Using keyhole technology to access buried utilities: Advantages to right-of-way owners and users

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Received (in revised form): 21st April, 2010

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Abstract

This paper discusses the benefits realised by the City of Overland Park, KS and its utilities contractors by employing the keyhole, coring and replacement (KCR) method of exposing buried utilities under pavement versus the traditional jackhammer/backhoe/street repair method. For the city, major benefits include: a reduction in excavation impacts in terms of much smaller affected area; far less impact to surrounding pavement; a waterproof, maintenance-free, permanent street repair; and a reduction in impact to the motoring public. This is accomplished due to the significantly reduced repair time involved versus traditional excavation activity. It should also be noted that the KCR method does not require full-size street plates, so the problems that they present (eg unpleasant noise, decreased ride quality, interference with snowploughing operations) are also eliminated. Benefits to the utility and/or their contractor include significantly reduced street repair costs, reduced work crew and traffic control mobilisation costs, and less damage to facilities. Benefits to the entire community are greatly reduced carbon footprint by virtue of having fewer spoils to dispose of, virtually no production of repair materials, and fewer pieces of equipment required. Air quality is also much higher during the KCR activities as opposed to traditional methods.

Keywords: keyhole/keyholing, coring, reinstatement, daylighting, excavation impact reduction

Journal of Public Works & Infrastructure
Vol. 2, No. 4, 2010, pp. 00–00

1755–0955

INTRODUCTION

Overland Park is the city with the second largest population in the state of Kansas, and part of the Kansas City metropolitan area. It is a progressive community of approximately 173,000 residents and also a relatively young city, having incorporated in 1960. It is home to the Sprint World Headquarters Campus and a number of other corporate and business headquarters. Overland Park may soon be known as the home of national soccer tournaments as it recently opened a 12-field, all-weather synthetic turf soccer complex that is already booking regional and national soccer tournaments.

Overland Park encompasses 75 square miles (194km^2), eight of which are relatively undeveloped and still predominantly rural. It maintains 1,811 miles (3,042km) of roadways, which include four and six-lane arterials, two-lane collectors and residential streets. It also owns and maintains the storm-sewer system, street-light system and a fibre-optic network used for facility interconnectivity and operation of the 253 city-owned traffic signals and 80 CCTV cameras. Resident surveys consistently rank ease of movement (traffic flow) throughout the city, and the condition/ maintenance of the roads, as two of the most important factors in maintaining the quality of life that residents have come to expect. Keeping the streets open to traffic and protecting the quality of the road surface is where the keyhole, coring and reinstatement (KCR) process comes into play.

Prior to the advent of KCR, a typical excavation to locate a buried utility would have had (at least) a three-day impact on traffic in the form of lane closures during the day and the noise generated by vehicles driving over a street plate through the night. While KCR does still require a travel lane to be closed, this closure rarely lasts more than one day, with no further closures needed.

While the KCR process has already yielded numerous benefits for various utility/service providers, it has provided benefits to the municipality in which the process is used as well. From the perspective of the City's right-of-way (ROW) inspector/coordinator, the two most notable and noticed advantages are: (1) a reduction in excavation impacts (yielding both short and long-term benefits); and (2) a reduction in impact to the motoring public. Although Overland Park did not pioneer this method, it now mandates its use on all City streets by utility companies and their contractors.

It is a given that all buried utility infrastructure will at some time need repairs, and these repairs can range across a wide spectrum of involvement — from a simple valve repair to major line replacement. The vast majority of repair activities will fall into the 'point repair' category, and the KCR method is perfectly suited for this type of repair work. While this method is ideal for point repairs, the present paper will look at KCR in the context of exposing or 'daylighting' buried utilities.

Keyholing/coring and reinstatement means core drilling through pavement (using core diameters of 6–24 inches (15–60cm)); removing the core and using vacuum excavation to remove sub-grade material until the utility in question is found. Following utility repair, or other activity, the sub-grade is replaced and the previously removed core/coupon is then placed back into the corehole and secured with a bonding agent (the reinstatement step).

More detailed explanation of the KCR method is provided below.

