



Young worker injured when excavation wall collapses

A young worker was standing on a section of pipe in an unsloped, unshored trench about 6.5 feet deep. He was waiting for another worker to deliver a new section of pipe by excavator. The worker's supervisor noticed water at the bottom of the trench, about 6 to 8 feet from the worker, and told him to get out. The worker stepped off the pipe into the trench to retrieve a laser stick before exiting the trench. At that moment, part of the trench wall collapsed, burying the worker almost up to his chest and causing serious injuries.



Purpose of this report

The purpose of this online incident investigation report is to identify the causes and contributing factors of this incident to help prevent similar incidents and to support preventive actions by industry and WorkSafeBC. This online version is not the official WorkSafeBC report. It has been edited to remove personal identifying information and to focus on the main causes and underlying factors contributing to this incident.

Notice of Incident information

Number: 2007157410184

Outcome: Injuries

Core activity: Installing drain pipe in trench

Region: Lower Mainland

Date of incident: October 2007

Table of Contents

1	Factual Information	3
1.1	Employer	3
1.2	Sequence of events.....	3
1.2.1	Pre-incident activities.....	3
1.2.2	The incident	3
1.3	Equipment	4
1.4	The trench	6
1.4.1	Specifications of the trench excavation	6
1.4.2	Post-incident engineering report	7
1.5	Experience and qualifications	8
1.5.1	The Owner	8
1.5.2	Worker 1	8
1.6	Health and safety responsibilities	8
1.6.1	Notice of project	8
1.6.2	Supervision	8
1.6.3	Worker orientation and training.....	9
1.7	Good industry work practices for excavation work	9
1.7.1	Preventing collapse of the sides.....	9
1.7.2	Preventing materials from falling into the excavation.....	9
2	Analysis	9
2.1	Why did the trench wall collapse?	9
2.1.1	Sloping and shoring	10
2.1.2	Engineering	10
2.1.3	Groundwater, hydrostatic pressure, and vibration	10
2.1.4	Spoil piles.....	11
2.2	Why did Worker 1 decide to retrieve the laser stick?	11
2.3	Danger signs not recognized	11
3	Conclusions.....	11
3.1	Findings as to Causes.....	11
3.1.1	Lack of sloping and shoring, resulting in excavation collapse	11
3.2	Findings as to Underlying Factors	12
3.2.1	Groundwater and hydrostatic pressure.....	12
3.2.2	Vibration	12
3.2.3	Spoil piles.....	12
3.2.4	Lack of engineering plan	12
4	Orders Issued after the Investigation	12
4.1	Orders to the firm.....	12
5	Health and Safety Action Taken.....	13
5.1	The firm	13

1 Factual Information

1.1 Employer

The firm is a livestock-rearing business located on a farm of more than 100 acres. Several years before the incident, the firm registered with WorkSafeBC in order to hire employees for a golf course venture. The company continues to farm while developing the golf course.

The firm had three employees, all of whom were working on the day of the incident. The firm's Owner was also on site on the day of the incident.

1.2 Sequence of events

1.2.1 *Pre-incident activities*

As part of the golf course development, a 16-inch-diameter precast concrete pipe was being installed to drain water from a treed area to a pond about 250 feet away. The trench was to be 3 to 4 feet deep and 5 to 6 feet wide.

On the morning of the incident, the Owner arrived at the jobsite to assess the job before the three workers arrived. It was a cool, cloudy day and there was no rain. He did a layout, measured the length of the trench to be dug, and set up the laser to estimate the depth of the trench at various points. He marked an existing waterline that had to be crossed, then headed back to the shop to meet with Worker 1, Worker 2, and Worker 3.

The Owner instructed Worker 3 to check and warm up the excavator, which would be digging the trench, and instructed Worker 2 to check and warm up another excavator, which would be carrying pipe and placing it in the trench. The Owner and Worker 1 proceeded to the trench to meet up with the other two workers. Once they were all there, the Owner reviewed the layout of the trench, the purpose of the job, and what each worker would be doing. Worker 1 would be laying pipe in the trench and operating the laser level, a surveying instrument used to check trench depths and pipe elevations.

