fewer pavement cuts on both new and old projects.

The purpose of the questionnaire was to gather data about and identify common traits of the utility-relocation function in various agencies in order to identify the optimum location for this function. All but one state, Hawaii, had a specific unit established for the purpose of utility coordination, and in 19 agencies, one office handled the function for relocations required by both highway projects and new installations.

In most agencies, the right-of-way or the design division is considered the most appropriate location for the function if there is no separate utilities division. Utility relocation and accommodation are closely related to design details and joint uses of the highway right-of-way.

All of the states now have a statewide utility-accommodation policy, and 35 states have prepared a relocation procedure manual. Approximately 50 percent of them have some form of master agreement, and 25 percent use or plan to use the FHWA-approved alternate procedure to provide more lead time and reduce processing time.

The recommendations to make the utility-relocation function a division were outnumbered by the recommendations to not do so. However, the reasons for separating the utility function into a separate division were numerous and convincing. A separate utilities division could incorporate many of the desirable factors listed above.

This study is primarily a state-of-the-art finding and can be used as a basis for other studies, such as that of combining railroad relocations and utility relocations into one section.

REFERENCES

1. A Guide for Accommodating Utilities on Highway Rights-of-Way. AASHTO, Oct. 25, 1969.
2. Policies for Accommodation of Utilities on Highway Rights-of-Way. NCHRP, Synthesis of Highway Practice 34, 1976.
3. Accommodation of Utilities. Policy and Procedure Memorandum 30-4.1, Federal Highway Program Manual, Federal Highway Administration, Nov. 29, 1972.

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Standard Color Markings for Underground Facilities

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The one-number-to-call system is the latest and most effective tool in the continuing campaign to prevent damage to underground facilities by excavating equipment. Another project that should help to reduce such damage is the use of standard colors for the stakes that are used to mark the locations of underground facilities. In such a system, each type of utility is assigned a color for marking its facilities. (Unless the colors are standardized, utilities that serve more than one state, county, or area would need to stock all colors of markers, which could lead to errors in staking.) Contractors and highway maintenance workers would recognize the uniform colors and be able to identify the type of facility.

More and more utility facilities are being placed below ground every day, and considerable attention has been directed to the danger of damage to them during subsequent excavations. This damage can be caused by earth-moving or excavating equipment and other construction or digging activities, and identifying the responsibility for its prevention is complex. Contractors maintain that if engineers would accurately locate the utility lines on their construction plans, damage could be avoided.

But, before looking for a solution, consider the source of the problem: About 20 utilities, such as water, sanitary sewers, gas, electric power, telephone, telegraph, cable television, street lighting, traffic-signal cables, police-signal cables, fire-signal cables, steam lines, and drainage systems, can be found beneath the streets and highways. Each year, various corporations spend large sums of money to locate and mark their below-ground facilities to help prevent accidental damage. They have had some success, but more information is needed. Where does most of the damage occur? The problem appears to be most serious in areas that are growing rapidly and are highly populated. Naturally, construction activity increases in growing areas and, if they are densely populated, they will have a higher concentration of utilities.

There have been many attempts to identify the general group that is responsible for most of the dig-ins. One study found that private contractors constructing streets and highways, residences, industrial and commercial buildings, and sewer and drainage systems were responsible for 75 to 80 percent of the damage to buried gas systems. Another study blamed 78 percent on other utilities (including their contractors) or landscaping and fencing contractors (1). A recent survey showed that 25 percent of those interviewed considered the underground-damage situation very serious or critical. This is a reflection of the high cost of repairing damages and also of its severe impact on public opinion. The public normally is not aware of the reason why service is interrupted, and most utilities do not consider it a good policy to identify the specific individual or company who caused the situation. However, this policy is beginning to change, especially with regard to chronic offenders who are careless with underground facilities.

The one-number-to-call concept is being implemented in a number of locations. This is a system in which an excavator planning to dig in a given area can, with one telephone call, advise all participating utilities of his

plans. The receiver of this information records it and then transmits it to all participating owners of underground facilities in the area, usually by teletype or telephone. The participating owners then mark or stake the locations of their facilities in the field or advise the excavator that they have no facilities in the area. To be effective, all owners of underground facilities in an area covered by such a system must be included in that system.

Another project that should help reduce dig-ins is the use of standard color markings for the stakes that show the locations of underground facilities. In such a system, each type of utility is assigned a color to mark its facilities. One of the basic reasons for a standard color marking is administrative. Unless colors are standardized, utilities that serve more than one state, county, or region are required to stock all colors of markers, which can lead to errors in staking. Standard colors enable contractors working in different states and counties to recognize and identify the type of underground facility. Utilities and contractors today usually operate in more than one area. Some states have already passed legislation specifying particular color codes.

