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CONTINGENCY PLANNING FOR MICROTUNNELING: AN ESSENTIAL ACTIVITY

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ABSTRACT: This paper describes why contingency planning is an essential activity on any microtunneling and other trenchless construction projects¸ then summarizes what design engineers¸ owners¸ and contractors need to consider in developing contingency plans. The definitions for these terms are as follows:

> *Contingency*: An event that may occur but that is not likely or intended; a possibility; a possibility that must be prepared for; a future emergency[1]

> *Plan*: A scheme, program, or method worked out beforehand for the accomplishment of an objective[2]

As these definitions suggest¸ a contingency plan is one that is developed in advance of possible events to address possible events that will require a rapid response. These definitions also suggest the reasons why owners¸ designers¸ and contractors often don't develop contingency plans: the events are only possible and may not occur¸ and developing extensive¸ formal plans to deal with them¸ should they occur¸ often seems like a waste of resources.

1. INTRODUCTION

As these definitions suggest, a contingency plan is one that is developed in advance of possible events to address those possible events that will require a rapid response if the event occurs. These definitions also suggest the reasons why owners, designers, and contractors often don't develop contingency plans: the events are only *possible* and may not occur, and developing extensive formal plans to deal with them, should they occur, often seem like a waste of resources.

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[1] *The American Heritage® Dictionary of the English Language, Fourth Edition*. Houghton Mifflin Company, 2004. http://dictionary.reference.com/browse/planning (accessed: February 02, 2007)
[2] *The American Heritage® Dictionary of the English Language, Fourth Edition*. Houghton Mifflin Company, 2004. http://dictionary.reference.com/browse/planning (accessed: February 02, 2007)

This paper is intended to help demonstrate why developing a contingency plan for a microtunneling project is not a waste of time, but a useful and necessary activity due to the nature of microtunneling work. The paper also describes common considerations for microtunneling contingency plans. These considerations are intended to help designers, owners, and contractors get a cost- and time-effective start on contingency planning.

The contingency plans referred to herein are those that mediate events understood by the design engineer, owner, and contractor to be possible and likely to have a moderate to significant detrimental effect on the project. Effects could include negative impacts on any of the key project objectives; cost, schedule, environment, safety, public opinion, etc.

Contingency plans may vary from fairly simple and informal to quite complex and formal. They may be briefly or extensively documented as required submittals or may be incorporated into the contractor's operating plan. Regardless of their form, they should address the risks that are unique to the microtunneling method and common to construction projects.

2. TUNNELING "BLIND"—THE BIGGEST CHALLENGE OF MICROTUNNELING

The operators of microtunneling equipment face the unique challenge of never seeing the face of the excavation. Microtunneling is usually done in diameters that people either cannot enter at all or cannot enter practically. The microtunnel boring machine (MTBM) itself has a bulkhead that prevents access to the cutter face in most MTBMs manufactured in diameters less than 96 inches. Any obstacle, a known item that the MTBM cannot or should not tunnel through, should be avoided in design or removed or relocated before tunnel construction. Any obstruction, an unknown item that would stop the MTBM's progress and is beyond the MTBM's excavation capability, possibly including cobbles, boulders, pipes, timber, etc., must be removed during tunnel construction. Removing an obstruction often requires a contingency plan for the removal of the obstruction. And, if the MTBM does stop and is then unable to resume tunneling, the MTBM will have to be rescued, which also requires a contingency plan for a rescue shaft, pullback of the MTBM, or a back tunnel and resumption of tunneling. A back tunnel is a rescue tunnel from a shaft, along the alignment and in advance of the MTBM, back to the MTBM, allowing the MTBM to be encapsulated or pushed into the tunnel. Back tunneling completes a portion of the original tunnel with a different construction method.

Removal of the MTBM is the most common and often most costly contingency for a microtunneling project. Contractors are commonly required to develop contingency plans for this possibility. However, there are other common events that owners, designers, and contractors can consider and plan to include either in the design specifications, contract documents, or in a separate contingency plan.

