supported by the alternative infrastructure systems. While doing this, monitoring of alternative infrastructure systems have to be taken into account. Fiber optic sensors help on the health monitoring of infrastructure systems, mainly pipelines. Before deciding on what could be the alternative infrastructure systems, some cities that show the same characteristics with Istanbul have to be examined. For this aim, Trenchless pipe and cable laying technologies used in world cities with narrow streets and dense population were investigated.

KEYWORDS: Fiber optic sensors**;** infrastructure; Istanbul; trenchless technology.

1 INTRODUCTION

Trenchless technology is an innovative approach for the ease of the implementation of infrastructure elements. It gives lots of advantages such as time and labor cost conservation. Also trenchless technology can be helpful in some areas where the conventional implementation of infrastructure is not applicable. If the infrastructure system is intended to be placed on both sides of the road, and if it has to be joined at certain points to continue on a single line, extraneous excavations may be needed at the side connections. This kind of operation is not favorable since it is very expensive and also it prevents the transportation for a particular time due to an excavation.

Especially for narrow and steep hilly streets of Istanbul, the establishment of clamshell concrete channels (Utility Tunnels) will not be very feasible. Hence, the best approach may be the combination of multiple innovative technologies to get the optimum result on the implementation of infrastructure.

In this study trenchless pipe and cable laying technologies will be dealt with. Also, considering safety issues, application of fiber optic sensors that help on the health monitoring of infrastructure systems will be investigated.

2 TRENCHLESS INFRASTRUCTURE SYSTEM

Trenchless pipe and cable laying technologies are used in places especially where there is an obstacle against horizontal connection of two locations through a conventional excavation. For instance, if there is a river between two locations, the connection should be through underneath the river. However excavation of a tunnel takes long time and it requires skilled labors since the stability of the soil under the water is a hard issue to overcome.

This study claims that this innovative technology can also be used in narrow, steep streets and dense population areas successfully. For this aim, many places including United Arab Emirates, Canada and also China's Shanghai and Chongqing cities with narrow streets and dense population were investigated (Ariaratnam et al., 2006; Ariaratnam et al., 1999; Ma and Najafi, 2008; Zaneldin, 2007). Researches show that this technology is very feasible to overcome several problems regarding the implementation of infrastructure in narrow and steep streets without needing an excavation.

3 METHODOLOGY

Horizontal Directional Drilling (HDD) system may be used in order to avoid excavation. In this system, the pipes and cables can be laid underground without open excavation (Allouche, 2000; Tighe, 2002). It can be monitored from above ground at every stage, hence any damage to the existing structures and networks is prevented, and it is possible to enter and exit any desired point (see Figure 1, 2).

Figure 1: Horizontal Directional Drilling Equipment (Willoughby, 2005)

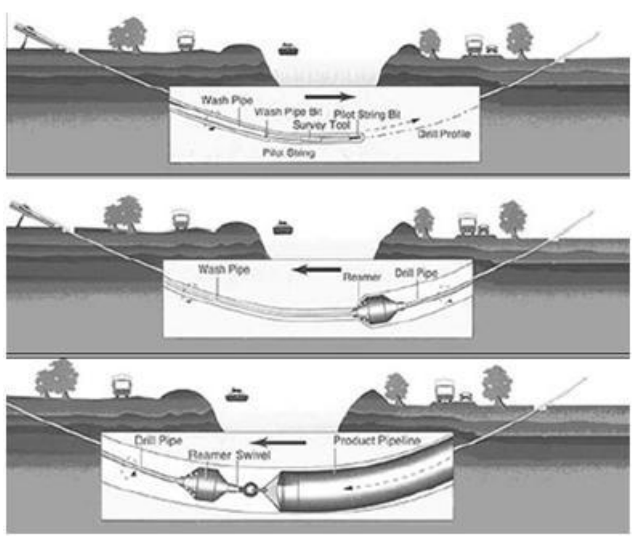

Figure 2: Stages of Horizontal Directional Drilling (Opening of the guide hole, expanding the hole and pulling the Pipe) (Willoughby, 2005)

