Excavation Safety

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Safety problems associated with routine excavations involving utility work are discussed, and the experience of the Taylor County Road Department with safety in the maintenance of timber bridges is used as an example. A method for slope protection in excavations behind existing bridge abutments is presented. Guidelines are offered to help the engineer in averting deaths and injuries of workers in these types of maintenance.

The safety of a worker in and around an excavation has been an obvious problem for many years. Unstable soils are likely to collapse at almost any depth of trench excavation. Special trenching techniques have been developed to protect the worker, equipment, and materials at an underground utility installation. The Occupational Safety and Health Administration (OSHA) and the National Safety Council have strict rules and regulations governing such work. It is an established fact that a trench cut vertically into many soils will be subject to collapse. This type of collapse has happened many times before and will happen many times again.

Construction involving one-way excavations (such as embankments, bridge abutments, culvert head walls, etc.) seems to have gone unnoticed as a safety hazard, but the results of a collapse can be extremely damaging to the unsuspecting individual caught in a slide. Examining this problem will show how careless we have been and, for most of us, how lucky we have been.

As the county engineer in a small county in Iowa, I have had the opportunity to view every aspect of our maintenance and construction operation. A major responsibility of a county engineer is to anticipate any unsafe practices and instruct field personnel in how to do each operation as safely as possible. Protection of our highway work zones is quite obvious: signs and lights are installed to direct motorists around obstructions; barricades are erected to protect the workers from the motorist. However, who looks out for the workers' protection against the collapse of a roadway embankment or bridge approach? This type of structure is not a hole in the ground where water could accumulate and weaken the otherwise stable sides. It is an earthen slope quite visible and certainly not a threat to anyone, or is it?

A short time ago, I had the opportunity to arrange a one-day seminar offered by a retired professor of Civil Engineering at Iowa State University on the subject of excavation safety. This presentation has now become part of a regular seminar in Iowa to acquaint engineers and construction personnel with the hazards of and safety precautions for excavations. Acquiring the necessary knowledge of the problem takes much more than one day and requires a fairly good understanding of soil mechanics, geology, and hydrology and an excellent supply of common sense. But, believe it or not, one day in this classroom was enough to put the fear of God in me, if it wasn't already there. Slides and videos were shown of excavations where workers' lives were in jeopardy and where lives were lost. Action by fellow workers or emergency personnel more often than not compounded the problem or placed one or more additional lives in jeopardy. Events happen so quickly that one cannot run from the problem, jump for safety, or grab the hand of a fellow worker.

The presentation principally covered the safety problems associated with routine excavations involving utility work. However, care was taken to demonstrate that any unprotected, unstable slope of cohesive soil, under the proper conditions, can rapidly and without warning seek a stable slope. This type of slope is basically the concern of this paper, not a lot of technical jargon from a textbook or a classroom, but the pure nuts and bolts for an individual who is responsible for the safety of other human beings.

As a county engineer, public works director, utility engineer, or maintenance-construction superintendent of a city or county, you can count yourself fortunate if you work in a part of the globe where the soils are stable rock to a Type A soil. Soil Type A has properties that permit it to safely stand at 53 degrees to the horizon (*1*, Table B-1). But those of you who deal with soils that are glacial to loessial, as I do in southern Iowa, should take heed.

Of the 257 bridges in my county, most were built of timber following an Iowa Department of Transportation (I.D.O.T.) standard that dates back to 1914. The majority are still timber with wooden pilings at the abutments. The roadway approach embankment is retained by timber planking spanning horizontally between wooden or steel pilings. The original plans normally provide for only five to seven 3 in. by 12 in. boards that form a separation between the earthen embankment and the bridge opening. Of course, alteration to the surface condition to accommodate corn and soybean farming and the unstable glacial or loessial soils that are prone to erosion and scour makes it easy to see what does and will happen. Erosion continues until the toe of the retaining boards becomes exposed, permitting the approach backfill to be washed away. If not maintained, it will ultimately cause the failure of the abutment. A common solution is to catch the problem early and add riprap to protect the eroding slope. However, where glacial and loessial soils exist, stone for riprap is almost nonexistent and is certainly an expensive proposition. An even more costly solution is to add an approach span to return to the bank condition that existed

