Scholarly Paper

Requirements and Practices of Underground Construction Activities: Review of Recently Updated Act

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Abstract: The Underground Utility Safety and Damage Prevention Act, hereinafter referred to as the Act, was created in the state of North Carolina to protect citizens, workers, and underground utilities from the inherent dangers that can occur during an excavation. In 2013, stakeholders introduced several changes to the Act to improve its overall performance. One of the most critical changes was the creation of the Underground Damage Prevention Review Board (UDPRB). The primary function of the UDPRB is to review complaints against parties violating the Act and to provide recommendations that are enforced by the North Carolina Utilities Commission. Active enforcement is a crucial component of any effective prevention program. Therefore, this paper explores the Act's requirements that relate to construction firms, as well as the scope and process of the UDPRB. Additionally, this paper addresses the influence of the creation and implementation of the UDPRB on relationships between various stakeholder groups, including construction firms. Finally, the paper also highlights the differences in underground utilities prevention acts and their impact on construction firms. Accordingly, this paper provides significant information to construction practitioners as well as legislators. **DOI: 10.1061/(ASCE)LA.1943-4170.0000300.**

Introduction

Damage to underground utilities is a daily issue at construction sites. In 2016, there were an estimated 379,000 damage incidents to underground utilities in US workplaces, at a cost to society of roughly $1.5 billion (Common Ground Alliance 2016). The North Carolina proportion of this number was 6.14% (i.e., 23,383 damage incidents). Accordingly, damage to underground utilities is a widespread challenge (Talmaki and Kamat 2014). The reported damage often happens to the following underground utilities: telecommunications, natural gas, cable TV, water, and sewer. In addition, the Pipeline and Hazardous Materials Safety Administration (PHMSA), which has federal jurisdiction over the natural gas industry, reported an average of 12 fatalities each year due to gas-distribution incidents (PHMSA 2018). Consequently, excavation crews have been involved in numerous significant accidents resulting in a loss of life and/or utility damage (Talmaki and Kamat 2014). In addition, utility owners allocate significant effort and workforce to repair these damages, which poses a challenge to today's workforce shortage.

Per the North Carolina Underground Utility Safety and Damage Prevention Act (hereinafter called the Act) § 87-117, an excavator is any individual, owner, corporation, partnership, association, or any other entity, organized under the laws of any state, who engage in excavation or demolition. Excavators often get hired by a wide range of employers such as contractors, counties, developers, farmers, municipalities, railroads, states, and utility owners. Fig. 1 illustrates the facilities damaged per type of employer in 2016. As shown, contractors caused the most damage to facilities (North Carolina 811 2016). The damage data over the years show similar trends. Per the Act, a facility is an underground line, system, or infrastructure used for producing, storing, conveying, transmitting, or distributing communication, electricity, gas, petroleum, water, or sewage. For a breakdown of the damage to communications (i.e., cable TV and telecommunications), natural gas, electrical, water, and sewer facilities, see Fig. 1. Clearly, most of the damage to underground utilities resulted from construction activities since most of damage was a result of contractors' activities. This poses a challenge to the construction industry. Therefore, it is crucial that the construction industry takes the lead in providing and adopting damage prevention techniques to reduce the high number of damage incidents.

In order to reduce damage to underground utilities, damage prevention acts have been created in all states to ensure that citizens and workers are protected. In general, prevention acts require contractors (i.e., excavators) to contact the state notification centers, commonly known as one call centers, before work starts. One call centers in turn have to notify facility owners to mark their utilities in order to avoid damage. However, this approach comes with three limitations, which are the lack of depth information of marked utilities, the accuracy degree of marks, and the temporary nature of them (Talmaki and Kamat 2014). Also, there are a few factors in favor of not utilizing this approach by excavators (Ariaratnam and Proszek 2006). These factors include that penalties are too low to modify excavators' behavior, making it less expensive to damage facilities than to excavate safely.