Another important issue is to maintain the security of the infrastructure system. For this purpose, the use of heat sensitive fiber optic cable can be recommended, which is frequently applied in the world for a long time. Ishii et al. (1997) tested this system in a study conducted in 1997, and obtained successful results with 5 m and 5 °C sensitivities in a tunnel 2 km long. More precise results are expected with similar systems developed in today's technology. Fiber optic temperature sensing and monitoring techniques have provided new opportunities with applications in various areas such as civil engineering, oil and gas, power plants, fire detection, and so on (Bartholmai et al., 2013; Rajeev et al., 2013). Although there can be practical difficulties for existing infrastructure, the fiber optic technology can be utilized in order to reduce the costs of repairs and renewal of the alternative infrastructure systems and to minimize excavation. Prior to insertion of pipeline into the tunnel, it is necessary to install these cables (see Figure 3). In some systems, the fiber optic cables are clamped onto the pipe (see Figure 4). In case of any leakage and temperature change, the fault location will be determined automatically by the system (Li et al., 2004). Leak detection by cables placed above and below the pipe is shown in Figures 5 and 6. After leakage, the system determines the fault and its location by means of computer technology. Fiber optic sensors should be integrated into an infrastructure during the Horizontal Directional Drilling.

Figure 3: Fiber optic cables are laid below 10 cm of pipeline (Inaudi and Glisic, 2008)

Figure 4: The temperature sensor cables on the gas pipeline SMARTape (Glisic and Inaudi, 2007; Nikles et al., 2004)

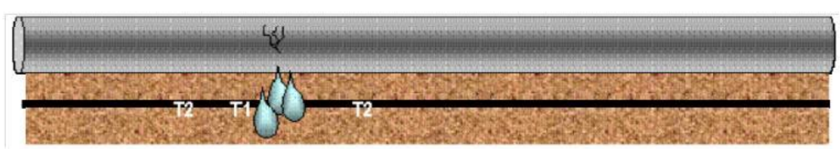

Figure 5: The detection of the water leakage with the help of the cables, laid below the pipeline (Inaudi and Glisic, 2006)

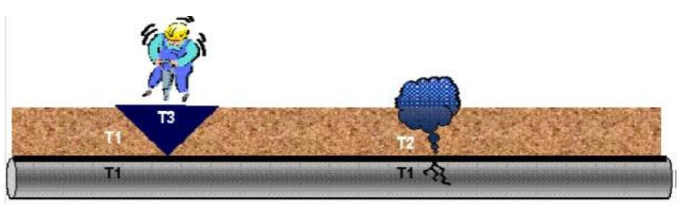

Figure 6: The detection of the gas leakage with the help of the cables, laid above the pipeline (Inaudi and Glisic, 2006)

4 CONCLUSION

The infrastructure system should be designed by an academic group considering the city plan. Unique solutions are not easy if there are many geographical or land use changes are existed. The infrastructure system should be the combination of a few systems which may be the answer to problems regarding these topographical changes. Within this study, Horizontal Directional Drilling (HDD) system was proposed for the Istanbul. In this system, the pipes and cables can be laid underground without open excavation. This technique avoids the excavation and decrease operation cost. Use of an integrated fiber optic sensor for the infrastructure safety was the other proposal. Fiber optic sensors should be integrated into an infrastructure during the Horizontal Directional Drilling for pipeline monitoring.

There is a strong relation between the urban form and infrastructure costs. Alternative scenarios can be developed for the future with the use of GIS (Geographic Information Systems). The minimum cost infrastructure maps can be created with the help of GIS. This technology can be a powerful tool in order to ensure sustainable development of urbanized regions of the Istanbul.

Simulation allows testing the feasibility of a planned work. It is a powerful tool for decision making. The construction, cost and implementation stages of an application proposed by the academic and professional engineers are visualized through simulation during the decision making process and the optimum quality is reached in the implementation (Keirstead and Shah, 2013; Rehan et al., 2013). Before the application of proposed systems, all have to be simulated considering many factors including geography and land use. In case of applying the proposed technique, infrastructure problems of Istanbul's narrow and steep streets significantly to be solved.