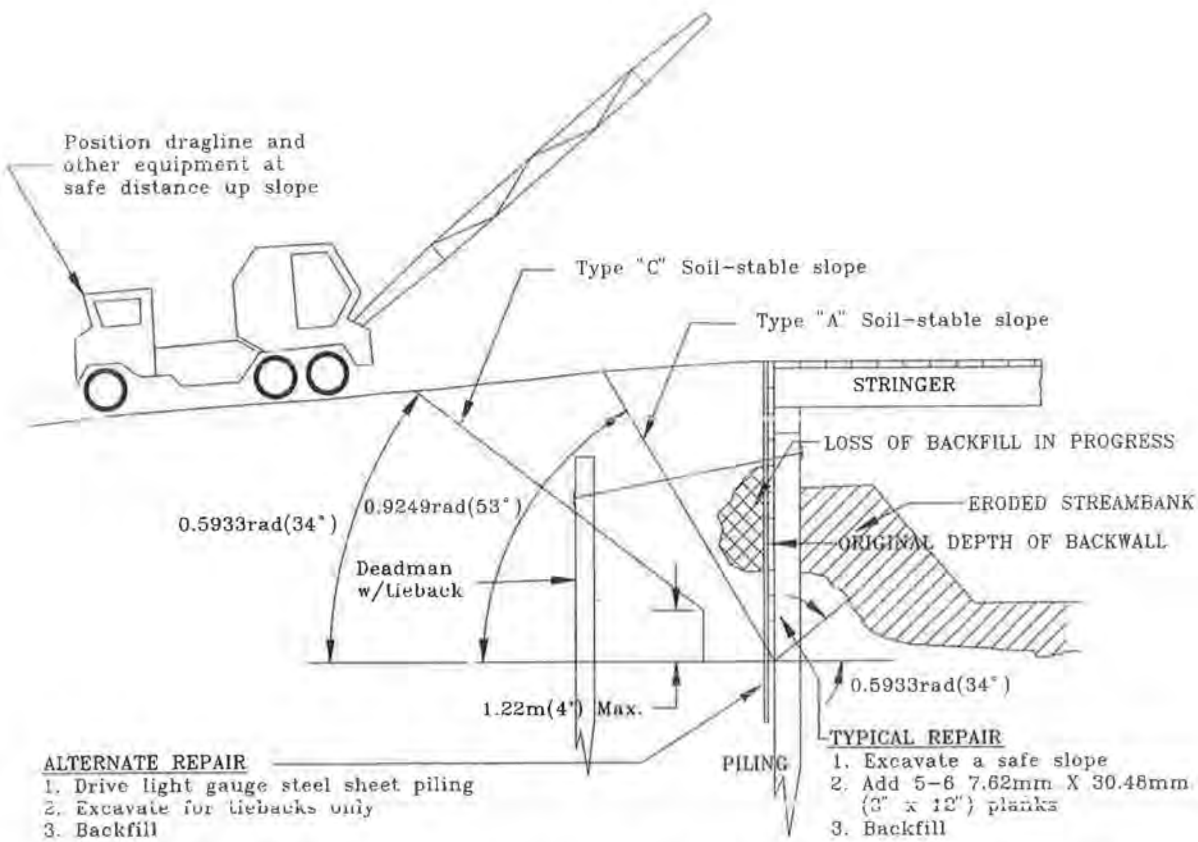

FIGURE 1 Typical timber bridge abutment: descriptions of and pertinent items relating to bridge backwall repair.