North Carolina Underground Utility Safety and Damage Prevention Act

Every state entered the one call process at different times. In North Carolina, the Utilities Locating Company (ULOCO) was incorporated in 1978, primarily for receiving requests from excavators and transmitting those requests to the member utilities. At that time,

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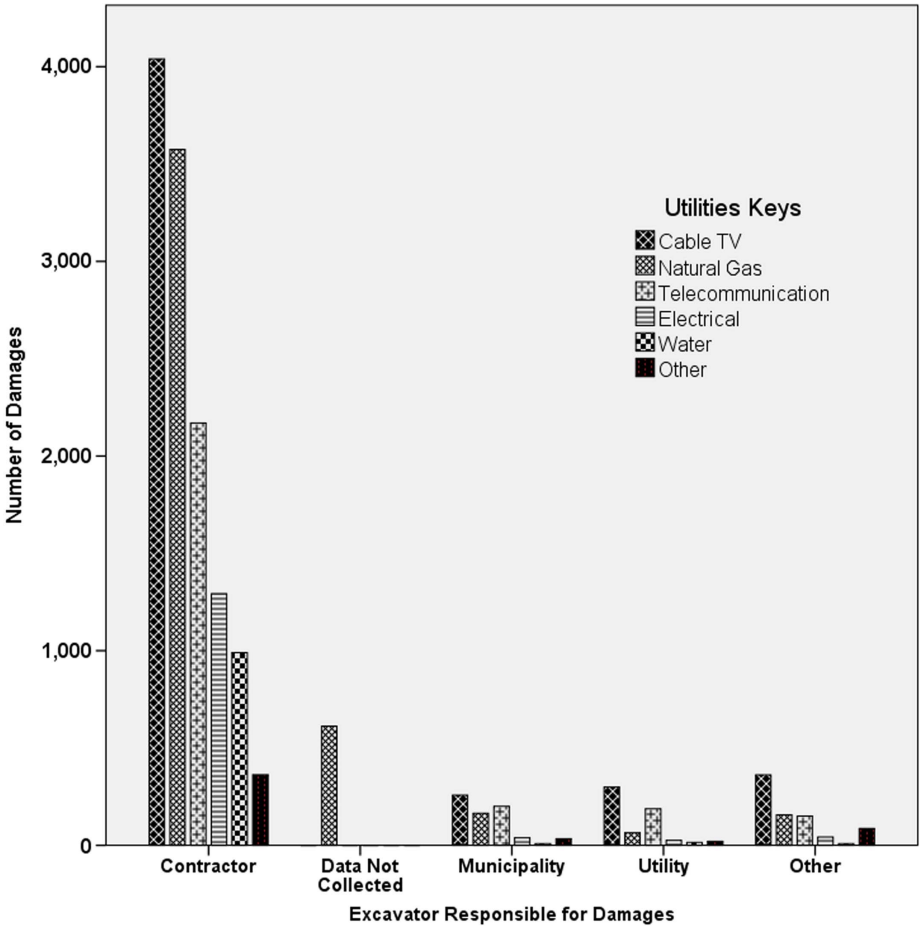

Fig. 1. Damage to North Carolina underground utilities by employer in 2016.

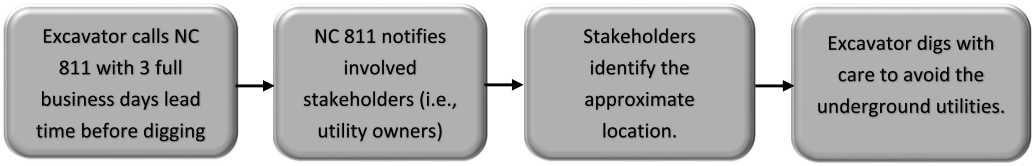

Fig. 2. NC 811 notification workflow.

there were no legal requirements for owners and operators to join the ULOCO, and participation was voluntary. Consequently, excavators were required to make multiple calls to ensure they had complete knowledge of the underground facilities affected in their work area. Moreover, there were no requirements for any type of damage reporting, and as a result, the numbers of damage incidents that were caused by excavators that are not the utilities' owners or their contractors (i.e., third-party damage) were unknown. In 1985, the General Assembly of North Carolina passed the Underground Damage Prevention Act, which required excavators to notify the utility owners of all proposed excavations. The 1985 law also placed a requirement on all owners to provide contact information to the register of deeds of each county in which the owner had underground utilities. This gave the excavator two places to receive information about the owners of utilities, from ULOCO and/or the register of deeds. The 1985 law remained unchanged for 28 years, until the current law passed in 2013. North Carolina's Underground Utility Safety and Damage Prevention Act went into effect October 1, 2014. The development of the new law was in response to a fatality that involved an excavator boring into an underground electric cable that was not marked by the owner in 2010. The revisions to the preexisting law were extensive and included components designed to improve the process of communication and provide for enforcement of the Act. Appropriately, the new law aimed to improve the overall effectiveness of the process. North Carolina stakeholders began meeting to create language that would improve the process by fixing critical elements lacking in the existing law. Employers and excavators are required by law to report planned excavation activities to North Carolina 811 (NC 811) (i.e., one call center) to request that the owners of involved utilities identify their underground utilities within the excavation's boundaries. The Act requires all involved stakeholders to perform specific tasks in a timely manner to effectively communicate the location of underground facilities to the excavator. Fig. 2 illustrates the workflow that satisfies the Act.