REFERENCES

Allouche, E. N., Ariaratnam, S. T., Lueke, J. S. 2000. Horizontal directional drilling: profile of an emerging industry. Journal of Construction Engineering and Management, 126(1), pp. 68-76.

Ariaratnam, S. T., Chan, W., Choi, D. 2006. Utilization of trenchless construction methods in mainland China to sustain urban infrastructure. Practice Periodical on Structural Design and Construction, 11(3), pp. 134-141.

Ariaratnam, S. T., Lueke, J. S., Allouche, E. N. 1999. Utilization of trenchless construction methods by Canadian municipalities. Journal of construction engineering and management, 125(2), pp.76-86.

Bartholmai, M., Neumann, P. P., Lazik, D. 2013. Multifunctional Sensor for Monitoring of CO_2 Underground Storage by Comprehensive and Spatially Resolved Measuring of Gas Concentrations, Temperature and Structural Changes. Energy Procedia, 37, pp.4033-4040.

Glisic, B., Inaudi, D. 2007. Fibre Optic Methods for Structural Health Monitoring. John Wiley & Sons, Ltd. ISBN: 978-0-470-06142-8.

Inaudi D., Glisic B. 2006. Reliability and field testing of distributed strain and temperature sensors. SPIE Smart Structures and Materials Conference in San Diego.

Inaudi D., Glisic B., Figini A., Walder R. 2007. Pipeline leakage detection and localization using distributed fiber optic sensing. Rio Pipeline Conference & Exposition.

Inaudi, D., Glisic, B. 2008. Overview of fibre optic sensing to structural health monitoring applications. 4th IAG Symposium on Geodesy for Geotechnical and Structural Engineering. LNEC, LisbonMay pp. 12-15.

Ishii, H., Kawamura, K., Ono, T., Megumi, H., Kikkawa, A. 1997. A fire detection system using optical fibres for utility tunnels. Fire safety journal, 29(2), pp. 87-98.

Keirstead, J., Shah, N. 2013. The Changing Role of Optimization in Urban Planning. In Optimization, Simulation, and Control, Springer New York, pp. 175-193.

Li, H. N., Li, D. S., Song, G. B. 2004. Recent applications of fiber optic sensors to health monitoring in civil engineering. Engineering structures, 26(11), pp.1647-1657.

Ma, B., Najafi, M. 2008. Development and applications of trenchless technology in China. Tunnelling and Underground Space Technology, 23(4), pp.476-480.

Nikles, M., Vogel, B., Fabien, B., Grosswig, S., Sauser, F., Luebbecke, S., Bals, A., Pfeiffer, T. 2004. Leakage detection using fiber optics distributed temperature monitoring. Smart Structures and Materials 2004: Smart Sensor Technology and Measurement Systems. Edited by Udd, Eric; Inaudi, Daniele. Proceedings of the SPIE, Volume 5384, pp.18-25.

Rajeev, P., Kodikara, J., Chiu, W. K., Kuen, T. 2013. Distributed Optical Fibre Sensors and Their Applications in Pipeline Monitoring. Key Engineering Materials, 558, pp. 424-434.

Rehan, R., Knight, M. A., Unger, A. J. A., Haas, C. T. 2013. Financially sustainable management strategies for urban wastewater collection infrastructure–Development of a system dynamics model. Tunnelling and Underground Space Technology, 39, pp.1-14.

Tighe, S., Knight, M., Papoutsis, D., Rodriguez, V., Walker, C. 2002. User cost savings in eliminating pavement excavations through employing trenchless technologies. Canadian Journal of Civil Engineering, 29(5), pp.751-761.

Willoughby, D. A. 2005. Horizontal Directional Drilling: Utility and Pipeline Applications. The McGraw-Hill Companies, Inc.

Zaneldin, E. K. 2007. Trenchless construction: an emerging technology in United Arab Emirates. Tunnelling and underground space technology, 22(1), pp.96-105.