CORING

Coring, the first step of the process, involves cutting and removing the circular core of pavement, also known as the coupon. Depending on intended purpose, the core can range from 6–24 inches (15–60cm) in diameter. These cores are then removed for the purpose of exposing utilities buried beneath the roadway (also known as ‘potholing’), and will range from 6 to 12 inches (15–30cm) in diameter. This diameter is adequate for the introduction of the suction hose and water/air lance used in the next step. Core diameters of up to 24 inches (60cm) are typically used for point repairs. Special long-handled tools have been developed, enabling repairs to be effected from the street surface.

Types of core drilling equipment also vary widely depending on the size of the core to be drilled. For smaller cores, generally up to 10 inches (25cm) in diameter, small handheld electric-powered units or a vacuum base electric-powered unit are used (Figure 1). Cores in excess of 10 inches require a larger drilling platform. This larger platform will include drills mounted on a tow behind trailer, skid-steer loader or mounted on a pickup or two-ton (1,800kg) truck chassis. Core drilling bits are manufactured from high-strength steel and tipped with diamond cutting surfaces[ed1].

After completing the drilling phase, the core must be removed. Once again, how this is accomplished differs depending on the core size. Smaller cores (<10 inches) can generally be removed by using two pry-bars on either side of the core and ‘walking’ the core up out of the hole (Figure 2). Larger (>10 inches) core bits generally have a pilot bit that drills a hole in the centre of the core as the core is being cut. A core-puller apparatus is then inserted into the pilot hole and the core is then lifted out manually or hydraulically[ed2].

Figure 1: Core being cut with manually operated drill

Figure 2: Core being manually extracted

KEYHOLING

The next step involves the removal of the sub-grade through the newly-drilled core opening in the pavement. This is accomplished by use of vacuum excavation equipment. For those unfamiliar with this process, vacuum excavation or 'soft digging' uses high-pressure water or air streams to break loose the compacted sub-grade, which is then removed with a high-powered vacuum.

The area of the material removed beneath the street surface can be significantly larger than the core diameter, hence the name 'Keyholing'. A cross-section of this removed material would appear as an inverted funnel. The ability to enlarge the search area without enlarging the size of the surface cut is one of the crucial elements of the KCR process.

When the utility line in question has been exposed, its location and depth are recorded, usually with the aid of GPS mapping, which gives the utility X, Y and Z coordinates. GPS mapping of utilities is a relatively new procedure, but is finding ever-increasing acceptance due to the accuracy of the coordinates and the fact that utility locations are no longer tied to a geographic landmark (eg distance from a kerb) that may change over time.

If the utility exploration was necessitated by planned construction, in particular construction employing trenchless technology methods such as horizontal directional drilling, best management practices would suggest that the excavation be left open until the utility has been crossed by new installation, allowing visual confirmation that the existing utility has not been damaged by the construction activities happening in close proximity to it.

REINSTATEMENT

The third and final step is replacement or reinstatement of the core. There are two options for backfill of the excavation: (1) reuse the vacuum-excavated spoil, or (2) use flowable fill (controlled low-strength material). Using the former option, material haul-off and replacement costs are eliminated, thereby reducing costs and making for a more environmentally friendly process. Overland Park, however, has chosen the latter option (Figure 3). Due to the potential irregular size and shape of the excavation, adequate compaction cannot be guaranteed using mechanical compaction equipment. Compaction testing, which is required in the absence of flowable fill, would likewise be very difficult to perform[ed3].

The term 'reinstatement' actually refers to the process of placing the previously removed core back in the core hole and bonding it in place. Modern bonding agents can provide a load-bearing strength of 50,000 lbs (22,680kg) within 30 minutes of placement, which is significantly higher than the American Association of State Highway and Transportation Officials (AASHTO) H-25 load-bearing safety standards. This also provides a waterproof seal which will eliminate water infiltration into the sub-grade. In addition, the repair is virtually invisible and therefore aesthetically pleasing.

Inevitably, a situation will present itself wherein the core or coupon fails to remain intact during removal. The most frequent cause of this failure is delamination or the separation of individual lifts or layers of

Figure 3: Flowable fill backfill being placed in core hole

asphalt which renders the core unusable. Should this occur, there are three options available to the contractor. These options address only the repair of the street profile and assume that sub-grade backfill has already been accomplished.