Although many changes resulted from the new law, the following four components are the focus of this paper:

1. Mandatory membership;
2. Mandatory positive response;
3. Mandatory damage reporting to the NC 811; and
4. Enforcement.

Mandatory Membership

For the process of NC 811 to work, all owners of underground facilities (i.e., stakeholders) need to be notified through a single point of contact. This necessitated membership become mandatory so that the excavator could be assured that all affected owners had been notified of the planned excavation. Mandatory membership was phased in over a 3-year period to allow smaller entities time to do what was needed to reach compliance. By October 2017, all owners and operators of underground facilities were required to join NC 811. Currently, there are 614 voting or associate members. Voting members are companies that own or operate underground facilities as defined by the statute, while associate members are excavators, locators, or other companies. However, there are still some small entities that have not become members because these entities, such as homeowner associations, are not aware of the requirement. Ultimately the responsibility falls on the owners to know and understand the Act. Consequently, the ability for an owner to receive compensation for damage is removed if they have failed to become a member of NC 811.

Mandatory Positive Response

Electronic positive response requires the owners and operators use a system in place at NC 811 to indicate the disposition of each excavation request within 3 full business days. In this manner, they can report whether there is a conflict with the facility and whether it has been located, as well as if there is no conflict or if they have negotiated an arrangement with the excavator to be on site. Excavators are also required, per the Act, to review the positive responses supplied prior to commencing their excavation. At the end of the 3-full-day waiting period, NC 811 sends an email indicating the responses from each notified member. Table 1 shows the possible codes of positive responses that must be reported by owners and operators, and their meaning. In 2016, the most frequent codes were Code 20 (34.06%), Code 10 (33.19%), and Code 999 (11.12%).

Table 1. Meaning of positive response codes

Code	Meaning
10	No conflict, the utility is outside of the stated work area.
20	Marked.
30	Not complete.
32	Locate not complete, additional communication with the excavator required. Unable to contact the excavator.
40	Could not gain access to the property, the locator will contact excavator.
50	Critical facility not marked, the utility owner or their designated representative have contacted the excavator and have agreed to a period that an owner representative must be present during excavation to identify the unmarked facility and/or monitor the excavation.
55	Critical facility marked. The utility owner or their designated representative have contacted the excavator and have agreed that an owner representative must be present during excavation.
60	Locator and excavator agreed and documented the marking schedule.
70	Excavator completed work prior to the due date.
80	Member's master contractor is responsible for locating facilities.
90	Survey design request—Facility has been marked in the field.
92	Survey design request—No facilities in the area.
94	Survey design request—Facility records provided.
98	Survey design request—Access to facility records provided.
100	Location request denied due to homeland security concern. Member utility operator needs to confirm the legitimacy of the proposed excavation and may need additional information.
110	Subaqueous facilities present. Member utility owner will locate facilities within 10 full working days.
888	Extraordinary circumstances exist. Member utility owner is unable to complete location request until (date/time).
999	Member has not responded by the required time.