LEGAL REQUIREMENTS

The National Transportation Safety Board has recommended that the American Public Works Association standardize colors that could be used for temporary marking and staking for the identification of underground facilities, and has urged local chapters to support the adoption and use of these standard colors (1).

The U.S. Department of Labor Occupational Safety and Health Administration has said (2) that

> prior to opening an excavation, effort shall be made to determine whether underground installations; i.e., sewer, telephone, water, electric and such, will be encountered, and if so, where such underground installations are located. When the excavation approaches the estimated location of such an installation, the exact location shall be determined, and when it is uncovered, proper supports shall be provided for the consisting installation. Utility companies shall be contracted and advised of proposed work prior to the start of actual excavation.

The New York industrial code states the following (3):

> 53-3.6 Staking, marking, or other designation. (a) Every underground facility in or within 4.6 m (15 ft) of a proposed excavation or demolition work area shall be staked, marked, or otherwise designated by the operator in accordance with the provisions of subpart 53-4 of this rule. Every excavator shall be familiar with such provisions, especially those relating to size and depth indications, color coding, centerline or offset staking or marking, and the location of underground facilities by designations other than staking or marking. (b) Whenever the excavator determines that a review of the staking, marking, or other designation is necessary or that additional information is required before he commences the excavation or demolition work, he shall so notify the operators. 53-3.7 After commencement of excavation, the excavator shall be responsible for protecting and preserving the staking, marking, or other designation until no longer required for proper and safe excavation or demolition work at or near the underground facility. 53-3.8 Where any underground facility has been staked, marked, or otherwise designated by the operator within a proposed work area, the excavator shall verify the exact type, size, direction of run, and depth of such underground facility or its encasement before he commences the proposed excavation work.
>
> 53-4.7 Uniform color code required: The following uniform color code shall be utilized on staking and marking used to designate the location of underground facilities:

Color	Utility or Type of Product
Yellow	Gas, oil, petroleum products, steam, compressed air, compressed gases, and all other hazardous liquid or gaseous materials except water
Red	Electric power lines or conduits
Orange	Communication lines or cables, including but not limited to telephone, telegraph, fire signals, cable television, civil defense, data systems, electronic controls, and other instrumentation
Blue	Water
Green	Storm and sanitary sewers including force mains and other nonhazardous materials
Purple	Radioactive materials

In Michigan a public utility served with a notice of excavation is required (4) to "establish the precise location of the underground facilities in advance of construction." The approximate location of the underground facility must be marked with stakes or other physical means that follow a prescribed color code (4).

The following legislation has been enacted in Wisconsin (5).

> 182.0175(2)(e) Every person owning transmission facilities shall, upon receipt of notice under paragraph (a)3, mark in a reasonable manner the locations of transmission facilities in the field so as to enable the person engaged in excavation or demolition to locate the transmission facilities without endangering the security of such facilities. The marking of facilities shall be accomplished within 3 working days after receipt of the notice, except if notice is given more than 10 days before the excavation or demolition is scheduled to begin; marking need not be accomplished more than 3 working days before excavation or demolition is scheduled to begin. If the approximate location of an underground transmission facility is marked with stakes or other physical means, the public utility shall follow the color coding prescribed herein.

Color	Utility or Type of Product
Safety red	Electric power distribution and transmission
Safety red	Municipal electric systems
High-visibility safety yellow	Natural gas distribution and transmission
High-visibility safety yellow	Oil distribution and transmission
Safety-alert orange	Telephone and telegraph systems
Safety-alert orange	Cable television
Safety-alert orange	Police and fire communications
Safety-precaution blue	Water systems
Safety green	Sewer systems

The following resolution was passed by the St. Petersburg City Council (6).

> Whereas, utilities in street rights-of-way within the city are being placed underground in increasing numbers; and, whereas, the St. Petersburg Utilities Coordination Group has recommended that all utilities placed underground can, when necessary, be color-coded above ground to facilitate their identification prior to the commencement of construction work in an area known to contain underground utilities; now, therefore, be it resolved by the city council of the city of St. Petersburg, Florida: That the following color codes are hereby designated and assigned to the utilities listed herein for the purpose of facilitating the identification of these utilities in street rights-of-way when the pipe, conduits, drains, cables, or wires of said utilities are placed underground:

Color	Type of Utility
Orange	Telephone
Green	Cable television
Red	Fire alarm
Black	Traffic signals
Yellow	Power
Gray	Sanitary sewer and storm drainage
Brown	Nonpotable
White	Gas
Blue	Water

> Be it further resolved: That upon the request of application to the city for a permit to excavate ground that is likely to contain underground

Table 1. Edison Electric Institute questions and replies.