An example of a successful execution of a MTBM contingency rescue plan occurred when an MTBM failed to advance while under a major thoroughfare in California. The project included a bid item for all cost elements for completing a rescue shaft including traffic control, relocating utilities, shaft construction, back tunneling to retrieve the MTBM, relocating the jacking equipment to the new location, and resuming tunneling. The bid item also included standby costs, overhead costs, direct costs, and incremental schedule allowances for each of these activities. The contractor had to disclose the shaft construction method, back tunnel excavation method, and tunnel support system in the bid documents with a formal plan submitted before tunneling commenced. During the project, the MTBM encountered difficulty and was unable to advance. An obstruction was found at the front of the MTBM. The owner directed the contractor to perform a rescue shaft in front of the MTBM and the owner paid for the rescue shaft and related items only and the contractor was granted a schedule extension. Since no back tunneling was required, that portion of the bid item was not paid and the contractor did not receive a time extension for that portion of the work.

3. CONSIDERATIONS FOR OWNERS

Owners establish the project objectives, either alone or in cooperation with regulatory agencies and other stakeholders. This means that the owner's priorities for project cost, schedule, safety, environmental factors, etc. are one of the driving forces behind contingency planning. The design engineer and the owner identify project risks. After each risk is identified, the design engineer and owner determine the potential of each risk to the project objectives. Once the potential impact is quantified, it is then determined if the current design requirements require changes, which may include, changing the project alignment to remove the risk, increased project definition like better geological investigation, changing the construction method to minimize risk, require project specific experience to bid, developing and submitting a contingency plan to control exposure, the owner accepting the risk, or transferring the risk to the contractor.

Situations within a project that commonly require contingency planning are under-crossings of rivers and channels, airport runways, freeways, buildings, and sensitive habitats. In these projects, contingency plans might be needed for: the MTBM becoming inoperable, slurry or lubricant reaching the surface, sinkholes, jacking pipe breaks, inability to maintain line or grade, jacking forces increasing to the point that the jacking system can't complete the drive, contaminated ground or groundwater, or hazardous/explosive conditions in the tunnel. It may also be necessary to gain permission from owners (e.g., state department of transportation, railroads, and the United States Army Corps of Engineers) to execute a contingency plan. If third party approval is required to execute a contingency plan, then it is wise to develop an agreement that allows the work to progress in a timely and efficient manner. The agreement may include triggers that include notification, specific actions, notices, or revised work practices.

An example of negotiating with a permitting agency occurred on a project in California. The microtunneling project undercrossed wetlands, and the contingency plan for an inadvertent return was negotiated with the California Coastal Commission. The California Coastal Commission is a third party permitting agency for projects within the coastal areas of California. An inadvertent return is the slurry or lubrication reaching the surface or entering the water. In this case, the requirements to restart work were to clean up the fluid, address operating issues in writing, wait until the next regularly scheduled work day to resume work, and increase visual monitoring in the event of another inadvertent return. Because negotiations with the California Coastal Commission were completed in advance of the project bidding, the contractor was aware of and able to efficiently fulfill the requirements, and thus restart work more quickly if the undesirable event occurred. Because the requirements and impacts were clearly defined in the specifications the contractor carefully monitored their performance to avoid an inadvertent return and avoid the costly clean-up and monitoring procedures required by the permit and the specifications.

On a different project that passed under a Caltrans (California Department of Transportation) freeway a MTBM was unable to advance. The construction of an emergency shaft within the Caltrans right-right-of-way was negotiated after the machine stopped. It took approximately 8 months to gain approval to construct the rescue shaft and an additional 6 months to gain approval to resume tunneling. Had a contingency plan been negotiated and accepted by Caltrans before the bid, the project may have been completed approximately one year sooner. Special work procedures on previous projects have been negotiated with Caltrans to reduce the risk to Caltrans.

On another project the contractor was required to prepare a bid item for rescue shafts. The bid price included 2 weeks downtime for the microtunneling equipment before commencing shaft construction. The plan also required disclosure of the back tunneling method and cost. The contractor was allowed contract schedule extensions and costs based upon which of the above items were actually performed. The bid item was included in the bid evaluation but the value was not required to be bonded. The location of the rescue shaft and MTBM rescue was predetermined and disclosed in the specifications so the contractor could develop a comprehensive bid price and list the identified construction materials and methods.

4. CONSIDERATIONS FOR DESIGN ENGINEERS

The design engineer typically identifies potentially risky items based on the owner's priorities. Common risk factors include obstructions that prevent the MTBM from advancing, different subsurface conditions, flooding, misidentified or mis-located utilities, or a line/grade that inhibits the intended performance of the pipeline.