First, as a temporary measure, it is possible to use a hot or cold mix asphalt to fill the corehole until it can be permanently repaired. Another temporary fix would be to leave in place a cover plate (described below) until permanent repair can be effected. Secondly, a high early strength concrete could be used to fill the corehole in lieu of the failed core. The third and preferred method is replacement with a core of like material. This can be accomplished through a concept known as 'core farming'. Core farming involves constructing a small area of pavement of varying thicknesses in a remote location (eg the corner of the contractor's lot or yard). When the need for a replacement core arises, a new core of the correct diameter can be cut from the 'farm' and used to complete the repair.

BENEFITS TO THE CITY OF OVERLAND PARK

Reduction in excavation impacts

The major excavation impact is in the form of much smaller openings in the street. A typical traditional saw-cut/jackhammer excavation would be 2 square feet (0.18m^2)or larger. Given that most of the cores drilled have 6–12-inch (15–30cm) diameters, this represents up to a 90 per cent reduction in affected area. Additionally, the 'loss of confining stresses' (loss of lateral support that allows trench walls to sag into the new opening) that is typically encountered with any open trench cut is significantly reduced or eliminated.

Further problems encountered with traditional excavation and repair methods include cracking of surrounding pavement due to the percussive effects of jackhammers and open saw cuts at corners of the excavation. These are also eliminated with the KCR method.

As per the City's standard street repair detail, the 'traditional' excavation must be over-cut by 12-inches (30cm) through pavement depth on all four sides. High early strength concrete is placed to be topped with a 2-inch (5cm) asphalt overlay. Each of these joints between new and old asphalt are vulnerable to water infiltration. Over time, the asphalt overlay likely will deteriorate, becoming a maintenance issue. This is important in that the City's ROW management ordinance requires the utility/contractor to be responsible for their repair work for the two years following the completion of repairs. After this point, it becomes the responsibility of the City's street maintenance department, meaning that taxpayer dollars are being used. Cracks in the pavement may also radiate out from excavation corners. All of these problems are eliminated with the KCR method. The properly completed core reinstatement is virtually invisible, impervious to water infiltration and will be maintenance-free. The replaced core exactly matches the composition of the original road and also reinstates the road to its original weight-bearing capacity.

Finally, the core reinstatement represents the permanent repair. Winter in the Midwest can pose significant problems when trying to complete street repairs. Extended periods of snow, ice and sub-freezing temperatures will prevent any placement of asphalt (depending on mix design specifications, asphalt will require an air temperature of 50 °F (10°C) and rising to allow placement) and may also be sufficiently severe that concrete cannot be placed without danger of freezing. These conditions can easily push a typical street repair into the next spring, leaving the city to deal with a street plate and the problems it creates for snow-removal operations throughout the winter. Core bonding agents, meanwhile, can be safely used down to 32 °F (0°C), and as mentioned previously, should achieve adequate strength within 30 minutes. Regarding the pavement degradation issue, only now is the real difference in the two methods showing itself. The City has cores that were reinstated approximately four to five years ago, so it is now possible to make a comparison between traditional repairs that were completed during the same timeframe. The [ed4]accompanying pictures speak volumes about the ongoing repair requirements for the traditional square excavation vs the reinstated core — both repairs are over four years old (Figures 4 and 5).

As a function of the benefit of reduced excavation impacts, the City has realised a decrease in damage to the utilities that were being daylighted as well as other utility lines in close proximity. To use a medical analogy, if one likens the traditional jackhammer/backhoe method to open heart surgery, then the KCR method is like microsurgery. In the microsurgeon role, the vacuum excavation process rises above any other method of exposing utilities. Excavation size and shape can be very precisely controlled and if properly employed, both pneumatic and water systems are effective in spoil dislodgement without fear of damage to buried utilities. The same cannot be said of a backhoe or even a shovel. Each system has its own unique capabilities and the decision of which type to use is most dependent on the conditions under which the work is to be carried out (eg frozen ground, type of utility, spoil reuse, etc).