Mandatory Damage Reporting

Damage reporting to the facility operators has been in place since the original 1985 law. However, reporting to NC 811 was an important addition to the Act because it allowed for better tracking of work types and the root cause of damages. With the change in 2014, all excavators became required to report damages to NC 811, as well as the facility owner. This change in the law allows tracking of excavation damage in North Carolina through the capture of data about reported damages. Data include the specific location, type of work being performed when the damage occurred, affected facility type, and whether or not a valid ticket was associated with the excavation. Since the new law took effect, a total of 35,307 damage incidents have been reported to NC 811. The most damaged type of facilities reported were telecommunications and TV cables, which could be a result of the fact that their depth is around 45.72 cm (18-in.) deep. The number of damage incidents that have been reported to the Common Ground Alliance (CGA) is often higher than that for those reported to NC 811. CGA is a national member-driven association of 1,700 individuals, organizations, and sponsors in every facet of the underground utility industry. For example, CGA reported 23,566 damage incidents in North Carolina in 2016, creating a difference of 8,395 more reported damages than those reported to NC 811. This difference is a result of the fact that some excavators who cause or find damage do not notify NC 811. Instead, they may contact a contract locator, the utility owner, or no one at all. This action, however, conflicts with the Act § 87-126, which requires the excavator performing an excavation or demolition that results in damage to immediately notify NC 811 and the facility operator. Fig. 3 illustrates the current process of damage reporting. The figure suggests that notifying NC 811 could eliminate the need to notify the facility owner since NC 811 will notify the owner. This fact could be unknown to many excavators in North Carolina, which contributes to the difference in damages reported to NC 811 and CGA.

Enforcement

In 2009, the PHMSA identified nine elements of effective damage prevention in response to the Pipeline Inspection, Protection, Enforcement, and Safety (PIPES) Act of 2006 (PHMSA 2009). The goal was to identify gaps in states' processes so that corrections could be made legislatively. Enforcement was one of the nine effective elements. North Carolina did not have any enforcement at that time, and so began to create a complaint process legislatively. Ultimately, the Act included specific provisions for enforcement of any violations identified, with penalties that included training and/or fines up to $2,500 per violation. Article 87-129 of the North Carolina General Statutes (NCGS) established the Underground Damage Prevention Review Board (UDPRB). The UDPRB was created to ensure the enforcement element of the Act. This provided

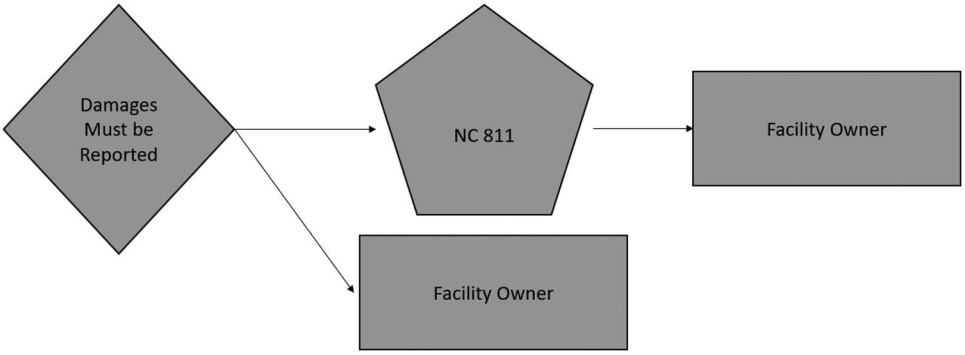

Fig. 3. Damage reporting process: NC 811.

for a complaint-driven process and review of alleged violations by a cross section of stakeholders, with ultimate recommendations of penalties to be followed through by the North Carolina Utilities Commission (NCUC). This paper will discuss how the Act, and specifically UDPRB, has made an impact on damage incidents in North Carolina.

Underground Damage Prevention Review Board

The UDPRB is made up of 15 people, appointed by the governor. These individuals represent members of the stakeholders involved in the damage prevention process. The UDPRB reviews the complaints received but does not perform any investigation on site. Determination of a violation is made based on the information provided to the UDPRB by the parties themselves. The complaints are received by NC 811, where they are scanned and made available to the UDPRB members. The UDPRB meets quarterly to review new cases received. If no objection exists to the finding, the recommended penalties are sent to the NCUC. The NCUC is an agency of the State of North Carolina created by the General Assembly to regulate the rates and services of all investor-owned public utilities in North Carolina. The NCUC regulates companies that provide electricity, telephone service, natural gas, water, wastewater, household goods movers, buses, brokers, and ferryboats. The concept of a stakeholder-driven board to review complaints was in place in several states prior to North Carolina's adoption. However, the unique nature of the NC UDPRB is that the violations must be reported to be addressed and can include any party that may have failed to discharge their responsibilities (e.g., excavator, utility owner, notification center). Damages and failing to contact NC 811 do not trigger a complaint or financial penalties, as they do in some states such as Virginia, Kentucky, and Georgia. For example, Virginia's Underground Utility Damage Prevention Act § 56-265.17 (A) states: "Except for counties, cities, and towns, an excavator who willfully fails to notify the notification center of proposed excavation or demolition shall be liable to the operator whose facilities are damaged by that excavator, for three times the cost to repair the damaged property." Also, the NC UDPRB does not conduct field investigations like other states, such as Maryland. The NC UDPRB is only able to determine whether a violation occurred using the information provided by the parties involved.

