UTILITY CUTS IN PAVED ROADS

FIELD GUIDE

U.S. Department
of Transportation
**Federal Highway
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FOREWORD

Just about every road and street in the country has utility installations nearby: lines, pipes, poles, conduits, cables, cabinets, manholes, meters—you name it. Whether overhead, on the surface, or underground, a wide variety of facilities accompany our local roadways and provide our communities with the electric, gas, water, sewer, telephone, cable television, and other services that we so much enjoy and rely on.

However, because local government agencies are required by law to accommodate utility facilities on their road and street rights-of-way, they are challenged to maintain traffic flow and road surface quality even while faced with frequent installations of new facilities as well as repairs and adjustments of existing ones. Of course, utility operations along road*sides*, or those that close a travel lane but do not involve a pavement opening, are usually less troublesome than those requiring cutting the pavement and excavating into the roadbed. Beyond disrupting traffic, the latter also risk leaving defects in the roadway if subgrade and pavement restoration are not properly carried out.

Poor-quality restoration typically stems from excavating improperly, using unsuitable backfill materials, placing or compacting the backfill inadequately, or patching the pavement incorrectly. The resultant defects include bumps, depressions, and ravelling—and, with further deterioration, potholes and complete base or pavement failure.

More than merely being unsightly and annoying to drivers, these defects can and do result in a rougher ride, vehicle damage, increased accidents, added road repair costs, and even shortened pavement life. Many other problems can arise if utility cuts are poorly made and restored—from minor inconveniences to major hazards.

This pocket guide focuses on making and restoring utility cuts in a timely and safe manner, with as little disruption of traffic and commerce as possible, and without leaving behind a defective pavement. Proper procedures, precautions, work steps, methods, equipment, and materials are highlighted. In addition, references are made to other sources of information on related topics.

Accompanying this pocket guide is a videotape presentation. It was produced for use in training seminars sponsored by the Technology Transfer Centers around the country. Alternatively, individuals may borrow the videotape and order copies of the pocket guide from their T^2 Center. The information they present is intended for a wide audience including road and street maintenance supervisors and crew members, utility company supervisors and crew members, utility contractor personnel, paving contractor personnel, and local elected officials having responsibility for public works—including utilities and roadways.

There is certainly diversity in the sizes, structures, and budgets of local governments. There is even a lot of variation in *who* performs utility work: Sometimes utility companies handle it all, including patching the pavement after the utility work is completed. In other cases utility companies contract out the patching to contractors specialized in pavement repair. In another scenario the government agency does the restoration, either with its own forces or with a contractor it hires for the purpose. Then the agency bills the utility for the work.

One thing doesn't vary: local government retains the ultimate responsibility, regardless of who actually does the work. This responsibility requires that utility cuts be prepared for, regulated, coordinated, monitored, inspected, and documented.

Section One
COORDINATION AND CONTROL

The coordination and control of utility cuts is affected by who performs the work: local government agencies, public and private utility companies, utility contractors, paving contractors. Yet, despite who does what—in terms of utility installations, modifications, or repairs—the local government agency has the ultimate responsibility for seeing that utility cuts are properly made and pavements are properly restored.

Agencies can ensure that utility work is properly carried out through:

- permit requirements,
- performance bonds,
- liability insurance,
- specifications,
- identification markings,
- inspection, and
- communication.

PERMIT REQUIREMENTS

All organizations or individuals planning construction on public roads or streets should be required to obtain a permit from the responsible government unit in advance. Permit forms may be simple or comprehensive, according to the agency's structure. Permit contents should typically include the:

- name of the organization or individual requesting permission—who?

- nature and purpose of the work to be done—what and why?
- location of the work along a road or street—where?
- timing of the work, the starting and completion dates—when and how long?
- requirements for work methods and materials, work hours, safety measures, and other issues.
- applicable special provisions.
- agency's fee, if any. Agencies that provide inspection services and pavement restoration work usually charge more than those that charge for handling costs only. Some agencies charge a flat fee; others charge by the length of street or road affected. Some agencies separate permit fee from inspection fee.

The permit process should make it clear that the local government agency is in charge of the roads and streets. Utility companies must understand that they are bound thereby to comply fully with all of the agency's requirements.

PERFORMANCE BONDS

A performance or surety bond is typically required of the utility company by the local government agency. It protects the agency in case the utility company's work is deficient or incomplete. The bond's value should be enough to pay for the agency to step in and correct or complete the work.

Recommendation: Agencies should hold such bonds for at least three years, or they should require utility companies to maintain *standing* bonds so that a new bond is not needed for each new cut.

LIABILITY INSURANCE

The local government agency should require the permittee to buy comprehensive public liability and property damage insurance that names the agency as "additional insured." This policy could also include coverage insuring that the permittee will perform the work to specification. Such performance insurance, also in force for at least three years after the work date, would be in lieu of the performance *bond.* Minimum coverage limits should be specified. Although variable from place to place, the limits should be at least $300,000 per claim occurrence. Legal counsel should always be consulted to establish a bond and insurance requirements appropriate to the community's needs.

SPECIFICATIONS

Agency specifications should guide both the permittee's performance of the work and the agency's inspection of it. A drawing or sketch should accompany the specifications to clarify how the work is to be done. In particular, the specifications should emphasize:

- work procedures and quality,
- promptness of performance,
- safety measures for workers and the public,
- the appearance of the completed patch,
- the smoothness of the patched surface,
- the endurance of the patch, and
- penalties for noncompliance.

In terms of *safety*, the permittee should be required to observe all local, state, and federal (OSHA) codes.

Care should be used in setting and invoking penalties. In the first place, penalties need to be reasonable; unreasonable penalties can result in hardship to utility customers. To penalize a non-complying permittee, an agency may:

- deny future permits until the current problem is resolved;
- levy fines that can be increased incrementally after the due date expires; and/or
- notify the bonding or insurance carrier of the problem.

Some agencies supplement their specifications with a one-year maintenance agreement or warranty. Such an agreement or warranty stipulates the circumstances under which any needed corrective work would be done, and who would do it.

IDENTIFICATION MARKINGS

In addition to utility *location* markings placed on roadways in advance of the work, *identification* markings are recommended. The local government agency should have each permittee spray-paint the utility company ID, in the appropriate color, next to the patched utility cut. The agency should also require that the permittee maintain the identification marking there for one year. This way, the agency—and the public—will know who is responsible for any settlement or failure of the patched surface. Such "advertising" should encourage better-quality patching.

Be sure, though, that these markings are not so wide as to conflict with permanent traffic markings and confuse motorists. One recommendation is to paint an approximate 50 mm by 100 mm rectangular patch on a nearby curbside, or a 75 mm-diameter disc at the cut's leading edge.