Figure 4: Traditional street cut after four years

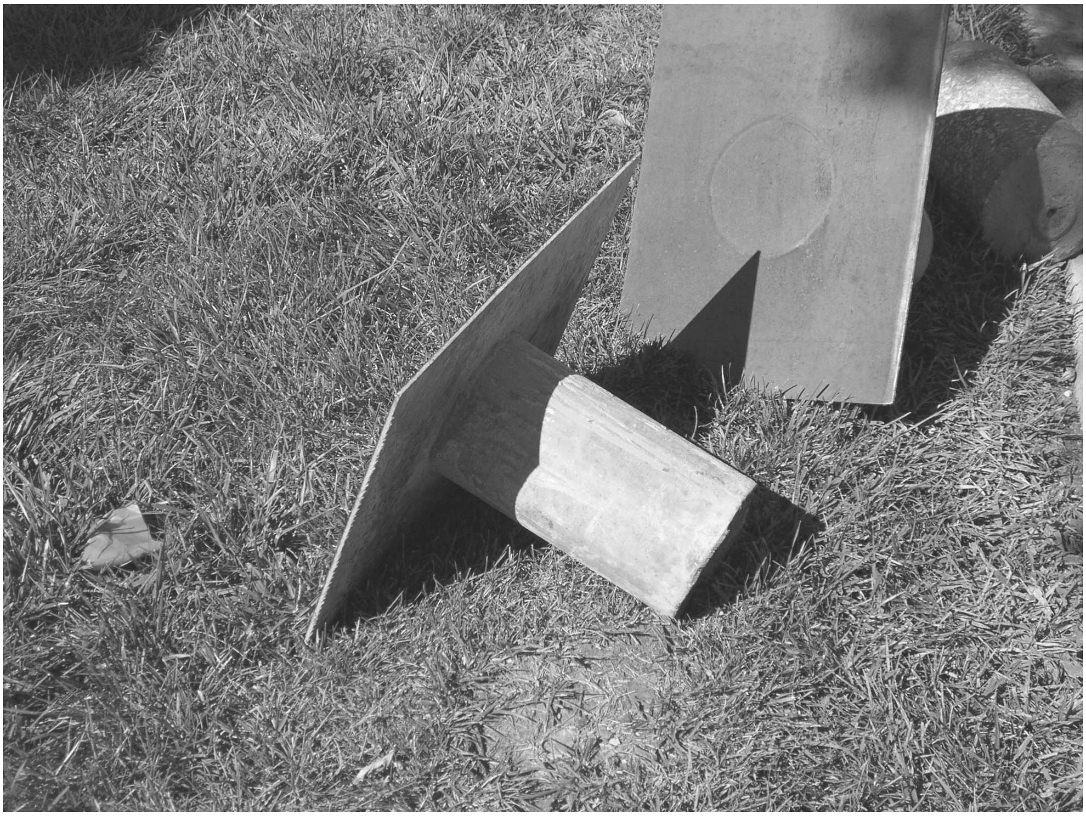
Figure 5: Reinstated cores after four years

Reduction in impact to the motoring public

If the corehole needs to be left open for an extended period, it is easily covered with a small (18 × 18 inch (45 × 45cm) steel plate with a pilot shaft of slightly smaller diameter than the corehole welded on the bottom side (Figure 6). This type of street plate is lightweight and relatively small, meaning that it can be easily placed by a single worker. Once in place, the street plate is virtually impossible to move by accident[ed5].

The rattling or banging noise that is created when a vehicle drives over a regular (full-size) street plate (Figure 7) is one of the most common complaints fielded by the City's ROW staff. With a full-size plate (typically 8 × 8 feet (244 × 244cm) or larger), it is impossible to place it in such a way as to keep it out of at least one wheel path within a travel lane. However, if the core can be drilled out of the normal wheel-path of vehicles, there is no contact between the cover plate and the vehicle, and therefore no noise. The City's guidelines require street plates to be 'ramped' with asphalt on both the leading and trailing edges as well as secured ('pinned') to the existing pavement. By using the small cover plate (Figure 8), both of these requirements are negated. This [ed6]also results in far fewer complaints from motorists and residents.

Figure 6: Small plate used to cover core hole



The second form of reduced impact to the motoring public is a substantial reduction in repair time and consequently much shorter-duration lane closures or other impediments to traffic flow.

As mentioned previously, a typical street repair consists of three steps: (1) flowable fill backfill is placed in the excavation from repair up to the bottom of existing asphalt street surface; (2) after enlarging by one foot (30cm) on all sides of the excavation through pavement thickness for the 'bench cut', a minimum 6-inch (15cm) thick concrete base is poured; and (3) a 2-inch (5cm) thick asphalt cap is placed.