Process Flow

Complaints are received by NC 811, where they are scanned and made available to the UDPRB members. A complaint could be created against any person who violates the Act. A person (i.e., construction establishments) according to the Act is defined as any individual, owner, corporation, partnership, association, or any other entity organized under the laws of any state. After reviewing the complaints, the recommended penalties are sent to the NCUC, if no objection exists to the finding. According to the Act § 87-129 (b1), the UDPRB shall determine the appropriate action or penalty to impose for each violation. However, actions and penalties may include training, education, and a civil penalty not to exceed $2,500. Fig. 4 illustrates the process flow of the UDPRB. A person determined to be in violation of the Act may request a hearing before the UDPRB within 30 days from the date of the board's initial recommendation, which may reverse or maintain its original finding. The final penalty will be communicated to NCUC, which shall issue an order imposing the penalty. The method of imposing the penalty is totally different in some states such as Iowa, where the attorney general orders the necessary actions to enforce the penalty (i.e., Iowa Code, Chapter 480.6.2).

Enforcement by the Numbers

The UDPRB has reviewed a total of 165 complaints received from utilities owners, as well as from homeowners, excavators, and claim companies, since October 2014. The largest submitter of complaints has been a claims management company, which submits

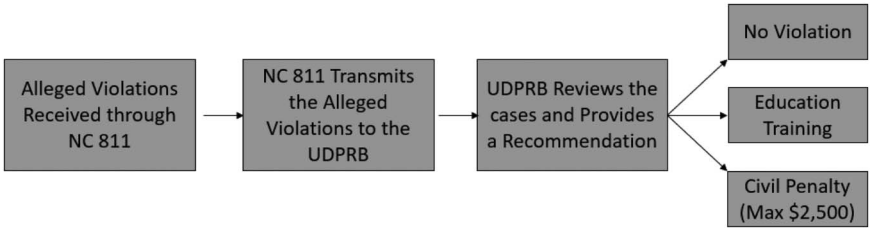

Fig. 4. Underground Damage Prevention Review Board's review process.

complaints to help in the recovery of damage from a large utility company. Out of the 165 complaints, only 98 violations (i.e., 68%) have been determined by the UDPRB, which means 67 complaints (i.e., 32%) have been dismissed due to the fact that no sufficient evidence was provided. There were only three violations that included financial penalty recommendations, while the remaining violations were recommended for training only. Financial penalties are considered for cases of repeat offenses by a company, willful negligence, or violations that present a high threat of incident. In the three cases where financial penalties were applied, one was a repeat offender who persisted in excavating before the full 3 days. The second was a company that excavated over a high-pressure gas pipeline without coordinating efforts with the owner. Finally, the third case involved an excavator who refused to stop digging even when told they needed to contact NC 811.

According to the UDPRB, training penalties were recommended for 96.5% (i.e., 83 cases) of excavator violations. Training is provided via a free online program developed by the stakeholders, known as PIPES Plus. The training should be completed by the person who violated the Act; however, it is important to evaluate overall employer practices because imposing the penalty on one person instead of the employer indicates that the damage was a human error. A person's (i.e., employee's) actions that lead to damage to an underground utility could be an employer error, not a human error. When the employer's excavation practices and policies do not fully meet NC 811's and the Act's requirements, then damage will eventually occur. In these cases, the penalty must require employers to improve their excavation practices. This could be done by requiring all the firm's field employees to take the training, not just one excavator. Table 2 shows that most of the violations were reported against excavators (e.g., construction establishments), which may indicate that more understanding of the damage incidents' root causes is needed in order to provide better educational material to excavators. Furthermore, failing to contact NC 811 prior to excavation represents 69% (i.e., 58 cases) of excavators' violations, which indicates there is a need for more information about why this is happening. In addition, there were 17 cases (20%) where the excavators failed to wait for the ticket to close out (i.e., 3 full business days or all positive responses received from the utilities). It is crucial for excavators such as construction establishments to realize that calling one call center such as NC 811 before digging is not enough. They must wait until the legal start date of the ticket and acknowledge positive response from all stakeholders. Furthermore, excavators should proceed with care after receiving all positive responses. Table 2 show seven cases (7.2%) where excavators did not proceed with care after they did call NC 811 and waited for the ticket to close out. For the excavator to proceed with care, not only must they physically locate the underground utilities through hand digging, but they must also protect them through the life of the excavation (e.g., support them or even relocate them when needed).