1.2.2 *The incident*

The Owner instructed Worker 3 to dig the trench wide and deposit the excavated dirt into a "spoil" pile on the north side of the trench. He also directed Worker 3 to slope back both sides of the trench using the entire width of the excavator bucket so that soil wouldn't fall back into the trench or onto the piping.

That morning, Worker 3 excavated 190 feet of the trench, and Worker 2 laid fourteen 10-foot sections of 16-inch-diameter precast concrete pipe into the trench, guided by Worker 1, who

stood in the trench to direct him. The Owner continued to monitor the work before calling a coffee break, and the equipment was shut down.

After the coffee break, Worker 2 and Worker 3 resumed their work using the excavators, while Worker 1 stepped onto the pipe in the trench and awaited another section of pipe. The Owner stood at the start of the excavation on the west end (about 2 feet deep), where the first pipe was laid in the trench, and turned on the laser to continue checking the pipe elevations.

The Owner began walking along the excavation toward Worker 1 when he noticed that a spring had developed near the bottom of the trench, about 6 to 8 feet away from where Worker 1 was standing. The Owner, who was now standing 10 to 15 feet away from Worker 1, pointed to the spring and told Worker 1 to get out of the trench. Both Worker 1 and Worker 3 acknowledged that the bank appeared “unsteady,” although they did not recognize any sign of potential collapse. However, they did notice the spring breaking through, according to Worker 1. Worker 1 unexpectedly stepped off the pipe, into the trench and towards the spring, to retrieve a laser stick (a calibrated rod used with a laser level to determine pipe elevations) that had been left in the trench when the crew went for coffee. Worker 1 decided to retrieve the stick so that the excavator could continue to scale back the excavation sides.

The Owner said that he noticed soil starting to break away from the face of the trench, next to the spoil piles. As he yelled at Worker 1 to get out, Worker 1 turned and looked at the soil. At that moment a large chunk of soil broke away, burying Worker 1 almost up to his chest.

Worker 2 contacted 9-1-1 while the Owner and Worker 3 extricated Worker 1 with shovels and by using the excavator bucket to hold back dirt. Worker 1 was airlifted to hospital. He suffered serious injuries.

1.3 Equipment

There were two excavators in use on the day of the incident, one to dig the trench (see Figure 1) and another to deliver the pipe to the trench (see Figure 2).



Figure 1: The excavator used to dig the trench.



Figure 2: The excavator used to deliver pipe to the trench.

1.4 The trench

1.4.1 Specifications of the trench excavation

The trench was to be 280 feet long and 5 to 6 feet wide. The excavation started at the pond at the west end and moved in an easterly direction (see Figure 3). For much of its length the trench followed an existing road. By the time of the incident, 190 feet had been dug. At the west end, the trench was 2 feet deep, although most of it was 3 to 4 feet deep. However, the excavation reached a depth of about 7 feet where it joined the existing road, sloping down on either side of the road's high point or "crown."

The edges of the trench were cut back somewhat. The spoil pile, over 2 feet high, was dumped on the north side of the trench, 3 to 5 feet away from its sides.

