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Pipeman:Safety in Trenches

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PEPEMAN: SAFETY IN TRENCHES

THE NEED

Even though heavy construction equipment such as a crane or backhoe excavator, is used to perform the task of pipe laying in the trench, workers are required to be inside the trench to guide the excavation, pipe laying, and final alignment. Work place safety has become a major concern in the construction industry over the past few decades, and trench cave-ins have caused serious and often fatal injuries to workers in the United States. It has become of crucial importance to implement the use of new technologies to prevent accidents in trench excavation and pipe installation.

FIGURE 1 PIPE MANIPULATOR MOUNTED ON THE EXCAVATOR

Diverse approaches such as shoring, shielding, and sloping have been applied to protect workers from cave-ins in trenching and pipe laying operations. However, even when support systems are used, the danger of cave-ins still exists due to the nature of the soil and unexpected circumstances.

FIGURE 2 OVERVIEW OF PIPE MANIPULATOR

The Construction Automation and Robotics Laboratory(CARL) at North Carolina State University has developed an alternative which involves advanced new technology: the prototype robotic excavation and pipe installation system.

THE TECHNOLOGY

The basic concept consists of a 3-D spatial positioning system(SPS), which is interfaced with an excavator to provide the location of the excavator and a beam laser. A pipe manipulator prototype is attached to the bucket of the excavator, which is capable of handling pipes of various sizes. A beam laser is also used to help the operator align pipes. Integration of SPS with a CAD system will update the excavator position in real-time and provide an as-built drawing of pipe laying.

FIGURE 3 LAYOUT OF THE ROBOTIC TRENCHING AND PIPE INSTALLATION SYSTEM(HUANG & BERNOLD, 1993)

The main components of the concept are the man-machine interface, actuation system, laser beam and feedback system. The man-machine interface is used to keep the operator in a safe area and allow him to guide the Pipeman intelligently, while the Pipeman works in a hazardous environment. The man-machine interface also includes manipulation and visualization functions. The operator will have two different joysticks to control 1) the excavator, and 2) the pipe manipulator prototype. The operator will see his/her manipulation status through visualization functions.

- H.Motor(M_Rot1): A hydraulic motor provides +/- 100 degrees rotation of the pipe in order to line up the pipe.
- H.Motor(M_Rot2): A hydraulic motor provides a locking mechanism on the back of the pipe manipulator prototype to prevent the pipe manipulator from sliding from the bucket.
- H.Cylinder(C_Trans): A hydraulic cylinder provides a linear activation of the pipe to joint the new pipe to the pipe already laid.
- H.Bladders(B_Clamp): Hydraulic bladders provide inflating and deflating mechanisms to clamp the pipe manipulator to the bucket

- E.Winch(W-Hold): An electric winch is used to attach the pipe with a quick release.

FIGURE 4 SCHEMATIC OVERVIEW OF THE PIPEMAN

The amount of clearance available to insert the bucket is 10.5 inches(26.7 cm)in order to fit the bucket more easily. Bladders(B_Clamp) have been mounted to support the bucket and to prevent it from slipping off in operation. The basic principle of the bladder system is to introduce the hydraulic fluid into the unit trough the bladder intake, causing the bladders to inflate, which clamps the pipe manipulator to the bucket. To eliminate slippage, a rubber plate of 1 inch(2.54 cm) of thickness is also attached both at the bottom of the upper part of the cantilever hook and on the top of the steel plate over the bladders. Additionally, to prevent the pipe manipulator from sliding off the bucket, a locking mechanism on the back of the pipe manipulator has been designed as a mechanical stop. A rotational motor (M-Rot2) will rotate steel bars(backstop) toward the back of the bucket.

A simple joystick and on/off switches are applied for easy manual control and the electro-hydraulic valves are used to activate each actuation function. The beam laser system is also used to align the pipes. Two laser targets are used to make sure that the grade is correct. Micro cameras as feedback system are mounted to improve the machine interface. This system allows the operator to have a real-time visual control for the final alignment of the pipe joint.

THE BENEFITS

- The greatest advantage of the Pipeman is that it offers a new technological approach to pipe installation which has the potential of improving safety.

- One key item in every project is the cost associated with OSHA(Occupational Safety and Health Administration) to protect workers in an open trench. By removing the need for workers going into the trench, the OSHA regulations do not have to be followed, therefore a major cost factor is eliminated.
- Also, this technology will drastically reduce the number of fatal accidents and lost workdays due to injuries, because the robotic manipulator will reduce or eliminate the exposure of humans to risks such as collapsing trenches, and cave-ins.
- Preliminary evaluations of the economic benefits shows excellent results and monetary savings using conservative assumptions. The evaluation does not include reduction in insurance premiums and possible increases in productivity. Therefore, it is possible to reduce costs and improve safety by implementing this technology.

STATUS

The prototype robotic excavation and pipe installation system has been developed by the Construction Automation and Robotics Laboratory(CARL) at North Carolina State University. It is sponsored by the National Institute for Occupational Safety and Health(NIOSH).

Work is continuing on testing the system with different soils and depths. An economic evaluation of the performance will also be performed with statically sound data analysis.

POINTS OF CONTACT

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REFERENCES

1. Lee Junbok, Lorenc Steven, Bernold Leonhard. Saving Lives and Money with Robotic Trenching and Pipe Installation. Construction Automation and Robotics Laboratory(CARL) at North Carolina State University.
2. PIPEMAN: Safety in trenches. ConExpo March 23-27
3. Tele-Robotic Excavation/Remote Pipe-Laying
4. Bernold Leonhard, Huang Xiaodong. CAD-Integrated Real-Time Control for Robotic Excavation and Pipe Laying:Development and Testing. North Carolina State University, Dept. of Civil Engineering, Raleigh NC. August 1997

REVIEWERS

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