Table 2. Violations to the Act in North Carolina: UDPRB

Violation type based on the Act	Frequency
Section 87-122: Excavator responsibilities	84 total
87-122 (a): Failing to contact NC 811 prior to excavation	58
87-122 (c) 4: Failing to wait for the 3 full days to excavate	17
87-122 (c) 6: Failing to call in a 3-h notice when visible indications of a facility exist	2
87-122 (c) 9: Failing to exercise duty of care	6
87-122 (c) 10: Failing to coordinate with a transmission pipeline operator when working in the ROW	1
Section 87-121: Facility operator requirements	14 total
87-121 (a) 1: Failing to provide accurate marks of underground utilities	1
87-121 (b) 1: Failing to mark on time	3
87-121 (c) 1-4: Failure to provide a positive response to the notification center within the 3 full working days.	10

Note: ROW = right-of-way.

UDPRB Challenges

Several challenges to the UDPRB have been identified during the past 3 years, which represent the life of the UDPRB. These challenges need to be addressed to improve the overall effectiveness of the UDPRB in order to reduce the underground damage incidents in North Carolina. The following is a brief explanation for the identified challenges:

Lack of Funding and Procedures

The law that created the UDPRB did not include any appropriations to fund the activities. This left a void in both administrative and legal assistance to the UDPRB. While the UDPRB has worked to pitch in and overcome these obstacles, a request will be made in 2019 to secure state funding. In other states, the monies received from financial penalties can be channeled to the enforcement activities. For example, Act of West Virginia Underground Facilities Damage Prevention act Chapter 24-C (a) states that "All sources of funds collected by the board under this article, including, but not limited to, grants, assessments, and civil penalties collected pursuant to this article, shall be deposited into the WV underground damage prevention fund." Similarly, § 56-265.32 (D) of Virginia's Underground Utility Damage Prevention Act states that "All civil penalties collected pursuant to this section shall be deposited into the Underground Utility Damage Prevention Special Fund." However, North Carolina's constitution does not allow these funds to be retained. Instead, any collected fines are placed in the general fund for statewide education. With no funding in place, administration functions of the UDPRB must be absorbed by NC 811 budget, and this is not a function that NC 811, a private not-for-profit company, should be engaged in. The board is a state-created entity and should be funded as such. Therefore, currently there is an effort to explore allowing the UDPRB to contract out administrative services from a third party.

The law also did not include detailed rules or procedures for the UDPRB to follow. Consequently, the UDPRB was required to create these internally. According to the Act § 87-129 (a6), the UDPRB may adopt rules to implement the reviewing process. As a result, several components of the process and procedures were agreed to by the UDPRB. However, there is a need to create more formalized and legal rules that, based on counsel from the North Carolina Attorney General's Office, will be proposed in 2019.

Lack of Clarity in Enforcement Process

Enforcement in North Carolina requires multiple parties to work in concert to produce results. From the initial receipt of the complaints through the final order issued by the North Carolina Utilities Commission, each identified step requires a person to move the process forward. NC 811 is sometimes placed in the position of handling additional administrative functions simply because there is no one else to deliver it. Consequently, the public may believe that NC 811 has a more involved role than what is legislated. NC 811 has worked to reduce confusion by spelling out their limited responsibilities on a website that houses the complaint form. The complaint form itself includes language that also puts distance between the UDPRB and NC 811. Finally, all letters are sent from the UDPRB and signed by the chair of the UDPRB, with a contact number to the chair provided.

Identifying the Correct Contact Information

For anyone filing a complaint, the contact information of the person being complained about is a critical component. If this information is inaccurate, incomplete, or the wrong party has been identified, the UDPRB and North Carolina Utilities Commission are unable to proceed with the process for that case. There was some concern on the part of excavators when the law initially went into effect that it would be extremely difficult for anyone to find the correct contact information, especially a homeowner unfamiliar with how to find the registered agent for a company. To help assist with this function, the UDPRB placed a link to the North Carolina Secretary of State on the website containing the complaint form. The link takes the user directly to a search page that can be used to find the registered agent for any company registered to work in North Carolina. It is hoped that this tool will help to reduce the number of complaints that must be rejected due to incomplete contact information.