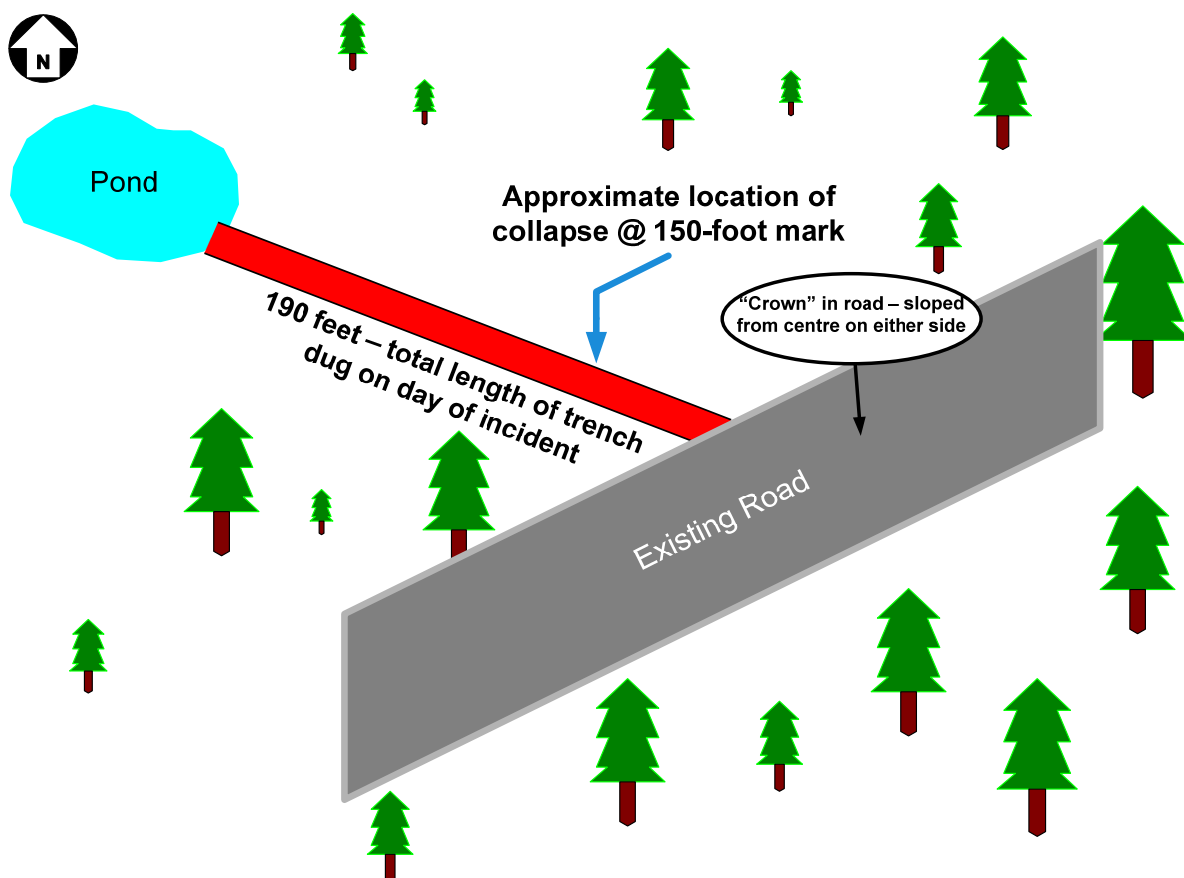


Figure 3: Site layout.

