OVERVIEW

The fire service has been installing emergency shores in trenches for several decades. Unfortunately, we have been using shoring techniques and designs that lack science and technology that is specific to trench walls with active soil conditions. One of the reasons for this is the fact that civil engineers are paid to design soil retention systems for underground construction projects, but for the most part, they have not engaged in the development of trench rescue shoring.

At construction sites the soil can be shored during or shortly after the excavation (digging) process. That allows the shores to support the soil before it starts to move or while it is “at rest”. At a trench rescue (collapse) the soil has begun to move (active). The soil conditions are different, and the shoring needs to be different. However, most rescuers learn construction based shoring practices and not collapsed trench shoring practices. In 2009, Dr. Marie LaBaw (P.E./PhD) conducted the only study that has ever been published on trench rescue shoring. Dr. LaBaw concluded; “Underground construction shoring and trench rescue shoring are significantly different. Many of the theories and field observations (and practices) that have been used for construction shoring may not be applicable to trench rescue shoring.”

Firefighters do not undergo enough training and do not have enough field experience to conduct accurate soil analysis. Firefighters should not attempt to use OSHA Competent Person soil analysis methods to classify soil. Furthermore, OSHA lateral earth pressure estimates (A-25, B-45 and C-80) are neither accurate nor do they account for soil conditions that include failure (collapse). A simple, fast and accurate method of determining lateral soil forces is needed but up until now, has been missing.

Dr. Oliver Taylor (P.E./PhD) is a Research Geotechnical Engineer with the U.S Army Corp of Engineers. Dr. Taylor has conducted research on trench rescue shoring and concluded; “Emergency trench shoring design for rescue operations has no reliable standard to determine lateral earth pressures. As a result, the first responder community is forced either to rely predominantly on either “rule-of-thumb” methods or similarly to assume the OSHA29 CFR for Type C soil to determine a “worst-case scenario.” However, the use of generalized methods, i.e., the C-80, is not officially supported by OSHA standards, which are overly conservative and do not reflect the observations of actual trench surface failures. Additionally, the shoring system requirements can be unnecessarily prohibitive in short-term emergency operations. The current “rule-of-thumb” method used by first responders’ underestimates braced earth pressures for weak sandy soils and is not recommended for continued use.”

In 2018 Dr. Oliver Taylor (P.E./PhD) and Dr. Marie LaBaw (P.E./PhD) developed a soil assessment method (T-L) that is designed for use by first responders. The T-L method accurately represents actual earth pressures and lateral forces based on the soil failure conditions. Determining lateral soil forces and interpreting the tabulated data (see attached tab data) has been reduced to the use of a tape measure and charts (pocket guides). The MUSAR “Rescue Soil Assessment” uses the T-L method for all trench rescue incidents. Additionally, visual assessment is used to determine collapse potential and the initial direction of the soil failure.

SOIL CLASSIFICATION- Rescuers should consider soil conditions at all trench rescues as unstable and heavy. The T-L method does that, and T-L soil conditions more accurately depict the soil conditions found at trench collapse incidents than the OSHA Type-C soil classification. Rescuers can safely classify all soils at trench rescue incidents as worst-case soil or as T-L soil.

SOIL FORCES- The T-L method utilizes soil pressure formulas and worst-case conditions (weight-133 pcf with an active earth pressure coefficient of 0.5). That means a lateral force of about 66 pcf. On a 4'x4' (16 square feet) section of shoring (half panel) 16 cubic feet (4' x 4' x 1') T-L soil will develop nearly 1,100 pounds of lateral force (16 ft2 x 66.4 psf= 1,062.5). Comparatively, 64 cubic feet (4' x 4' x 4') or L-4 will develop nearly 4,400 pounds of lateral force on each half panel and the associated struts and/or wales. Surcharged loads must be added as explained below.

DEFINITIONS

Simple L (SL): The distance (length) measured in feet from the original trench wall perpendicular to the furthest point of soil failure.