INSPECTION

Inspection of utility cut operations and the restored pavement surface will assure the local government agency that its specifications are complied with. By ordinance, regulation, or code, agencies should require inspection of the work as it progresses. Even so, the agency's policies and procedures should make it clear that inspections do not relieve the permittee of responsibility to the general public or of liability for loss, damage, or injury to persons or property.

Agencies should make advance notice procedures a part of the permit process. By these the permittee would be required to notify the proper authorities before starting to excavate, allowing the agency to schedule inspections.

Inspectors should be empowered to suspend work if it does not comply with government codes, specifications, or policies.

COMMUNICATION

Timely and effective communication is indispensable in the coordination and control of utility cuts. The forms of communication may consist of the:

- development and publication of agency policies, regulations, specifications, and procedures—and their dissemination to all interested parties;
- formation of Local Utility Coordinating Committees* to enable personnel of utility companies, contractors, and local government to get acquainted, discuss plans and problems, and coordinate activities during regularly scheduled meetings;
- timely notification to the media and to all emergency response agencies (including *911)* of scheduled utility cuts that will significantly affect traffic flow—with lanes and extent of roadway affected, suggested detour routes if applicable, and expected duration of the work; and
- establishment of procedures for handling emergencies—who to contact, in what cases, and how to do so.

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* Guidelines on how to organize local coordinating committees are available through the APWA's Utility Location and Coordination Council (*ULCC*).

Section Two
LOCATING & MARKING EXISTING UTILITIES

Most states have laws requiring anyone who intends to excavate to first determine what underground utility facilities are in the area where digging will be done. Buried pipes, cables, and all other facilities must be located as accurately as possible and then temporarily marked on the surface as a guide to the excavator. There are two reasons for locating underground utilities:

- to uncover them in order to make repairs or modifications. The work crew needs to know exactly where to dig to save time and effort in excavation and to disturb the pavement as little as possible.
- to avoid damaging or disrupting facilities that are close to the one to be repaired or modified, or those in the vicinity of a new facility to be installed.

So for a crew to work on an existing facility, it obviously must first locate it. And for a crew to either work on an existing facility or install a new one, it also must know where any *other* facilities are to avoid contacting them.

PRESERVATION AND PROTECTION

The reasons for avoiding contact with other utility facilities range from the desirability of maintaining good relationships and preventing inconveniences...to the necessity of protecting lives and property.

Facility Damage

Start with the possibility of damage. Utility companies have a big investment in their underground facilities. Mistakes during excavation can be expensive to correct. Even minor damage is costly because other workers, equipment, and materials may have to be brought in; additional excavation may be needed; and inspections and tests may be required to verify that the facility is again functional and safe.

In terms of business relationships, it's just not good practice for one utility company to harm another's facility. "You don't bother theirs and they won't bother yours" ought to be a golden rule for utility crews. No matter how unintended, incidents can strain the working relationships between organizations that should be striving for cooperation.

Service Disruption

Damage to utility facilities during excavation will likely disrupt utility service to nearby customers. So, besides whatever expense results from the physical damage to the facility, there often is the added cost of service interruption to residential, commercial, and/or institutional users. Cutting off electricity, gas, water, sewer, telephone, or other services may result in mere inconvenience or actual financial loss. One thing is certain in all cases: interruptions to service are never pleasing to anyone affected by them.

Life and Property Threat

But beyond facility damage and service disruption, mishaps during excavation can threaten the health and lives of workers and others in the vicinity, and result in extensive property damage. In particular, accidental contact with gas and electric facilities have often produced deadly consequences: fires, electrocutions, explosions—very real disasters resulting from a failure to know what's under the ground before digging.

Incident Reporting

To monitor and reduce accidental contacts with other facilities, some agencies require work crews to report any and all such incidents—even when *apparently* no damage has been done.

LOCATION SYSTEMS

One-call systems are the most widespread programs for locating existing underground utility facilities. These systems consist of a communications center established by two or more utilities, governmental agencies, or other operators of underground facilities. Members who are owner/operators of underground facilities share information that benefits all participants. Nearly all of our states and several countries have their own one-call centers. They operate under various working names or slogans: "Call before you dig," "Diggers Hotline," "Call Miss Utility," and so on. In addition to making technical information available to participants, one-call systems endeavor to alert and educate all parties about the necessity of knowing what's under the ground before starting to dig.

Basically, one telephone call to a center enables excavating contractors and private citizens alike to begin the process of identifying and locating the underground facilities at the location in which they are interested. The caller learns what types of facilities are at the location in question, who owns/operates them, and how to get them marked.

The utility companies or locating services that do the marking typically use sophisticated equipment to detect the positions of underground facilities. Usually this involves detecting radio or audio frequencies that the locator itself transmits directly through the facility (*conductive*) or indirectly to the facility (*in-*

ductive). Or it involves detecting the facility's own magnetic field (*passive*) without transmitting any frequency to the facility.

In locating *damaged* facilities, the break itself can often be detected by this technology of detecting transmitted frequencies.

The technology described above is used to determine and mark the alignment of underground facilities. However, it does not determine the width or depth of facilities with certifiable accuracy. Where this information is desired before excavation begins, or where verification of the alignment determined by one of the above methods is desired, *vacuum excavation* technology may be used. Vacuum excavators provide low-impact, non-destructive digging that will pinpoint the exact location of an underground facility. This is especially valuable at locations where underground facilities are congested.

Subsurface Utility Engineering (*SUE*) is an engineering process that incorporates new and existing technologies to accurately locate and map underground utility facilities during the early development of a highway project. Its components include designation, location, and data management. This system combines the use of:

- **designation**—using surface geophysical techniques to determine the existence and horizontal position of underground utilities to produce two-dimensional horizontal mapping information;
- **location**—using nondestructive digging equipment (particularly vacuum excavation equipment) at critical points along a subsurface utility's path to determine the precise horizontal and vertical position of buried utilities—providing three-dimensional horizontal and vertical mapping information; and
- **data management**—to survey the two-dimensional and three-dimensional information and enter it into systems such as CADD. The resulting information can then be used to examine the feasibility of project options and to

plan ahead to eliminate conflicts. The final result is a set of plans containing accurate locations of underground utilities.

TEMPORARY MARKINGS

The locations of underground facilities have to be effectively communicated to excavators through the use of temporary markings. These usually are spray-painted on pavement surfaces, as well as on adjacent shoulders, curbs and gutters, sidewalks, etc. The *Uniform Color Code* should always be used.

UTILITY LOCATION & COORDINATION COUNCIL **UNIFORM COLOR CODE**	
RED	Electric power lines, cables, conduit and lighting cables
YELLOW	Gas, oil, steam, petroleum or gaseous materials
ORANGE	Communication, alarm or signal lines, cables or conduit
BLUE	Water, irrigation and slurry lines
GREEN	Sewers and drain lines

Handy pocket cards illustrating the *Uniform Color Code* can be purchased from the American Public Works Association. Be sure that you have an up-to-date card, use the standard colors, and follow current marking guidelines.