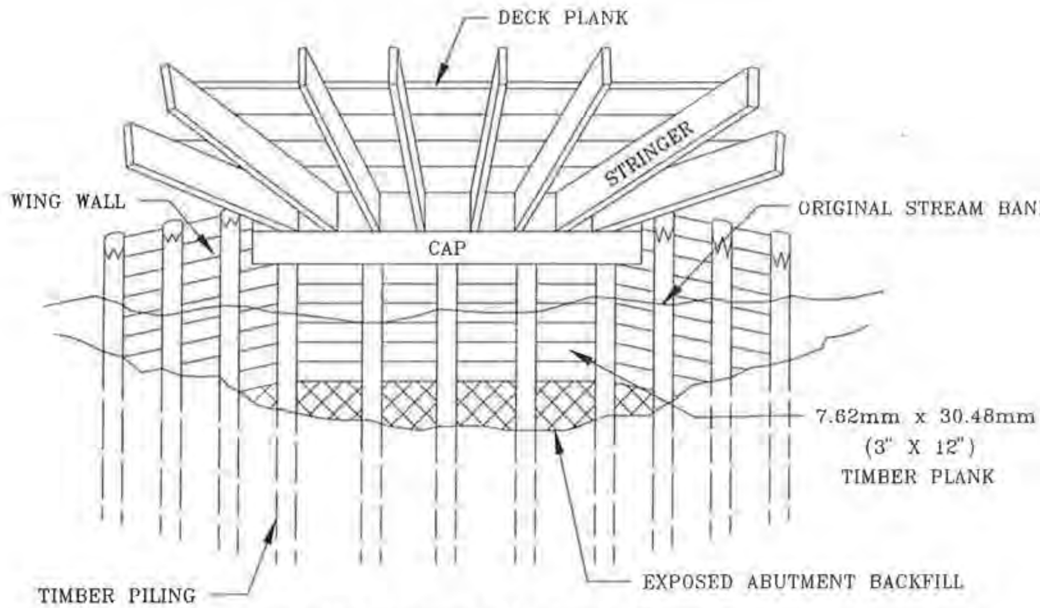

FIGURE 2 Typical timber bridge abutment with streambank erosion.