To allow for proper cure time, each of these steps requires a minimum of one day — another three days that traffic control, equipment and work crews must be mobilised and another three days of lane closure that affects the motoring public. If the municipality imposes a lane closure or lane restriction fee, this is an added cost to the contractor. Contrast this with the one-day repair where KCR has been used — flowable fill can be placed and the coupon/core reinstated in one day.

COST CONSIDERATIONS

From the City's perspective, the KCR process is ideal. There is no immediate cost to the City of Overland Park and future maintenance costs are drastically reduced or eliminated. In tracking performance characteristics over the last five years, properly reinstated cores have exhibited a 0 per cent failure rate. From the perspective of the utility or their contractor, costs are substantially reduced when compared with the traditional excavation and repair methods.

A recent survey of local utility contrac-

Figure 7: Regular size street plate

Figure 8: Small cover plate in use

tors found that a 12-inch (30cm) core, drilled and reinstated resulted in a cost of $225. By way of contrast, a traditional utility exploration excavation, nominally with three × five feet (91 × 152cm) dimensions, using excavation (backhoe and jackhammer) and repair (concrete base followed by asphalt cap) methods resulted in a cost exceeding $1,000. This disparity is due to repeated mobilisations of equipment and work crews, repeated traffic control measure deployment, more and larger pieces of equipment needed, greater material disposal fees, and substantially higher repair material costs. This example assumes no cost for backfill time or material as this element is common to both methods.

For the contractor, additional cost savings can be realised due to the KCR process being much less labour-intensive (with generally a two-man crew) and the relative skill level required being less than that of an equipment operator. Consequently, crewmember training costs are significantly reduced.

MAKING IT WORK IN PRACTICE

Initial implementation of the KCR requirement was met with varying levels of resistance. The biggest element of the resistance, from the contractor/utility perspective, was the change in their routine. The 'we've always done it this way' attitude, unfamiliarity with the KCR process, not having the equipment necessary to use the KCR method, and fear of additional operating costs among other factors all combined to set the stage for the slow acceptance of this new method.

Faced with a new requirement, the resourcefulness of the contractor/utility community slowly began to surface. Two local companies that already provided core drilling and vacuum excavation services, albeit services that were not in high demand, suddenly found themselves in the middle of a new market. Other contractors, seeing the potential to diversify, invested in core drilling and vacuum excavation equipment and soon generated a revenue stream that had not existed previously.

Familiarity and comfort with the KCR process gradually overcame the apprehensiveness and it has now become second nature to those required to use it. Backhoe and jackhammer operators especially favour the method as they no longer have to operate in a very confined space while trying to avoid causing damage to adjacent utilities.

REDUCED CARBON FOOTPRINT

Research has shown that the carbon footprint from traditional open cut/repair procedures is as much as six times greater than that produced by using the KCR method.[1] In one year, it is estimated that more than 3.6 million pavement cut permits are issued nationwide in the USA for different-sized utility cuts ranging from a two × four feet (61 × 122cm) excavation to a sizable trench for sewer work. It has also been estimated that 20–25 per cent of these permits (roughly 800,000) were for utility cuts that could have been performed using KCR.

If the KCR process had been used in those 800,000 small-hole utility cuts, it would have eliminated the need to produce more than 2 million tons (1.8m tonnes) of asphaltic concrete for street repair. In addition, it would have eliminated approximately 2.8 million hours of work-zone traffic delays and saved more than 1.9 million gallons (7.18m L) of otherwise wasted fuel.

CONCLUSION

From the viewpoint of a right-of-way coordinator, there are many major advantages of the keyhole, coring and reinstatement method of utility explorations — not just for the municipality, but also for utilities and their contractors. These include fewer and shorter-duration traffic disruptions, virtually no damage to surrounding pavement, zero future maintenance, a much more aesthetically appealing repair, lower cost, reduced environmental impact, and finally a substantial reduction in the damage done to existing utilities. The disadvantages are . . . yet to be identified.

REFERENCE

1. E. Marshall Pollock (2009) *A Comparison of Carbon Footprint of Conventional Utility Cut Repairs and Keyhole Coring and Reinstatement*, Utility Industry Workshop, AASHTO Right-of-Way & Utilities Subcommittee Conference, Oklahoma City, 20th April.

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4TS: *Figures 4 and 5 near here*
5TS: *Figure 6 near here*
6TS: *Figures 7 and 8 near here*