Among the guidelines you should follow are these:

- Wear a safety vest and always be careful when working in the traveled way. Avoid inconveniencing traffic.
- Besides indicating alignments and changes of direction, with the temporary markings, also show the name, initials, or logo of the company that owns or operates the facility.
- To avoid confusion, use *white* only to mark the boundaries of proposed excavations on the pavement surface, or to indicate the routes of proposed subsurface lines.
- Make markings narrow enough that drivers are not likely to confuse them with *permanent* pavement markings—lane lines, turn arrows, crosswalks, etc.
- To increase the visibility of pavement markings, place temporary stakes or flags to supplement them.
- Re-mark faded or obliterated markings to restore their visibility.

To avoid the undesirable consequences of accidental contact with underground utility facilities during excavation, utility companies and contractors must give high priority to locating and marking existing facilities thoroughly and accurately. It cannot be stressed often enough or strongly enough that excavators should never start digging until they know for sure where all the underground utilities in the area are located.

Section Three
TRAFFIC CONTROL

Proper traffic control allows traffic to move smoothly and safely through utility work zones; protecting not only vehicles and their occupants, but also pedestrians, workers, and the utility facilities themselves. It also minimizes agency liability for mishaps.

Motorists don't always distinguish between regular roadway repairs and improvements and utility work that takes place in the roadway. They tend to blame local government for congestion and delays caused by improper traffic control even when a utility company or contractor is responsible. So it behooves the local agency to concern itself with how traffic is controlled by all those it permits to open its pavements.

National, state, and local standards must be followed in planning, setting up, and maintaining traffic control devices and procedures. Common sense must be brought into play as well.

REFERENCES

Local government agencies, utility companies, and contractors should have available and use routinely the appropriate guidelines for traffic control:

- Manual on Uniform Traffic Control Devices (MUTCD), Part VI, of the U.S. DOT Federal Highway Administration.
- Additional state and local agency standards.

The handbook titled "Work Zone Safety—Guidelines for Municipalities, Utilities, and Contractors" is a useful pocket-size resource. Based on the MUTCD, it contains guidelines and examples of typical traffic control applications, with particular emphasis on short term work sites on roads and streets in rural areas and small urban areas. It was developed by the University of North Carolina Institute for Transportation Research and Education. Information on this publication is available through your Technology Transfer Center.

Utility companies and contractors should be encouraged to consult the standards frequently, and also to equip their crews with such handy references as the one just cited to get the needed information out to the field where it can be put into consistent practice.

SETUP

Traffic control for utility work must consider the work zone, the signs and devices needed to warn and direct motorists, the need for flaggers, and the measures for protecting pedestrians.

Work Zone Components

Each utility work site should be viewed as a traffic control *zone* —as measured from the first advance warning sign to the point beyond the work area where traffic is no longer affected.

Traffic control zones are made up of five parts:

- **ADVANCED WARNING AREA**—tells traffic what to expect ahead.
- **TRANSITION AREA**—moves traffic out of its normal path.
- **BUFFER AREA**—provides protection for traffic and workers.
- **WORK AREA**—contains the work itself as well as workers, equipment, and materials.
- **TERMINATION AREA**—lets traffic resume normal driving.

Signs and Devices

Traffic control signs and devices must be of the standard color, shape, size, message. They must be always be appropriate for the situation.

Sign and device placement should be based on proper spacing —according to the posted speed limit—and on visibility by motorists. Horizontal and vertical curves in the roadway should be taken into account; and roadside obstructions, distractions, and even shaded areas should be considered in determining where to position the signs and devices. Three flags placed at the top of each sign enhance visibility.

Signs that are used after daylight hours must be either lighted or retro-reflective.

Flaggers and Flagging

Flaggers must be properly equipped, attired, and trained in their duties and the procedures they are to follow. Proper equipment is a standard stop/slow paddle. Flags should be discouraged for planned utility work. Correct attire includes safety vest, hard hat, and workmanlike clothing and footgear.

Hand and arm movements, as well as other "body language" are always significant to motorists' interpretation of flagging. A flagger's poor posture or diverted gaze may transfer a casual attitude to drivers. Flaggers need to be alert, purposeful in their actions, and polite in their communications with the public.

MAINTENANCE OF DEVICES

Once traffic control signs and devices are set up properly they need to be kept that way in order to function effectively. If they are blown or knocked down, turned around, or otherwise blocked from drivers' view, it's as if they aren't there at all. Someone needs to check them occasionally. More often in windy conditions.

Sign and device legibility is greatly diminished by dirt. Grimy ones should be cleaned enough to restore visibility and retro-reflectivity. Those that have simply worn out should be replaced.

Driver trust in signs and devices, and respect for work zones, begin to wane when traffic controls are left in place after the work has ended...or when the conditions they describe no longer exist. After a few such deceptions, motorists may entirely ignore advanced warning signs and proceed through work zones without due alertness.

Signs and devices must be removed promptly after the work ends. Signs should be covered or turned aside when their message no longer applies. Leaving a "Flagger Ahead" sign in place after flagging has ceased is just plain bad practice. Worse still is warning traffic to change lanes by leaving a "Lane Closed Ahead" sign in place even though the channelizing devices were removed from the former closure hours earlier. Such oversights create bad will as they misinform and confuse.

SPECIAL CONTROL MEASURES

Special measures may sometimes be called for:

- steel plates to reopen lanes to traffic even before trenches are backfilled and pavements are restored.
- same-day patches, one lane at a time, when ADTs are high.
- restricting utility cuts to certain days or specific hours of the day...or to nighttime hours.
- detours when the roadway cannot be kept open.

A word about steel plates: Overall, motorists ought to approve of the use of steel plates—since they allow lanes that otherwise would remain closed to be open to traffic. Unfortunately, improper use often defeats the public's would-be approval. For example, plates that aren't seated properly tend to stick up and pose a hazard for vehicle tires and bicycles...or rock and make loud noises when tires run over them. They may even be displaced due to this action.

Local agencies should consider requiring that steel plates:

- overlap the pavement surface no less than 305 mm on each side,
- have firm support around all edges,
- be blocked in with bituminous concrete wedges around plate edges, and
- be pinned or otherwise fastened to the pavement to keep them from moving.

Section Four
PAVEMENT CUTTING

How pavements are cut and removed to enable utility work to take place will later affect the quality of the pavement restoration. The pavement cut will be restored either with a temporary patch initially or with a permanent patch outright. But in any case, care should be taken to lay out the cut correctly, cut and remove the pavement properly, and avoid damaging the pavement surrounding the cut.

LAYOUT

Laying out utility cuts involves marking the utility's location, determining the shape and dimensions of the cut, and outlining the cut on the pavement surface.