Impact on Excavator Practices

Construction establishments have been impacted by the various state underground damage prevention acts. The influence of these acts is different based on the location (i.e., state) of construction activities. However, it is important for construction establishments to be aware of these acts, as well as the differences between them, to ensure compliance and improve overall safety and productivity. For example, Table 3 illustrates the differences in advance notice and ticket duration or life for several states. Utilizing mechanized equipment within the tolerance zone [e.g., 60.96 cm (2 ft)] is another example of differences in the requirements of underground prevention acts. For example, excavators shall not utilize mechanized equipment within 2 ft of the extremities of all exposed utility in excavations that are not parallel to underground utility in Virginia (i.e., VGS § 56-265.24), while this is only required around facilities that are gas, oil, petroleum, or electric transmission lines in North Carolina (i.e., NCGS the Act § 87-122.10).

According to Ariaratnam and Proszek (2006), a negligence claim is the most common aspect of utility damages. Negligence claims occur when it is the construction establishment's duty to use care when digging around underground utilities and damage to underground utilities results from the construction establishment's breach of that duty. In North Carolina, there are two main sources that could be used to establish the duty of care. The Act is one of these two sources since it requires construction establishments to always exercise a duty of care to protect facilities (i.e., NCGS § 87-122.9.3). The Act, however, promotes shared responsibility; therefore, construction establishments in North Carolina are not liable to the nonresponding or improperly responding operator for damages to the operator's facilities (i.e., NCGS § 87-128). The shared responsibility approach that is inherent in the North Carolina act is one of few in the nation that construction establishments should be aware of while working in North Carolina. The second source that could be used to establish the duty of care is NCGS § 95-16, which is called the Occupational Safety and Health Act of North Carolina (OSHANC). OSHANC regulations regarding excavation set forth at § 1926.651 (b) (2) require excavators to ensure that the location of underground utilities is marked prior to the start of actual excavation. This requirement is designed to protect workers from unsafe conditions that may result from damage to underground utilities. Therefore, these two sources (i.e., NCGS § 87-122.9 and NCGS § 95-16) could be used to establish a standard of care, and a violation to any of them is evidence that the violator is negligent. The negligence could be a result of many factors such as a tight work schedule, or that it is often less expensive to damage underground utilities than to excavate safely.

The research team has solicited the feedback of 10 experts to assess their agreement or disagreement with the negligence claim. Most of the invited experts have worked with one of North Carolina's utility owners for years (i.e., average 25 years) as field supervisors and have extensive knowledge about the topic. Eight (i.e., 80%) have agreed that negligence claims should be used in the Act. However, they have also pointed out the important role of utility owners in reducing damage incidents by providing accurate and timely locations. There were 14 (14.3%) violations of the Act reported against utility owners among the cases that have been reviewed by UDPRB (Table 2). Accordingly, the role of utility owners should be considered in future efforts and legalizations that aim to reduce the damage incidents to underground utilities.

Table 3. Sample of difference in the requirements of underground prevention acts

State	Advanced notice	Units	Ticket duration	Units
Maryland	2	WD	12	WD
Michigan	3	WD	21	CD
New York	2	WD	10	WD
North Carolina	3	WD	15	WD
South Carolina	3	WD	15	WD
South Dakota	2	WD	21	CD
Tennessee	3	WD	15	CD
Texas	2	WD	14	CD
Virginia	2	WD	15	WD

Note: WD = working day; and CD = calendar day.

Recommendations

Underground utilities have a direct impact on the growth of national economies as well as citizens' well-being (Celik et al. 2017). Thus, reducing damage is everyone's responsibility. The damage prevention acts should clearly highlight the responsibilities of all stakeholders. Facility owners are responsible for locating their facilities accurately within the required time. Thus, any problem with the locating portion of the process is the responsibility of the facility owner. The role of one call centers is critical to damage prevention efforts. One call centers document the notifying calls, the positive responses, and the damage reports. Therefore, they offer the ability to measure the longitudinal effectiveness of enforcement on the reduction of damage incidents. Finally, excavators are responsible for making the notification to the one call center, waiting the required time for a positive response, checking the positive response, and excavating with care. As a result, the efforts of damage prevention education should emphasize the shared responsibility concept among all involved parties: excavators (including homeowners), utility owners, and the one call center. Comparing the number of damage incidentss and the number of cases reviewed by UDPRB indicates that the role of UDPRB is still not clearly comprehended by stakeholders. The enforcement element of the Act (i.e., UDPRB) is the first line of defense against violations and gives power to the Act itself. Thus, its role is vital for the success of prevention efforts. Accordingly, stakeholders, especially excavators, must be educated about the Act, the mechanism by which they can report violations, and the shared responsibility portion of it. Finally, a follow-up evaluation of the process with