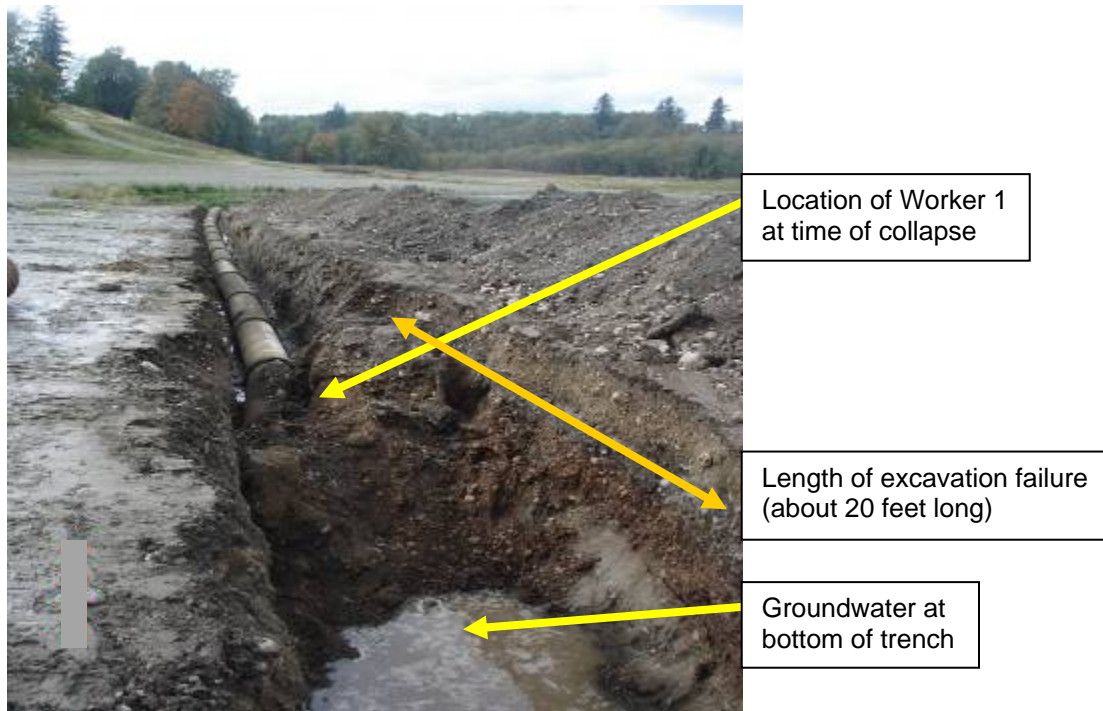


Figure 4: *The trench.*

The failure occurred about 150 feet from the pond. The collapsed embankment was about 20 feet long (see Figure 4). Undermining and sloughing of trench walls began at the 14-foot mark from the start of the trench, and at 30 feet even more sloughing was evident. The area where the incident occurred — that is, the area where Worker 1 was standing on top of the 20-inch-diameter pipe — was one of the deeper sections of the trench (6 feet, 6 inches).

The soil was generally sandy silt with rubble of 1 to 8 inches in diameter. It was primarily native and non-compacted. About 12 inches of topsoil had been stripped from the surface of the road and trench areas, about one year before excavating began. Gravel had been spread on top of the sand, at the road area, to make it driveable.

1.4.2 Post-incident engineering report

Photographs taken on the day of the incident show groundwater at the bottom of the trench, beneath the pipe. Some undermining and sloughing in the trench were obvious. The spoil piles, generally more than 2 feet deep, were close to the edge on the north side of the trench. In the area of the failure, the spoil pile was 5 feet away from the unsupported edge of the trench. There was no engineering input for the excavation work, and the trench was not excavated according to any plan or specification. The trench walls were not adequately sloped nor was any shoring used.

1.5 Experience and qualifications

1.5.1 The Owner

The Owner of the firm is also the co-owner of the property and acts as manager of operations. He has extensive experience operating farming and heavy equipment as well as experience assisting with excavator operator training, covering such areas as safety, maintenance, and operations. However, he has no formal certification related to excavation training, excavating machinery, or construction safety.

The Occupational Health and Safety Regulation states, in part, that a worker must not enter an excavation over 4 feet deep until the excavation sides are sloped or supported as specified by a professional engineer. The Owner was aware of this requirement.

1.5.2 Worker 1

At the time of the incident, Worker 1 had been employed by the firm as a labourer for about two years. Worker 1 was trained by the Owner to operate various types of equipment, including loaders, excavators, and dump trucks. However, it was not his job on the day of the incident to operate any of the equipment: his task was to lay pipe in the trench and operate the laser level to ensure that the pipe was properly installed.

When Worker 1 was asked about his knowledge of the safety requirements for working in and around excavations, he noted that he had a “basic” understanding of excavations but that he didn’t realize how easily things can go wrong or the severe consequences of not ensuring safe excavations. Specifically, he was not aware of the requirements under the Occupational Health and Safety Regulation for excavations over 4 feet deep.

1.6 Health and safety responsibilities

1.6.1 Notice of project

Whenever a construction project includes a trench deeper than 4 feet (1.2 metres) and longer than 100 feet (30.5 metres) and workers are required to enter that excavation, the owner or the prime contractor is required to submit a Notice of Project to WorkSafeBC. A WorkSafeBC officer may conduct a site visit to ensure compliance with the *Workers Compensation Act* and the Occupational Health and Safety Regulation.

In the case of this project, no Notice of Project was submitted to WorkSafeBC.

1.6.2 Supervision

The Owner acted as site supervisor on the project. On the day of the incident, the Owner supervised three workers at the site.

1.6.3 Worker orientation and training

The Owner did not have a health and safety program in place. The workers did not receive any formal orientation and training, although the Owner gave Worker 1 some guidance and instruction from the time he was hired until the day of the incident. However, Worker 1 did not receive formal training in recognizing the dangers of excavations.