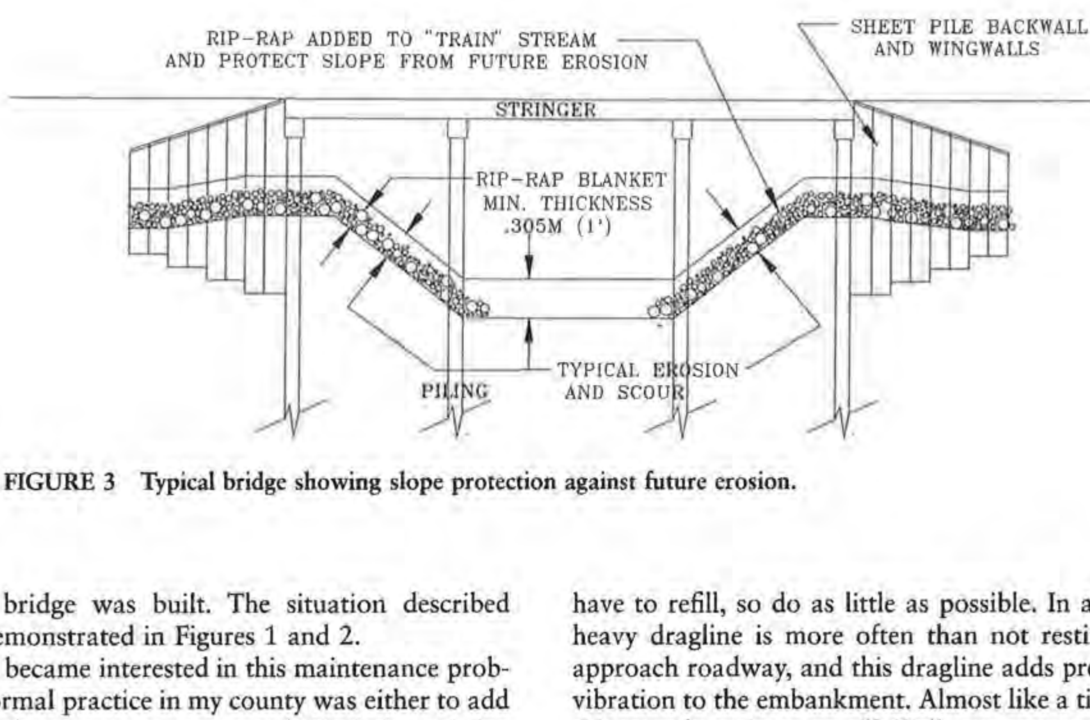

FIGURE 3 Typical bridge showing slope protection against future erosion.

when the bridge was built. The situation described above is demonstrated in Figures 1 and 2.

Before I became interested in this maintenance problem, the normal practice in my county was either to add the approach span or to excavate behind the existing backwall, dig deep enough to add sufficient protection (usually another 5 to 7 ft), fasten timber planking to the piling, and then backfill. Since this was maintenance work and needed to be performed as quickly as possible, little concern was given to the slope of the excavation down to the depth needed to add more planking. The economic thinking was that what you dig out you have to refill, so do as little as possible. In addition, a heavy dragline is more often than not resting on the approach roadway, and this dragline adds pressure and vibration to the embankment. Almost like a time bomb, this tragedy waits to go off. Well, our county was lucky. Though there were a few close calls, nothing catastrophic happened, but it was not for lack of care and knowledge of the potential problem on our part.

OSHA has been concerned about this safety hazard for many years. Most of us have known their regulations for construction, including excavations, for some time, yet we have often ignored them until it was too