Question	Reply
When requested, does your company temporarily mark the location of your underground facilities?	Yes (86); no (2)
If yes, does your company use a specific color?	Yes (61); no (27)
What color is used?	Red (31); yellow (15); blue (3); orange (5); yellow for distribution and red for transmission (1); yellow in one state and red in another (1); red or orange stakes (yellow on payment) (1); red flags or orange spray paint (1); blue stake with red top (1); red in one area and green in another (1); red for circuit route and yellow for submersible equipment (1)
Does your company participate in a one-number-to-call system?	Yes (39); no (49)
If yes, has each utility been assigned a color code?	Yes (26); no (13)
What color is used to denote electric facilities?	In use—red (23), blue (2), orange (1), no specific color (9); proposed—red and yellow (1); yellow (1); red (1)
Has the state(s) in which your company operates enacted or is the state(s) in which your company operates in the process of enacting legislation providing for notices to public utilities by persons excavating or discharging explosives near underground facilities?	Yes (51); no (37)
If yes, list name of state.	Enacted—Arizona, Connecticut, Colorado, Georgia, Illinois, Indiana, Kentucky, Maryland, Michigan, New York, Pennsylvania, Rhode Island, Wisconsin; pending—Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, New York, Ohio, Utah, Virginia
Does this legislation include color coding for marking location of underground facilities?	Yes (18); no (32)
If legislation includes color coding, what specific color is used for electrical facilities?	Red (4); blue (1); no reply (31)
Would safety red be acceptable to your company if proposed as an identifying color temporarily marking the location of your electrical underground facilities?	Yes (79); no (9)
If answer is no, please state reason.	Use blue; prefer yellow or orange; other utilities in state use red
If answer is no, please list preferred color.	Orange (3); yellow (5); blue with red top (1)

utilities, all utility companies shall be notified of the need for above-ground color-coded identification of the locations of their underground lines.

The highway-facilities committee of the New Jersey Utilities Association is preparing a uniform color code for designating the location of underground facilities. These markings will mark the location of underground facilities with a centerline location and by type of underground facility and follow the following guidelines.

1. Where centerline stakes or marks indicate the size of the underground facility, the facility shall be assumed to lie within a strip of land equal to the width of the facility plus 1.2 m (4 ft), with the centerline of such strip of land at the stakes or marks.
2. Where centerline stakes or marks do not indicate the size of the underground facility, such facility shall be assumed to lie within the strip of land 1.2 m (4 ft) in width, with the centerline of such strip of land at the stakes or marks.

The following standard color code shall be utilized and prominently displayed on any stake, marking, or other designation for an underground facility.

Color	Utility or Type of Product
Yellow	Gas, oil, petroleum products, steam, compressed air, compressed gases, and all other hazardous liquid or gaseous materials except water
Red	Electrical
Orange	Communications: telephone, telegraph, traffic signals, fire signals, cable television, civil defense, data systems, electronic controls, and other instrumentation or controls
White	Water
Green	Storm and sanitary sewers and all other nonhazardous materials

QUESTIONNAIRE

The Edison Electric Institute Transmission and Distribution Committee has surveyed 88 utility companies about their policies on the use of an identifying color for temporary markings to denote the locations of underground electrical facilities. The questions asked and the replies received are summarized in Table 1.

The uniform color code that is most commonly used in staking and marking the location of underground facilities is summarized below.

Color	Utility or Type of Product
Safety red	Electric power distribution and transmission
Safety red	Municipal electric systems
High-visibility safety yellow	Gas distribution and transmission
High-visibility safety yellow	Oil distribution and transmission
High-visibility safety yellow	Dangerous materials, product lines, and steam lines
Safety-alert orange	Telephone and telegraph systems
Safety-alert orange	Police and fire communications
Safety-alert orange	Cable television
Safety-precaution blue	Water systems
Safety-precaution blue	Slurry pipelines
Safety green	Sewer systems

The ideal way to make a standard color-code program effective would be through state legislation that makes it mandatory. By having standard color markings, excavators would know not only whose facilities were where, but also which utilities had not completed their location and marking work. For a marking system to be effective, it must

1. Follow a uniform system and
2. Use standard methods so that marking devices, such as color and stakes, will be readily recognizable and so that any stakes used will be different from survey stakes or other marking devices.