1.7 Good industry work practices for excavation work

In order to prevent accidents and to meet the standard of the Occupational Health and Safety Regulation, excavation work must be planned, managed, and supervised adequately. Before digging an excavation, it is very important to:

- plan against collapse of the sides
- plan against materials falling on workers working in the excavation
- locate underground utilities and services

The deeper the excavation is, the greater the risk of collapse. Higher excavation walls are more likely to collapse. A worker buried to chest level or above can suffocate very quickly.

1.7.1 Preventing collapse of the sides

The sides of an excavation can be prevented from collapsing by:

- sloping the sides to a safe angle that will ensure that the faces are stable
- benching the sides
- supporting the sides
- using prefabricated trench boxes or shoring cages
- working under the written instructions of a professional engineer

1.7.2 Preventing materials from falling into the excavation

Loose materials should be kept away from the edge of the excavation. Any excavation wall supports or shoring cages should extend at least one foot above the excavation to prevent loose material from falling into the excavation.

2 Analysis

This analysis looks at why the trench wall collapsed and why Worker 1 was in the trench during the collapse.

2.1 Why did the trench wall collapse?

WorkSafeBC's investigation looked at the following factors to determine why the trench wall collapsed:

- Sloping and shoring requirements
- Engineering requirements
- Vibration and hydrostatic pressure
- Groundwater
- Undermining and sloughing
- Spoil piles

The investigation found that the trench was not sloped, shored, or engineered according to the Occupational Health and Safety requirements. In addition, groundwater contributed to hydrostatic pressure. This, in turn, created undermining and sloughing of the trench walls until the soil gave way and the collapse occurred. These factors are discussed in detail below.

2.1.1 *Sloping and shoring*

The Occupational Health and Safety Regulation states, in part, that a worker must not enter an excavation over 4 feet in depth until the excavation sides are sloped or supported as specified by a professional engineer.

The employer did not fulfill these requirements. The Owner and the workers believed that the angle of the excavation sides was adequate because they kept opening up the trench width, by cutting back the edges, as the trench length increased.

Shoring cages and other means of protection were not used because the Owner intended not to go deeper than 4 feet. However, as the excavation progressed, sloughing occurred, and the workers continued excavating deeper and wider.

2.1.2 *Engineering*

The Occupational Health and Safety Regulation states that, in the absence of adequate shoring, excavation work must follow the written instructions of a professional engineer if the excavation is subject to vibration or hydrostatic pressure and/or the ground slopes away from the edge of the excavation at an angle steeper than 3 horizontal to 1 vertical. The Owner did not get engineering advice or an engineering plan before starting the excavation because he was unaware of this obligation.

2.1.3 *Groundwater, hydrostatic pressure, and vibration*

The low-lying site was characterized by high groundwater, that is, water located just beneath the ground surface. The groundwater was widespread, saturating the soil. The trenching activity caused the water table to drop rapidly.

Digging the trench caused the pressure of the groundwater to rise and fall, contributing to the instability of the trench walls. The fluctuations of this pressure were significant, considering that the soil was sandy silt and had little shear strength.

Machinery working next to an excavation can cause excessive vibration in the ground, which in turn causes the ground to shift. The Owner was using an excavator to dig the trench and another one to deliver pipe to the trench. The weight of these two machines and their vibration could have contributed to the ground shifting.

2.1.4 Spoil piles

The excavation was unsupported, and the resulting increase in lateral soil pressure was not taken into account. In addition, the depth of the spoil piles exceeded 2 feet on the north side of the trench. The location of spoil piles next to the trench increased both the vertical and the lateral pressure on the trench walls. This pressure forced soil out of the sides of the unsupported embankment, causing a cave-in.

2.2 Why did Worker 1 decide to retrieve the laser stick?

Worker 1 made a decision, based on his limited knowledge of excavation safety, to retrieve the laser stick before leaving the trench. His purpose in doing this was to allow the excavator to work in the area to further scale back the slopes. However, Worker 1 should have exited the trench the moment the water was spotted, and his delay put him in danger. This suggests that Worker 1 did not receive adequate training in recognizing the dangers of excavations.

2.3 Danger signs not recognized

The Owner stated that, while he and Worker 3 had in fact noticed some “minor” sloughing before the coffee break, it was determined to be of no significance, and they agreed to remedy the problem when they returned by scaling back the slopes. They did not, however, notice the water spring and the undermining of the trench walls until after returning from the coffee break and re-entering the trench.