Basic Guidelines

Utility trench dimensions must allow room for the utility facilities, workers and equipment, and the work itself. This means not only the equipment and work involved with the installation, repair, or adjustment of the utility, but also the operations required to successfully backfill and compact the trench and restore the pavement. So, as a rule, trench widths should equal the width of the utility facility plus a minimum of 460 mm of space on each side of it. This is a minimum because other factors— such as shoring or bracing—may demand a wider cut.

Overall, however, it's desirable that utility cuts be as narrow as possible to minimize the size of the pavement patch when the work is complete.

As mentioned in Section One, utility cut outlines should be marked in *white* to distinguish them from utility markings in the uniform color code colors. Alternatively, the routes of proposed subsurface lines may also be marked in white. Spray paint is the typical marking medium.

Concrete Pavements

Typically, local agencies require that utility cuts in concrete pavements (including concrete bases overlaid with a bituminous surface) be made wider and longer than the width and length of the trenches. These additional amounts of pavement that are cut and removed will later allow the concrete patches to span the trenches and be supported on undisturbed soil, as shown in Figure 4-1. Requirements for these added cut dimensions range from 150 to 600 mm beyond each trench edge, depending on the agency's specs.

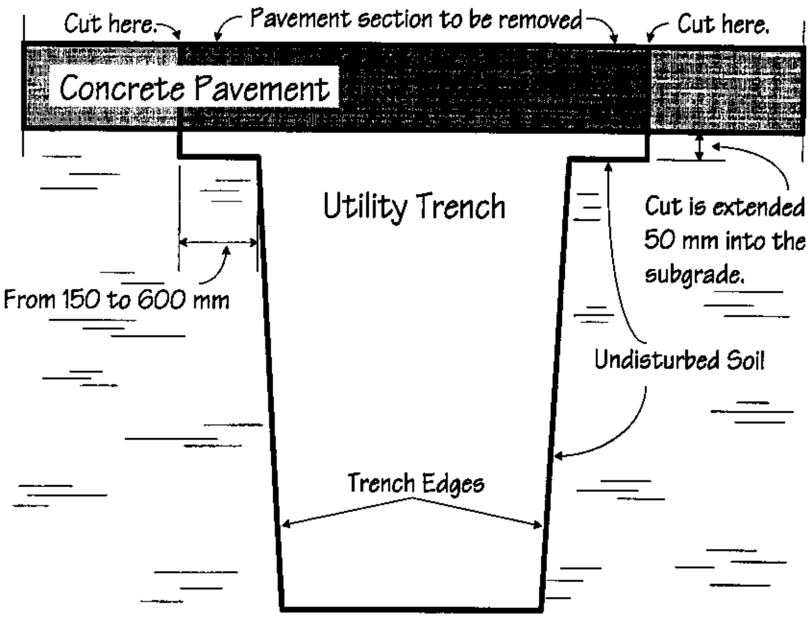

Figure 4-1: Cutting Beyond Trench Edge for Concrete Patches

Some agencies call for concrete bases to be constructed in the patches for *all* utility cuts—even those in all-bituminous pavements. So for them, extending cut boundaries beyond the trench edges is standard procedure.

Also affecting the size and shape of utility cuts on concrete pavements is the location of the cuts relative to existing pavement joints and edges. Reason: Repair sections must not be too close to the joints or edges or else small, independent sections of pavement will result. These tend to crack and break away under traffic loads. So the solution is to either:

- ensure that repair sections maintain a minimum distance from pavement joints and edges or, when they can't,
- extend repair sections to the joints or edges.

Agencies may specify, for example, that the minimum distance be as little as 600 mm as measured from the repair section's edge...or as much as 1.8 m as measured from the trench edge. In any case, whenever the specified minimum distance cannot be maintained, the repair section should be extended all the way to the pavement joint or edge. Because of this, some utility cuts may have to made substantially larger than they otherwise would.

Typical situations for laying out utility cuts on concrete pavements are described below, and depicted in Figure 4-2:

- **Full-width cuts (1)**—extending from curb to curb or pavement edge to pavement edge—should be at least 1.8 m wide. If a transverse joint falls within the cut, it will *not* need to be replaced when the cut is patched. Instead, the edges of the repair section will act as new transverse joints. However, the longitudinal joint will need to be restored during patching.
- **Single-lane cuts (2)**—typically extending from pavement edge to centerline—also should be at least 1.8 m wide. When the cut is later patched, a transverse joint located within the cut will need to be restored to its original posi-

tion to match the transverse joint in the other lane(s). Also, the longitudinal joint at centerline will need to be maintained.

- **Cuts at the edge of the pavement (3)** should be at least 1.2 m wide to maintain a stable pavement edge. Again, when the cut is patched, any transverse joint located within it will need to be restored to its original position to match the rest of the existing joint.
- **Interior cuts, with an adjacent joint, (4)** require no minimum width. If they *encompass* a joint, it will need to be restored to its original position to match the rest of the existing joint.
- **Interior cuts, with*out* an adjacent joint, (5)** also require no minimum width. As always, however, maintain at least 0.6 m distance to the nearest joint or edge—or else extend the repair section to it.

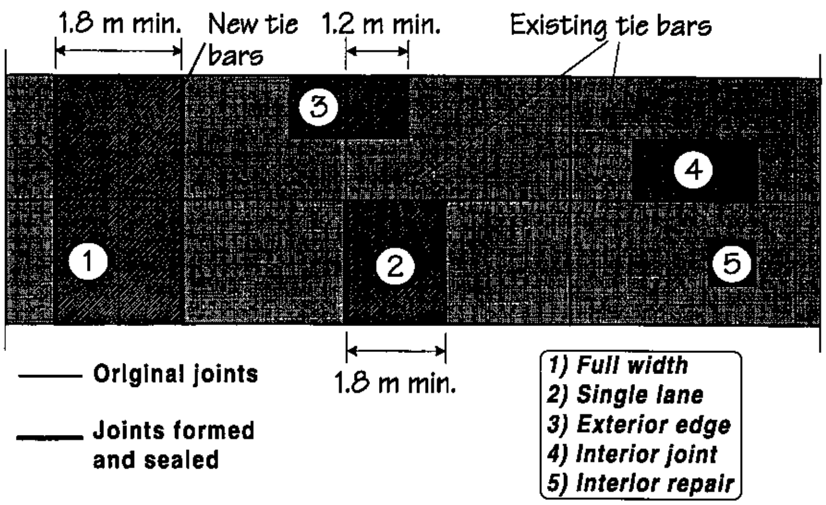

Figure 4-2: Repair Section Layouts in Plain Concrete Pavement

CUTTING

Pavement cuts should be straight and vertical. They should be made without damaging the surrounding pavement.