The design engineer can engineer solutions for some risk factors so contingency plans are reduced or are not required. For example, most MTBMs use circulating water-based slurry to balance the existing groundwater pressure and transport the excavated materials from the MTBM to the surface. The use of a groundwater dewatering system may, depending on subsurface conditions, draw the slurry away from the MTBM slurry circulation system and cause the excavation to fail. The design engineer may require watertight shaft design and construction as an engineering solution and thereby reduce the risk. A contractor cannot develop a contingency plan to respond to loss of slurry circulation short of a rescue shaft and the resumption of tunneling. In another case, the shafts may be located in dry ground and the tunnel may pass under a waterway. During tunnel excavation, the tunnel may connect the waterway to the shaft and if the shaft is not constructed using a water tight design, the shaft and MTBM may flood. The engineer, in this case, may require the shaft to be designed and constructed for full hydrostatic head with water tight shaft construction and without dewatering during tunnel excavation. This design and construction requirement does not require a contingency plan based upon shaft leakage. Once the MTBM and shaft are flooded then a recovery plan is required not a contingency plan. This issue must be resolved through engineering.

An example of successfully executed contingency planned for by the design team occurred on a project in California where petroleum distillates were known to have leaked into the ground. The need for a contingency plan was recognized and the specifications required that HAZWHOPPER-trained workers be on-site for the entire project and that the contractor use a slurry separation plant to reduce the potential volume of affected excavated soil and slurry. The volume of affected soil was estimated and the bid items included unit pricing for soil transportation and disposal. The owner assumed the cost for treatment and disposal of the process water once the solids were removed. This solution allowed work to progress more smoothly when the petroleum was encountered and mitigated disputes between the owner and contractor about who would assume the cost risk.

5. CONSIDERATIONS FOR CONTRACTORS

In several of the above examples the contractor was required to develop contingency plans that are required by the specifications and acceptable to the owner. The owner may, for some of the following incidents, require the contractor to monitor and record performance, submit contingency plans, perform remedial work, or let the contractor determine the need for a contingency plan.

The contractor needs to develop contingency plans for incidents that affect their performance and are not influenced by the owner. These items may include: operator issues, equipment maintenance, breakdowns, weather issues, loss of shaft integrity, pipe sidewall or joint failure, inaccurate or apparently inaccurate surveying, line and grade reference that appears to move due to heat in tunnel or shaft wall movement, loss of jacking pipe joint integrity where water or ground enters the tunnel, flooding, the project being stopped by a regulatory agency, relocating utility pipes that conflict with a shaft structure, and suppliers failing to deliver critical items in a timely manner. The contractor determines whether it is worthwhile to reduce risk, develop simple contingency plans, or to develop more extensive contingency plans to address some of these issues. The contractor should at least review the project for risks and consider contingency plans on a project-specific basis. Each contractor needs to determine the risk of an operational failure that is solely their responsibility and determine the risk to the project success through their financial, schedule, and legal risk analysis. The specifications cannot and should not tell the contactor how to perform their own risk analysis.

In order to prevent the MTBM from flooding, a contractor’s contingency plan might be as simple as placing a watertight plug across the open pipe in the jacking shaft at night to prevent a sump pump failure, storm water, or pipeline break from flooding the MTBM. The contractor may, in addition to the pipe plug, design a redundant sump pump system with a redundant power source to prevent flooding. In some cases the specification may allow the shaft wall to extend above the ground surface to prevent storm water inflows.

The contractor should include in their contingency planning how to implement the use of new technology and the expansion of their experience envelope. If a contractor has purchased a new guidance system, say a motorized theodolite or a gyroscope system, they may use their existing system in parallel with the new system noting the difference in readings and how the system responds to different steering actions or deflections before relying upon the new technology. The project owner may include a requirement in the specifications that requires the use of the new equipment on a low risk drive on the project before its use on a high risk drive. On a project currently scheduled to bid later this year with a drive length of approximately 1,800 feet, the specifications require the contractor to use a long distance guidance system on a drive with a more standard length of 1,000 feet before commencing the 1,800-foot drive. If a contractor is going to launch or retrieve a machine under higher water pressure than they have previously experienced, expanding their experience envelope, they may hold a brain storming discussion regarding impacts and potential issues and then develop operating plans ands procedures as well as contingency plans for these events. The contractor may also consider talking to other people with similar experience and performing a literature search.

6. CONCLUSION

A contingency plan is an essential tool for a successful microtunneling or trenchless construction project. If the design engineer, owner, and contractor develop well-thought-out and feasible contingency plans that include cost and schedule provisions, the project is likely to progress more smoothly and involve fewer disputes between the parties.