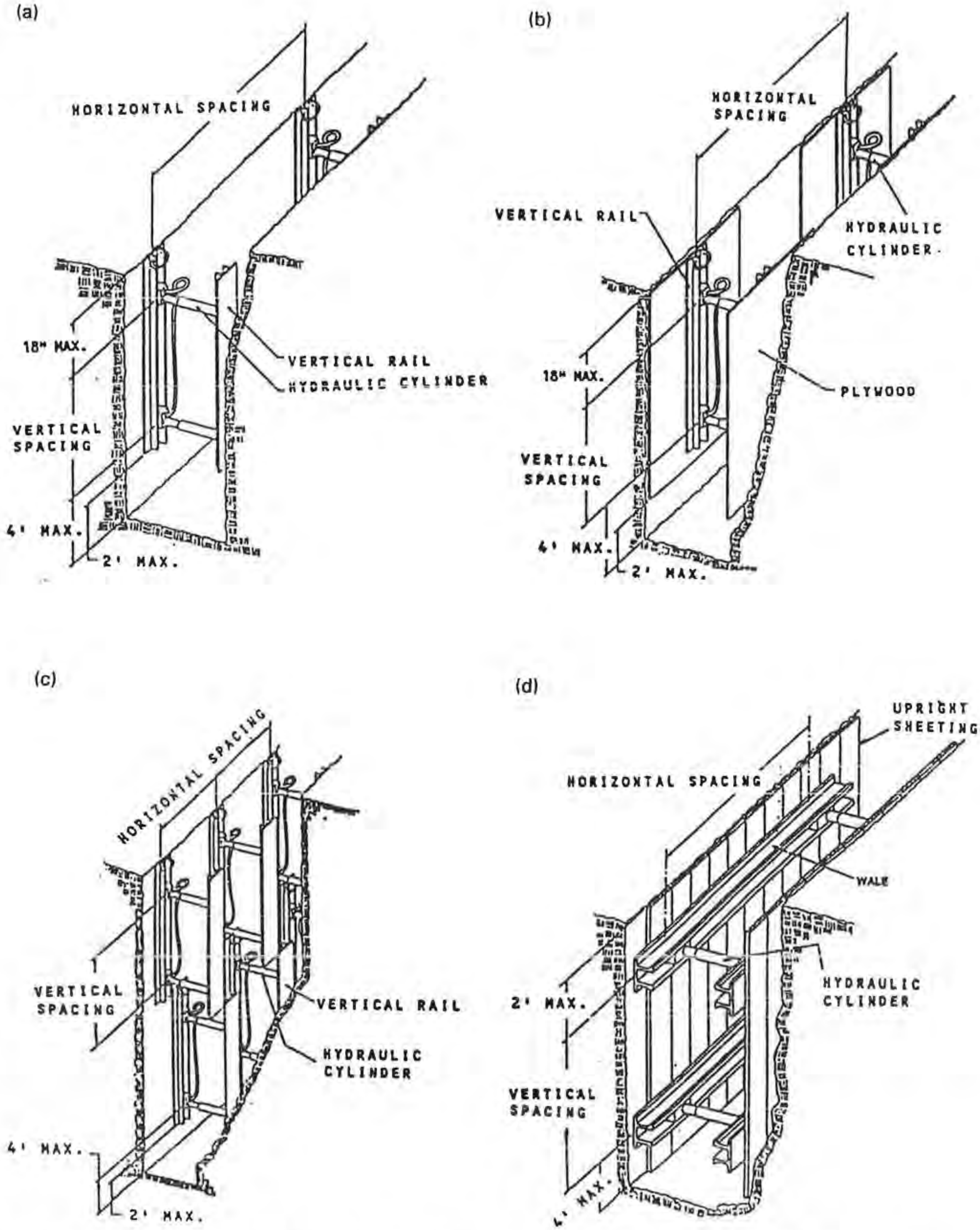

FIGURE 4 Typical installations of aluminum hydraulic shoring: (*a*) vertical shoring (spot bracing), (*b*) vertical shoring with plywood, (*c*) vertical shoring (stacked), (*d*) typical wale system.