3 Conclusions

3.1 Findings as to Causes

3.1.1 Lack of sloping and shoring, resulting in excavation collapse

Worker 1 was injured when the wall of a trench he was standing in collapsed and fell onto him. A WorkSafeBC engineer concluded that the prime cause of the cave-in was a lack of shoring or sloping to prevent this failure.

3.2 Findings as to Underlying Factors

3.2.1 *Groundwater and hydrostatic pressure*

The water table in the soil mass added hydrostatic pressure to the soil pressure. In addition, the stresses that accumulated from the depth of the spoil piles not only pushed down but also pushed out laterally. The unsupported trench cut was unstable and subject to collapse, as the lateral stresses pushed against the face of the trench wall.

3.2.2 *Vibration*

Vibration from the excavators likely contributed to some ground movement.

3.2.3 *Spoil piles*

The spoil piles were more than 2 feet deep and close to the edge of the trench excavation, creating lateral stresses on the soil.

3.2.4 *Lack of engineering plan*

The nature of the trench and the way it was being constructed required engineering assessment. The firm did not seek engineering advice before allowing a worker to enter the excavation.

4 Orders Issued after the Investigation

WorkSafeBC issued five orders to the employer after the investigation. An order requires an employer to take steps to comply with the *Workers Compensation Act* or Occupational Health and Safety Regulation, to take measures to protect worker health and safety, or to fix a hazardous condition. An order is intended to ensure that unsafe conditions are identified and corrected and that the employer complies with the Act and the Regulation. An employer may ask the Review Division to review an order; the Review Division may confirm, vary, or cancel an order.

In addition to issuing orders, WorkSafeBC may recommend proceeding with an administrative penalty against an employer. Penalties are fines for health and safety violations of the *Workers Compensation Act* and/or the Occupational Health and Safety Regulation. For information on when penalties are considered and how the amount of the penalty is calculated, see the [penalty FAQs](#) on WorkSafeBC.com. [Companies that have been penalized](#) are also listed on the web site.

4.1 Orders to the firm

This section summarizes five orders issued to the livestock-rearing business. The investigation found that this employer was in contravention of the following sections of the Occupational Health and Safety Regulation:

- [20.78](#)(1)(c), which states that excavation work must follow the written instructions of a professional engineer if the excavation is subject to vibration or hydrostatic pressure likely to result in ground movement hazardous to workers.
- [20.81](#)(1), which states that before a worker enters any excavation over 1.2 m (4 feet) deep or, while in the excavation, approaches closer to the side or bank than a distance equal to the excavation's depth, the employer must ensure that the sides of the excavation are sloped or supported as specified by a professional engineer, or that the sides are otherwise benched or supported as required.
- [20.90](#)(2), which states that excavated material must not be piled in any way that endangers workers.

The employer was also in contravention of the following sections of the *Workers Compensation Act*:

- [115](#)(1)(a), which states that an employer must ensure the health and safety of its workers and any other workers at its workplace.
- [115](#)(2)(e), which states that an employer must provide its workers with the information, instruction, training, and supervision necessary to ensure their health and safety as well as the health and safety of other workers at the workplace.

5 Health and Safety Action Taken

In addition to the specific actions below, employers, workers, or others in industry may have taken measures to prevent a recurrence of this type of incident. Employers are expected to comply with any orders issued. At WorkSafeBC, the Lessons Learned committee examines recommendations from incident investigations to see what can be done to prevent similar incidents.

5.1 The firm

After the incident, this firm began developing a Health and Safety Program to include everything necessary to ensure full adherence to the Occupational Health and Safety Regulation.

Copyright

© 2011 Workers' Compensation Board of British Columbia. All rights reserved. WorkSafeBC (Workers' Compensation Board of B.C.) encourages the copying, reproduction, and distribution of publications to promote health and safety in the workplace, provided that WorkSafeBC is acknowledged. However, no part of this publication may be copied, reproduced, or distributed for profit or other commercial enterprises or may be incorporated into any other publications or product without written permission of the Workers' Compensation Board of B.C.