Bituminous Pavements

Bituminous pavements may be opened by sawing, mechanical hammering, or a combination of the two. A backhoe bucket, however, should *not* be used to break out the pavement directly—it would severely disturb the surrounding pavement and leave a jagged, ugly cut. The cuts should be neat, straight, and vertical. Otherwise, when the cut is later patched, the patch will have a difficult time staying put or forming a good seal with the surrounding pavement.

One of three cutting procedures is recommended:

- Saw the pavement full-depth.
- Saw the pavement partial-depth, cutting to one-third the pavement thickness or at least 50 mm. Then use a mechanical hammer to cut the rest of the way down. The hammer should have a cutting edge of at least 100 mm.
- Use a mechanical hammer alone to do the cutting, but be sure to "square" the cuts before making final repairs. The edges of all cuts need to be vertical and straight.

With the perimeter of the repair section cut all around, the rest of the pavement can be broken out and removed with shovels, mechanical hammers, backhoe buckets, or front-end loader buckets. The pavement debris should be hauled from the work site as soon as possible, unless it will be reused.

Concrete Pavements

Concrete pavements should be opened by saw-cutting the marked boundary to a depth of no more than 40 to 50 mm regardless of slab thickness. The purpose of this saw cut is not to remove concrete, but to produce a straight, vertical face that will not spall. See Figure 4-3.

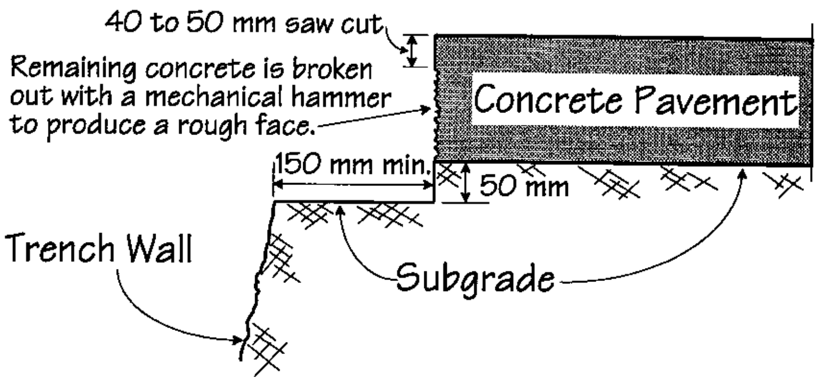

Figure 4-3: Cutting Concrete Pavements

The concrete below the saw cut should be broken out with a mechanical hammer to make a rough face. When the cut is later patched, the concrete placed against this rough face will tie the patch to the original pavement by "aggregate interlock."

A typical recommendation is that the cutting and breaking out should go to the bottom of the concrete slab and then another 50 mm into the subgrade. When placed later the concrete patch will thus have a thickness equal to the existing pavement depth plus 50 mm, giving it added strength.

To help remove the concrete without spalling the face of the surrounding pavement, additional less-deep saw cuts should be made a few millimeters inside the outline saw cut and parallel to it. These shallower saw cuts provide a toehold for the breaker point of the mechanical hammer.

As with bituminous pavements, the remaining concrete pavement can be broken out and removed with shovels, mechanical hammers, backhoe buckets, or front-end loader buckets. Broken pieces of the slab should be hauled away from the work site as soon as possible, assuming it will not be reused.

Section Five
EXCAVATION

Excavation for utility cuts—like all excavation—involves the removal of in-place subgrade soils and other materials in order to accomplish the necessary work. It also involves either the disposal of some or all of the removed materials, or the temporary storage of some or all of them for later reuse as backfill.

BASIC PROCEDURES AND PRECAUTIONS

After the marked portion of pavement has been cut and removed, excavation may proceed. Every aspect of it needs to be viewed with safety in mind.

Locating Underground Facilities

It cannot be stressed too much: *Locate and mark all underground utility facilities in the vicinity of the excavation before starting to dig.* In highly congested areas, consideration should be given to using non-destructive vacuum technologies to locate, uncover, and repair existing facilities. The more progressive localities using these technologies find that the extra work up front typically saves time and money.

Avoiding Contact with Facilities

As much as it's important to avoid contacting underground facilities, it's likewise necessary to avoid contacting surface and overhead facilities. The fact that above-ground facilities are visible doesn't mean that avoiding them is always easy.

It's often tempting for backhoe operators to try to excavate right up to a facility. But all the skill and experience an operator might have do not offset the risk of excavating too close.

Excavators should observe the "location tolerance zone" when excavating close to facilities. This zone consists of a buffer zone 0.46 m wide around the facility. Inside this zone the excavating should be performed with hand tools until the marked facility is exposed.

In addition, in spite of the best locating efforts, crews should always be alert for unanticipated facilities under ground.

Handling Surface Encumbrances

Surface encumbrances are above-ground structures or other objects—such as signs, trees, or shrubs—that might be in the way of the excavation or fall into the trench. These all need to be identified and then moved or supported.

Verifying Warning Systems

In the broadest sense, everything from warning signs for drivers and pedestrians to backup alarms on the backhoe/loader is a warning system...and each has an important purpose. All such systems should be properly set up and fully functioning.

Preventing Cave-Ins

The most hazardous activity for construction workers is working in a trench. Many workers are killed every year by cave-ins. It is imperative that OSHA regulations be adhered to during the excavation stage.

Trenches deeper than 1.2 m must always be shored or braced. Loose soils may require shoring or bracing at lesser excavation depths. Shoring and bracing should always be installed from the top of the trench down, and removed from the bottom up.

Gathering Information During Excavation

Excavations in roadways afford an opportunity for the government agency to gather useful information, if desired. Many agencies overlook this aspect of utility cuts. One type of information relates to pavement thickness and other data pertaining to pavement management systems. Another category of information concerns the soils encountered during excavation.

Maintaining Proper Distance from Trench

Equipment and spoil banks of excavated materials should both be kept at least 0.6 m away from trenches, to keep them from falling in.

Ensuring Proper Access and Egress

During excavation, both workers and their equipment should have proper ways of entering and exiting trenches that are deeper than 1.2 m. Such means of access and egress may be ladders, stairways, or ramps placed so that no one has to go more than 7.5 m within the trench to reach one.

Protecting Workers from Falling Loads

Removing loads from trenches or lowering them into trenches should not pose hazards to workers. Workers should not enter or remain in a trench while there is any possibility of a falling load. And always, trenches are "hard hat areas."

Protecting Workers from Hazardous Atmospheres

"Hazardous atmospheres" means unsafe air. Dust and equipment fumes can be worse than merely annoying if they're in high enough concentrations. The real culprits, however, are gases that may be toxic, flammable, or asphyxiating. Such gases may leak from utility facilities or be released from the soil during excavation.

Whatever the source, their presence needs to be detected and the workers need to be protected. Effective means of detection should be available and the crew should know how to use them. A calibrated, direct-reading instrument should be used to indicate when there's not enough oxygen in the trench, or when a volatile or toxic gas is present.