stakeholders who filed a complaint and/or have been determined to be violators should be conducted to reveal the impact on behavior and identify additional means of improving the process.

Concluding Remarks

Underground utilities damage prevention acts influence daily construction activities all over the United States. The number of yearly damage incidents represents a challenge to society, as well as underground infrastructure. It follows that construction firms should be familiar with the requirements to help reduce the high number of yearly damage incidents. While negligence is cited in OSHANC and more heavily penalized during the UDPRB complaint review process, other factors contribute to an environment in which damage is more likely to take place. These factors include delayed locating (i.e., beyond the 3 full business days), incorrect or incomplete marks, and records or plans that do not accurately reflect the true location of buried facilities. Therefore, further efforts are required to fully explore and uncover all the possible root causes of underground damage. Knowing the wide range of possible root causes would help lawmakers, stakeholders, and excavators reduce the overall number of damage incidents. The absence of a clear understanding of root causes could be the cause of damage that occurs in North Carolina despite the efforts expended by all parties.

It is also important to notice the differences in acts between states to better manage excavation activities and the consequences of damage. In addition, it is necessary to standardize the acts across the nation to ensure faster implementation (e.g., incorporating the process and requirements into contracts) and increase the contractors' learning curve. The Act and the UDPRB promote shared responsibility and establish enforcement and penalties for failure to comply. The responsibility is shared between the excavator, the facility operator, and NC 811. Accordingly, stakeholders are responsible for locating their utilities within a specified time and being sure their marks are within a tolerable distance. Otherwise, it is possible for excavators such as construction firms to file a complaint against stakeholders that failed to comply with the Act. Finally, the recommended penalties by the UDPRB should consider the employers' excavation practices to ensure the penalties address the system error.

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References

List of Statutes

Occupational Safety and Health Act of North Carolina, § 95.126-160.

Underground Facilities Damage Prevention of West Virginia, 2017 § 24C-1-1-8.

Underground Facilities Information, Iowa Code, 2017, § 48-1-10.

Underground Utility Damage Prevention Act, Virginia, 1979, c. 291, § 56-265.14-32.

Underground Utility Safety and Damage Prevention Act, 2013, North Carolina, § 87.115-130.

Works Cited

Ariaratnam, S. T., and J. J. Proszek. 2006. "Legal consequences of damages to underground facilities by horizontal directional drilling." *J. Prof. Issues Eng. Educ. Pract.* 132 (4): 342–354. https://doi.org/10.1061/(ASCE)1052-3928(2006)132:4(342).

Celik, S., S. Kamali, and Y. Arayici. 2017. "Social cost in construction projects." *Environ. Impact Assess. Rev.* 64: 77–86. https://doi.org/10.1016/j.eiar.2017.03.001.

Common Ground Alliance. 2016. "DIRT analysis and recommendations 2016." Accessed August 12, 2018. http://commongroundalliance.com/DIRT-2016-report.

North Carolina 811. 2016. "2016 Supermega spreadsheet." Accessed August 12, 2018. https://docs.google.com/spreadsheets/d/1QFvWqCVjSjOSCPYupXsGFXPvl5emByFmRhrLTeRH7B0/edit#gid=995030178.

PHMSA (Pipeline and Hazardous Materials Safety Administration). 2009. "Summary of damage prevention laws." Accessed July 11, 2018. https://primis.phmsa.dot.gov/comm/DamagePreventionSummary.htm.

PHMSA (Pipeline and Hazardous Materials Safety Administration). 2018. "Pipeline incident 20 year trends." Accessed July 11, 2018. https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends.

Talmaki, S., and V. R. Kamat. 2014. "Real-time hybrid virtuality for prevention of excavation related utility strikes." *J. Comput. Civ. Eng.* 28 (3): 04014001. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000269.