This color code is suggested as a model or guide toward uniformity and could be used by all utilities, agencies, contractors, and excavators.

CONCLUSIONS

Many utilities are interested in a uniform color code for

marking the locations of underground facilities because this would simplify their administrative and logistic problems. From the point of view of highway departments, a color code would make the underground plant within the confines of the highway right-of-way easily identifiable by maintenance crews.

REFERENCES

1. Prevention of Damage to Pipelines. National Transportation Safety Board, Rept. NTSB-PSS-73-1, June 7, 1973.
2. Construction Standards. Occupational Safety and Health Administration, 29CFR1926.651, Dec. 16, 1972.
3. Industrial Code. Board of Standards and Appeals, New York State Department of Labor, Rule 53, April 1, 1975.
4. 1974 Michigan Public Act 4700.
5. 1973 Wisconsin Laws, Chapter 277, Amendment to Section 1.182.0175(2), June 15, 1974.
6. Color Coding of Underground Utilities. St. Petersburg, Fla., City Council, Nov. 21, 1974.

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Computerized Mapping and Record Systems for Utilities

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In the telephone company, the outside-plant-location record is the permanent inventory of all outside plant in service. It serves as a primary document and tool for engineers designing additions, deletions, and changes in the plant. The use of this record is described briefly. The drafting effort required to maintain this large data base is discussed, and the difficulties in maintaining it by manual methods are emphasized. Explorations into applications of computer-graphics technology are reviewed. The implementation of a pilot, interactive-graphics minicomputer system that completely automates all drafting of outside-plant-location records and engineering work orders is described. This system is an on-line system that replaces paper records by electronically stored records that can be accessed and retrieved by a computer in real time at interactive-graphics terminals. It is used to demonstrate how future drafting and record drawing can be performed on displays at cathode-ray-tube terminals. It is cited as an example of a specialized computer-assisted, map-based record system. The advent of this new technology is a result of recent developments in computer hardware, computer systems, and digital graphic systems and has led to many new proposals for joint-use systems that have a common, fundamental map base. These are described in terms of their impact on land-ownership records. The efforts of the American Public Works Association to develop standards for this field are reviewed and the aims and purposes are described.

In the telephone company, the outside-plant-location record is the permanent inventory of all outside plant in service. It serves as the primary document and tool for engineers making additions, deletions, and changes in the plant.

Managing this program requires about 10 000 engineering and 10 000 equivalent-engineering, clerical people and an expenditure of about $100 million/year for drafting and allied areas. The record keeping associated with this is a complicated job that has not changed basically in 40 years.

A result of this highly labor-intensive activity is that, even with good management, there are cycles and phases when the records are not current. The error rates rise where it is necessary to keep duplicate records. The master copies deteriorate with time whether they are on paper or mylar, and it is difficult to enforce uniformity of record-keeping methods. Furthermore, when records are kept on paper, they are not continuous, and there is a major problem in ensuring that all appropriate sheets are updated when changes are made. Because the engineering work is designed on the basis of these records and there are times when the actual field conditions are different, delays in construction or the restoration of the physical plant can occur, and an inefficient use of personnel and equipment can result. As a result, some engineers maintain private copies of the record at their own level of requirements.

The number of people and the expense that goes into this work have been increasing in recent years. Figure 1 outlines the work flow for the keeping of records of construction work orders.

In the manually kept system, there are at least three redrawings of the appropriate symbology. Each retranscription increases the probability of error, and there is a lengthening lead time when the work load is heavy.

COMPUTER-ASSISTED DRAFTING

A new technology called interactive graphics has emerged in recent years. This uses a combination of devices that are linked together and operated by a computer program. A typical installation has a computer including its software, various peripheral devices, and the interactive-graphics terminals. The computer electronically updates and processes data. It must be fed software, that is, a set of encoded programs of instructions to control its operations. A variety of input and output devices and peripherals can be coupled to the computer: A disk unit can serve as a means of on-line magnetic storage of data, a plotter can transform this data into paper drawings (magnetic tapes can also serve as storage devices for the data and are more readily transportable), and a digitizer can convert information on a paper map or record into an electronically stored record in usable computer language. The graphics terminals are devices to access and interact with the electronically stored record (the data base). These cathode-ray-tube (CRT) terminals can have various characteristics in these systems. They can be local or