When unsafe air is likely, emergency breathing equipment should be close at hand. But, someone on the job needs to have been properly trained to operate it. It may be necessary to have other emergency rescue equipment nearby, according to OSHA regulations and agency or company policy.

Excavating in Wet Conditions

Well points or other means of removing water from trenches or diverting it around them may need to be used to provide proper, safe working conditions during excavation.

TRENCHLESS TECHNOLOGIES

Technologies that enable utility facilities to be installed and maintained without the need for trenching across roadways have many advantages. Obviously they avoid the cutting and restoring of the pavement structure and the interruption of traffic. Of course, they're not always feasible or practicable from an engineering or budgetary standpoint.

Jacking and boring are methods of installing pipes and cables beneath roadways. Although they have been in use for some time, they have been improved through the years. When facilities are installed inside sleeves or casings, adjustments and repairs can be made without the need of [re]opening the pavement and excavating a trench. Instead, access can be made from the shoulders or roadside.

More recent advancements in trenchless technologies include procedures such as live insertion, small hole vacuum excavation technology, service terminations utilizing specially designed extension tools, *pipe-lining*, and *pipe-bursting*. They replace existing pipes without having to first remove them.

All such technologies should be considered as alternatives to conventional trenching when costs and other factors permit.

Section Six
BACKFILL

Generally, backfilling a utility cut trench means putting back the material that was removed during excavation, and compacting it sufficiently. Sometimes, however, the properties of the soil excavated from a trench make it unsuitable for use as backfill. In these cases, select material must be used instead.

On the other hand, an alternative to conventional soil backfill is increasingly used in utility cuts. It's *non-shrink fill,* also called *unshrinkable fill* or *flowable fill.*

SOIL BACKFILL

Basically, fill material should match the subgrade material of the rest of the roadway (assuming that the latter is suitable). Usable backfill includes granular materials, clay, sand, and cement-stabilized sand.

Especially in urban areas, a wide assortment of unsuitable materials may be uncovered during excavation. The older the area the more likely it is that excavation will turn up such objects and materials as large rocks, cobblestones, bricks, railroad ties, and other remnants of buildings, abandoned utilities, and other bygone public works. Other undesirable materials include muck, plant matter, frozen lumps of earth, and all sorts of debris. Naturally, any such materials must *not* be included with the backfill, but must instead be removed from the work site and discarded.

Bedding materials placed in the bottoms of trenches to support pipes are typically different from the rest of the backfill—for example, gravel, sand, or stone dust. Similarly, the top portions of trenches may be filled with a different material—for example, crushed stone—to replace the base course material removed during excavation. Of course, the ultimate objective is to rebuild the disturbed portion of the road or street, by replacing the subgrade, base course, and pavement.

Soil backfill should be placed in layers, or "lifts," typically with a loose depth of about 150 mm.

The moisture content of the backfill material will affect compaction and density. It may be necessary to moisten the material before it is placed in the trench.

Crews often place metallic identifying tape between backfill lifts and above and in line with the utility facility. This tape makes future relocation of the facility much easier.

COMPACTION REQUIREMENTS

The in-place backfill needs to form a dense mass that will not settle under its own weight or from pavement or traffic loads. Placement effort alone will not produce sufficient density; compactive effort is necessary. Typically, local agencies specify that utility cut backfill be compacted to 95% of maximum density, as determined by standard proctor tests.

Compactive effort is supplied by compaction equipment. Manually operated gas-powered or pneumatic-powered tampers are typically used to compact utility trench backfill. Larger, self-propelled equipment may be used where trench width allows.

Proper compaction requires that each loose lift of backfill material be separately compacted as it's placed...until the final lift reaches the elevation of the top of the subgrade.

The only way of knowing for sure that adequate density has been achieved is through density testing. Nuclear gauge may be the most common means of density testing, but sand cone and Clegg testing meter are other typical methods. Local agencies vary not only in *how* they test backfill density, but also *how frequently* they test it. For that matter, they vary in whether they test for density at all. Agencies that do not perform density tests on their utility cut backfill should strongly consider doing so. The alternative is to rely on stricter compaction requirements: for lift thickness, type of compaction equipment, and number of compaction passes by the equipment.

FLOWABLE FILL

Flowable fill is an alternative to conventional soil backfill. It's a concrete-like mixture, minus the coarse aggregate and with enough water to make it flow freely.

The advantages of flowable fill over soil backfill are that it:

- can be placed in narrower trenches,
- is placed easily and quickly,
- readily flows into and fills up hard-to-reach areas,
- displaces any standing water,
- self-consolidates,
- attains maximum density,
- doesn't settle,
- can be dug up, and
- requires less inspection.

There are *dis*advantages as well. Flowable fill may not be available in some locations, or at all times. In addition, it must be protected while it sets up (hardens).

Speaking of setting up, probably the best means for protecting in-place flowable fill is by placing steel plates over it. Then traffic can be maintained while the material sets up.

Section Seven
SURFACE RESTORATION

After backfilling the trench, the work crew continues with its repair of a utility cut in a paved road by restoring the surface—whether bituminous concrete (asphalt), portland cement concrete (p.c.c.), or bituminous over p.c.c. base. Pavements disrupted by utility cuts should generally be replaced with materials and structure matching the original. The objective is a patched road or street surface that is sound, stable, and durable. The restored pavement should blend with the surrounding surface both in appearance and riding quality.

Basically, there are two kinds of pavement patching: temporary and permanent. However, within a short time temporary patches should be replaced with permanent ones.

TEMPORARY PATCHES

Despite their temporary nature, these patches ought to be constructed well enough to not settle or begin disintegrating during the short run. Cold bituminous mix is typically used to make them, whether in bituminous concrete or p.c.c. pavements.

If the pavement was cut properly in the beginning, the patch area will have at least fairly straight sides with clean, vertical edges. However, it may be necessary to clean up and/or trim the edges a bit. Of course, the top of the subgrade should be at the proper grade, well-compacted, and free of debris. An asphaltic prime coat may be desirable.

Then, the bituminous mix should be placed in thin lifts and thoroughly compacted. Enough mix should be placed and compacted in the top lift to leave the patch slightly above the level of the surrounding pavement. Thereafter, traffic will further compact the patch and make it flush with the surrounding pavement.

Obviously, if *too much* mix is placed, that final lift will end up as a bump. If *too little* is placed, traffic compaction will form a dip in the road. Even though it's temporary, the patch should be neither a bump nor a dip during the weeks or months that it serves until a permanent patch replaces it.

PERMANENT BITUMINOUS PATCHES

Permanent bituminous patches may be made immediately upon completion of the trench backfilling operation, or sometime later to replace temporary patches. In the latter case, they may or may not be made by the same crew from the same contractor/utility/agency that made the temporary ones, as discussed in Section One. But no matter *who* does the work, it should be of good quality to ensure neat, smooth, and durable patches.