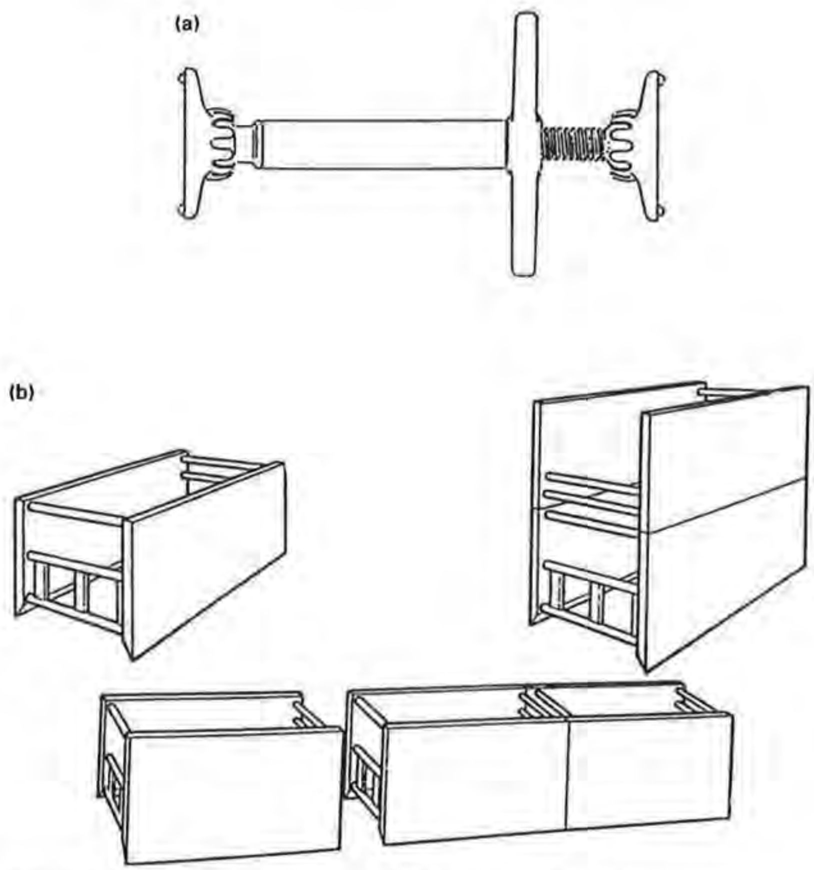

FIGURE 5 (*a*) Trench jacks (screw jacks); (*b*) trench shields.

late. Maybe, like you, I envisioned the regulations to apply to trenches. In emergency cases and to avoid the safety hazard resulting from excavating behind an existing abutment, I now use steel sheet piling upland of the timber planking, driven to a depth adequate for long-term protection of the toe. The normal theory for the design of a sheet pile wall is applied, tie-backs are installed, and a secure and safe abutment is restored. However, I'm still a strong advocate of riprap or other slope protection and recommend doing everything possible within budget constraints and "train" the stream, creek, or river from an irregular configuration upstream, through the bridge, and back to its downstream configuration with the least possible erosion or scour. Figure 3 illustrates slope protection against future erosion.

The abutment and wingwalls of an "in-house" bridge replacement are now designed using steel H-piling for load-bearing and steel sheet piling for backfill retention. The flood of 1993 was a good proving ground for our recent design. No significant damage was experienced at any bridge site at which we had installed the steel sheet piling. Some 22 timber bridges were severely damaged by eroding banks from stream discharge rates that some experts called a 500-year storm event.

If you are the professional who is responsible and liable for deaths and injuries to workers on your project, I have several suggestions that may save the life of a worker and even your license to practice engineering:

1. Obtain a copy of OSHA's Rules and Regulations for Excavations, learn your responsibilities and liability, and apply what you learn.

2. If you are in doubt about what type of protection to use for an excavation, assume a Type C soil. A Type C soil will stand safely at 34 degrees to the horizontal (*1*, Table B-1).

3. If you are the "competent person," as defined by OSHA, on the job or have selected and trained an assistant to comply with this requirement, you or that person must be prepared to direct the method of excavation safety, and if it is not the flat-slope method required for Type C soils, use extreme caution in your decision making. Soil testing and classifying should follow in strict compliance with OSHA methods. If conditions dictate the use of prefabricated, preengineered trench shields or hydraulic shoring devices, do not alter

or in any way modify them. (Several examples of these devices are included as Figures 4 and 5.) As excavations get deeper or as soil or moisture conditions change through the reach of the excavation, become more observant of the entire site, the position of every worker, and every piece of equipment and, above all, stop immediately any construction or maintenance activity not in compliance with your instructions or job specifications for safety management.

4. Do not be fooled by embankment type or "one-way" soil slopes. They, too, can fail and, under the right conditions, can collapse on a worker much faster than he can move to safety.

5. Take your responsibility seriously. Though you may think that only a few hundred workers lose their lives annually to excavation cave-ins (less than lose their lives to lightning strikes), the many others that lose limbs, are paralyzed, or are reduced in their capacity to earn a living cause enough liability claims to keep a host of attorneys busy.

6. In addition to adding OSHA's Rules and Regulations about excavation (29 CFR Part 1926) to your bookshelf, I strongly recommend that you consider a publication entitled *Excavation Safety* by Mickle.

REFERENCES

1. Occupational Safety and Health Administration. *Rules and Regulations Relative to Excavation Safety*. 29 CFR, Part 1926, July 1, 1993. (Available through the Superintendent of Documents, P.O. Box 371954, Pittsburgh, Pa. 15250-7954; current price is $33.)
2. Mickle, J. L. *Excavation Safety*. (Available from Jack L. Mickle, 1903 Linn Street, Boone, Iowa 50036; price $29.)