Surcharged L (ScL): Surcharged loads (spoil piles/equipment), that are within the area that is between the original trench faces and the furthest point of soil failure. Measured in feet perpendicular to the trench wall.

Total L (L): The Simple L (SL) plus the Surcharge L (ScL) if one exists.

PART 1

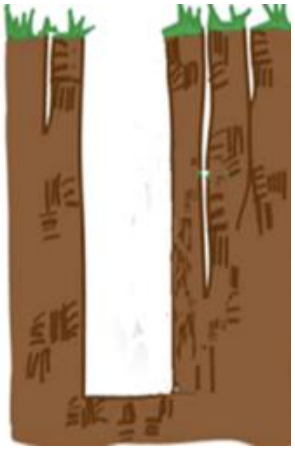
HOW TO USE THE T-L METHOD

For rescue situations (trench collapse) with trench walls that can be shored with panels and struts we can accurately estimate the lateral force on our shoring by using the T-L method.

A tape measure is used to find the distance (SL) from the original trench face (wall) to the farthest point of soil failure and to measure the amount of surcharge (ScL) within the affected area. Common failures include:

Open Lip Failure

Closed Lip Failure

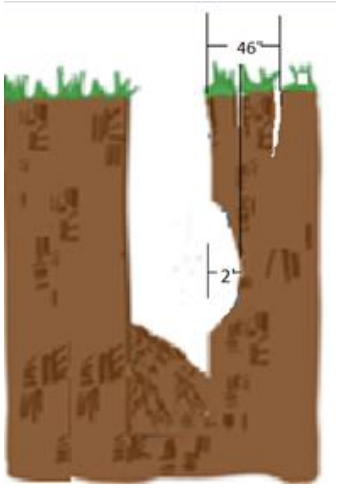


Fissures

PROCEDURE:

* From a safe area on the lip, measure the distance from the original trench wall (face) perpendicular to the furthest failure point.

Example: In the case below we have a closed lip failure at 2' (24") and fissures at both 24" and 46". The furthest point is 46".



* Round that measurement (46") up to the next foot. In this case 4'. The simple L (SL) is 4.

  If no surcharged load exists, the simple (SL) is the total (L) which is used in the shoring charts and shown as L=4

* If a surcharge load exists, we must add the result from the surcharge load (ScL) to the Simple L (SL) determine the Total L (L). (see below)

TABULATED DATA- Our group of professional engineers have established tabulated data specifically for collapsed trench conditions. All of our shoring charts (tabulated data) are based on a "Total L" value. Look at the Wale Chart and find the wales that can support the L-4 value that we just came up with in the previous example.

WALE CHART

4' Maximum Vertical Spacing

DISTRIBUTED LOAD CHART

Wale Type	8" Span	12' Span
6"x6"	Maximum Total L-2	Maximum TotalL-1
8"x8"	Maximum Total L-5	Maximum Total L-2
7"x7" LVL	Maximum Total L-12	Maximum Total L-4
Paratech	Maximum Total L-10	Maximum Total L-1

NOTES:

*Span is the distance between the struts supporting the wales

*Gaps between the wales and panels at the panel edges and both ends of the wales must be filled with spacers and/or wedges

*2' vertical Spacing will increase the capacity (Total L Value) of each wale by 150% (Total L x 1.5)

*6"x6" and 8"x8" timber capacities are based on #1 Douglas Fir/SPF

*7"x7" LVL capacity is based on bending strength of 3,100

You should see that for wales with an 8’ span between struts a 6”x6” timber cannot carry the load (Total L). However, an 8’x8” timber, 7”x7” LVL and a Paratech aluminum wale all can safely support (2:1 factor of safety) the L-4.