Preparing the Patch Area

The first step in making the permanent patch—in a *bituminous concrete* pavement—is to mark the outline of the repair area. The perimeter needs to be marked *beyond* the limits of the temporary patch. The patch outline should be rectangular, with straight sides, regardless of the exact shape of the temporary patch. The sides should be either parallel or at right angles to the roadway centerline.

Then, the recommended way of cutting the pavement is to saw it. Sawing both facilitates the removal of the pavement inside the patch perimeter and helps produce straight, vertical sides.

The patch area should then be broken out; the debris should be completely removed; and the sides should be left in a clean, vertical, and straight condition.

Now, the next steps depend on whether a full-depth bituminous patch will be made, or a p.c.c. base will first be placed.

Portland Cement Concrete Base

For pavements consisting of a bituminous surface over a p.c.c. base, the mix used to repair the base should be similar to that used in the original concrete pavement. Many agencies however favor high-early-strength concretes, so that the road may be opened to traffic sooner. These mixes can attain adequate strengths for carrying traffic within as little as four hours. They usually have a high cement content and are made with Type III (high-early-strength) portland cement. Low water/cement ratios also speed strength gains. A *super-plasticizing admixture* often is used to maintain workability of the mix at a low water/cement ratio. *Accelerating admixtures* are also used to speed up the setting time. Of these, calcium chloride is the most common.

Many agencies specify that their repair sections be slightly thicker than the original pavement. This added thickness of concrete gives the repair sections extra strength to span across any settlement of the underlying backfill. Figure 7-1 shows a suggested standard for repairing utility cuts in a bituminous concrete pavement with a portland cement concrete base.

The first step in placing repair concrete is to moisten the subgrade and sides of the patch. Care should be taken, however, not to leave puddles of water. The concrete should then be placed directly on the subgrade, consolidated by internal vibration, and struck off to match the thickness of the existing concrete slab. Striking off the concrete parallel to the direction of traffic is recommended because it produces a smoother pavement. The surface should then be textured to match the surrounding pavement.

Joints can be tooled into the fresh concrete or later sawed into the hardened concrete. The edges of repairs not located at joints can be finished flush against the existing pavement.

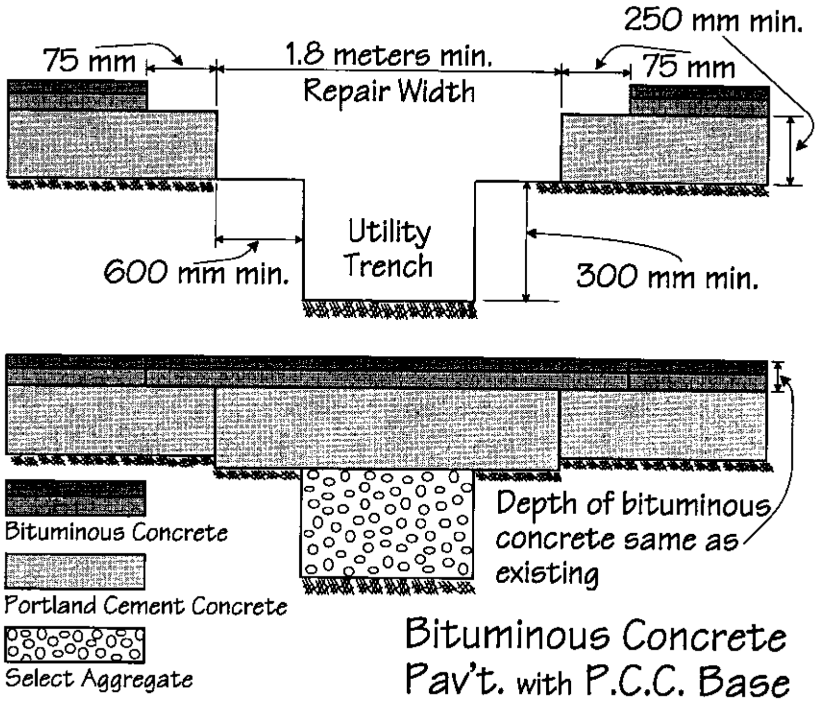

Figure 7-1: Surface Restoration in a Bituminous Concrete Pavement with a Portland Cement Concrete Base

Curing the concrete properly ensures adequate strength gain. After the surface is finished, it should be covered with plastic sheets or a curing compound. Insulation boards or blankets may be placed on the concrete during cold weather or when rapid strength gain is required to open the street to traffic sooner. Both the method and time of curing depend on the concrete mix and the weather.

If the lane or lanes occupied by the patch have to be reopened to traffic before curing is completed, steel plates may be placed to protect the concrete.

Finally, the cured concrete base is covered with a hot mix *cap* —perhaps after a tack coat is first applied. The bituminous cap should be thoroughly rolled and have a uniform thickness of at least 50 mm. At the same time, the crew should finish the patch to match the contour of the surrounding road surface.

Many agencies require that a p.c.c. base be constructed as part of *all* permanent utility patches—even when the pavement is full-depth bituminous concrete. These p.c.c. bases span the backfilled trenches. Their rigidity resists settlement even if the backfill beneath them does settle.

Full-Depth Bituminous Concrete

Other agencies, however, prefer to construct *full-depth* bituminous patches in restoring bituminous concrete pavements. Such patches should be as thick as the original pavement—or at least 100 mm in any case. Figure 7-2 shows a suggested standard for repairing utility cuts in a full-depth bituminous concrete pavement.

Placing, Compacting, and Finishing the Patch

Whether for full-depth or cap-over-concrete-base patching, hot mix should always be placed and compacted in separate, uniform lifts, thin enough to be compacted to proper density.

Before any hot mix is placed, however, a tack coat should be applied to the vertical faces of the patch area. This will help prevent moisture from entering the base and/or subgrade.

Mix temperature requirements should be complied with whether the bituminous patch is full depth or cap only.

Proper compaction procedures likewise should be followed in either case. For one thing, this means rolling the patch in the correct pattern: edges first, then the rest of the patch surface—in both directions.

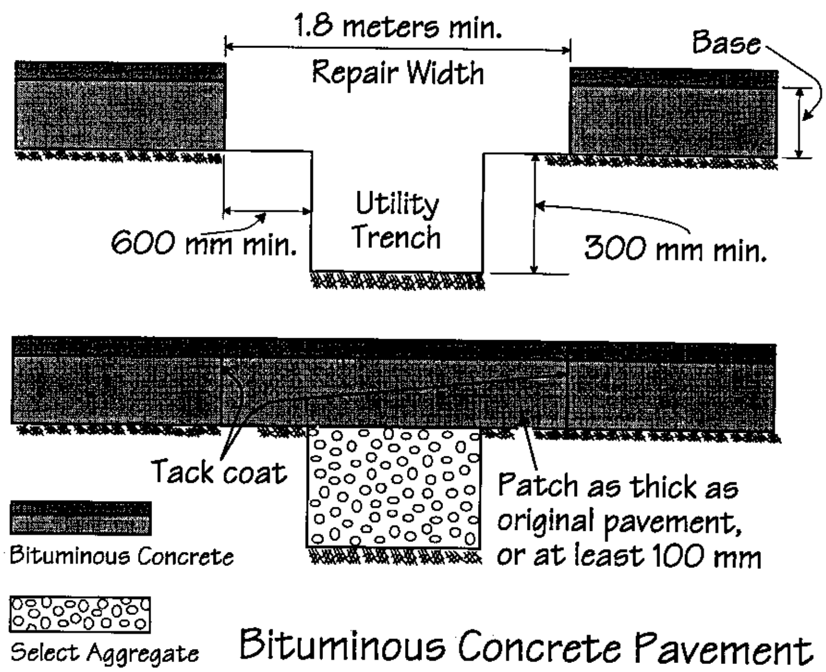

Figure 7-2: Surface Restoration in a Bituminous Concrete Pavement

The finished patch surface should be smooth, and conform to the surrounding pavement surface—no bump, dip, or other noticeable difference in the riding quality.

A follow-up inspection should be made to verify that each patch is now flush with the adjacent pavement (has not formed a permanent bump or begun to settle) and is not ravelling or otherwise deteriorating.

PORTLAND CEMENT CONCRETE PATCHES

Portland cement concrete patches for utility cuts in p.c.c. pavements should be made similarly to the concrete bases discussed above. In addition, the new concrete should be tied to the existing pavement by dowel bars or aggregate interlock. Figure 7-3 shows a suggested standard for this type of repair.

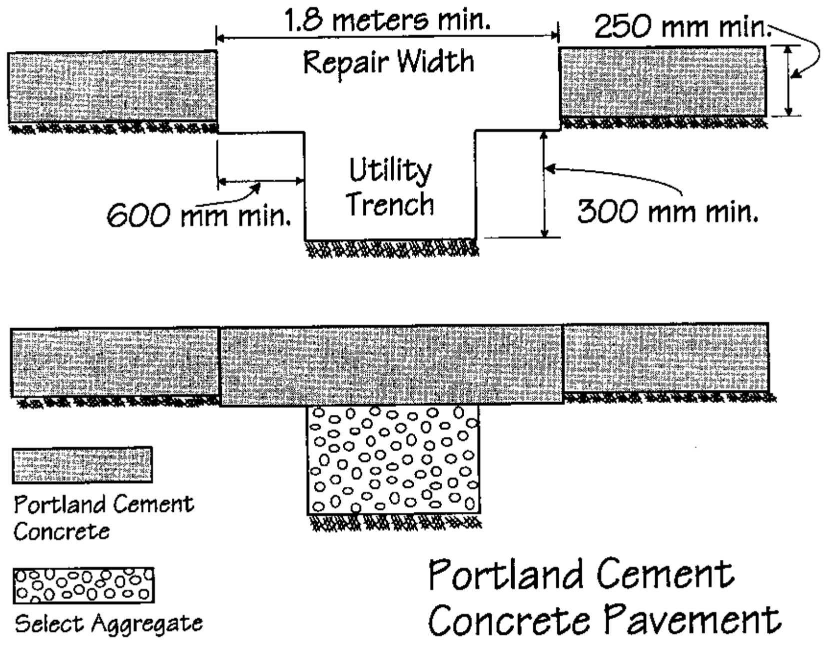

Figure 7-3: Surface Restoration in a Portland Cement Concrete Pavement

Section Eight
SITE CLEAN-UP

What would otherwise be considered a properly handled utility cut in a paved road could turn ugly if the work site is left a mess. The public's patience during the operation could be easily lost if the reopening of the road or street is shoddily and haphazardly managed, or if unwanted mementos of the work are left behind. Furthermore, the traffic control signs and devices that were a necessity during the job become a nuisance if they remain in place after no longer applying.

ASPECTS OF CLEAN-UP

Three aspects of site clean-up need to be addressed.

Removal of Materials and Equipment

All work materials and equipment must be removed from the site. *Materials* includes all leftovers from the excavating, backfilling, surface restoring, and utility work itself: pieces of pavement, soil, crushed stone, asphalt mix, concrete, sections of pipe or cable, and so on. Regardless of a material's condition, reusability, or value, it should not be left behind—on the traveled way, shoulder, roadside ditches, or public or private property.

The same goes for equipment. Although it's perhaps less likely to be left on site after the work is concluded, the crew should still ensure that it's all removed as soon as possible. And not just the big vehicles and machines; but all support units, attachments, accessories, and hand tools should be taken away too.

Clean-Up of Pavement and Adjacent Areas

Stray stones; spilled fuel, lubricants, or other substances; bits of asphalt mix or concrete; caked-on soil; accumulated dust; miscellaneous debris—all should be picked up, swept off, or washed away as appropriate. The intent is to restore not just the pavement but the entire work site to its former condition—and, to the degree possible, to its former *appearance*.

Coatings of dust; spots of clay, asphalt, or concrete; puddles of various substances; accumulations of loose gravel. More than just unsightly, they can be dangerous—obliterating pavement markings, creating bumps or slick spots, becoming projectiles that crack windshields.

Whatever combination of powered equipment and manual labor is required, the pavement and adjoining surfaces should be broomed off, wiped up, and hosed down.

Removal of Traffic Control Signs and Devices

With materials and equipment removed, and the work site and adjacent areas satisfactorily cleaned up, warning signs and other traffic control devices should be picked up. Signs should be removed in the reverse order to the way they were set up, according to the *MUTCD*.

While it's necessary to remove signs and devices when the job *ends*, it's also important to remove, cover, or turn them aside *temporarily* whenever their information and guidance no longer apply. Examples are: at the close of each workday on multiple-day jobs, and during other significant pauses in the operations. The simple but critical guideline is: Don't let signs and devices misinform and misguide motorists.

Work that extends from one day to the next also calls for barricading open trenches—or covering them with steel plates—to keep vehicles and pedestrians out.

RESPONSIBILITY FOR THE WORK

The responsibility for cleaning up the work site and reopening the roadway to traffic is an integral part of the overall responsibility for carrying out the utility work/pavement restoration. Marking the utility company's or agency's logo or other identification next to the restored utility cut clearly links the responsible entity with the quality of the entire job, from start to finish.

As long as utility facilities are located beneath our roads and streets, government agencies, utility companies, and contractors must do everything possible to ensure that utility cuts are made and repaired correctly and safely—with minimal disruption of traffic, and without leaving behind a defective pavement.

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