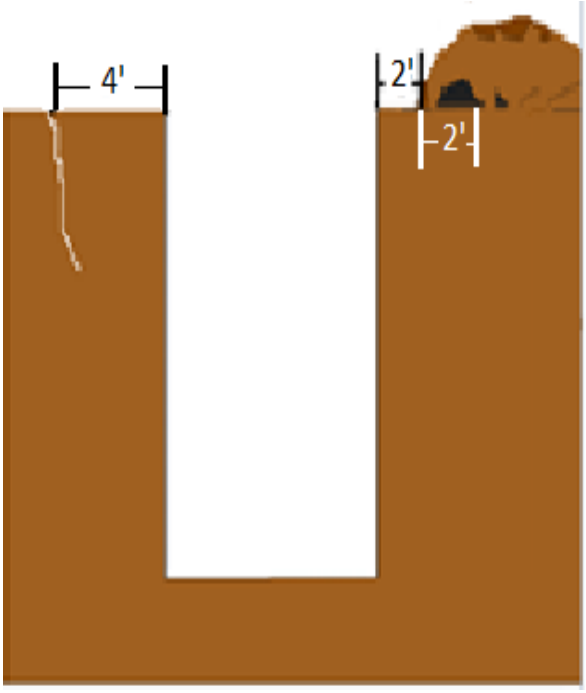
STOP:

Complete Quiz #1 before continuing to Part 2

PART 2

SURCHARGED LOADS- Surcharged loads at a trench site usually include the spoil pile and construction equipment. Construction equipment can include but is not limited to excavators, dump trucks, trench boxes and pipes. Surcharged loads, that are within the area between the original trench faces and the furthest point of soil failure, can add significant lateral forces to our shoring systems. Those additional forces must be added to the Simple L (SL) to obtain the Total L (L) that is used in the shoring charts. A user-friendly chart has been provided as a pocket guide to allow you to easily factor in surcharged loads.

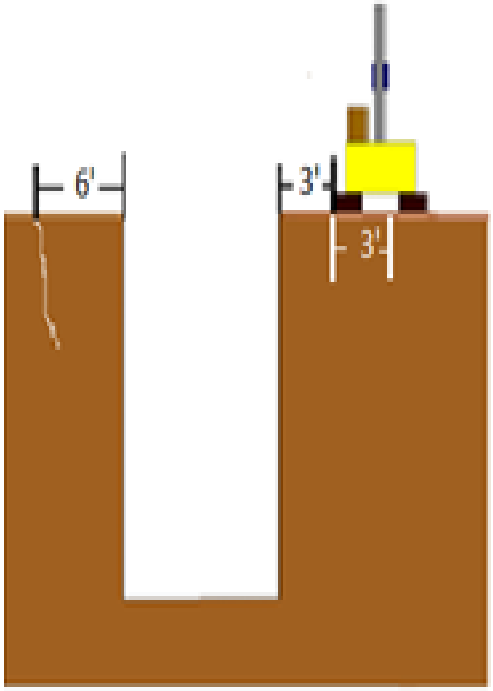
SPOIL PILE SURCHARGE- Measure the amount of spoil (ScL) that is within the Simple L (SL). Round the measurement up to the next foot to determine the ScL.
Example: Simple L (SL) is 4. Two feet of the spoil pile is within the (SL). Use 2’ as the Surcharge L (ScL) and refer to the Surcharge Pocket Guide below (Spoil column) to determine the value that must be added to the SL.



SURCHARGE (ScL)- Feet within Simple L (SL)				
SPOIL	Add to SL		EQUIP.	Add to SL
1	1		1	1
2	1		2	2
3	1		3	3
4	2		4	5
5	3		5	8
6	4		6	11
7	5		7	N/A
8	7		8	N/A
9	9		9	N/A
10	10		10	N/A
Note: Total L (L)=Simple L (SL) plus Surcharge L (ScL)				
Charts are valid for Total L of 20 or less				

In this case with a spoil pile surcharge (ScL) of 2 the pocket guide tells you to add 1 for a Total L (L) of 5.

EQUIPMENT SURCHARGE- Measure the amount of equipment (ScL) that is within the simple “L”. Round the measurement up to the next foot to determine the (ScL). Example: Simple L (SL) is 6. 3 feet of the equipment is within the (SL). Use 3’ as the surcharge “ScL” and refer to the Surcharge Pocket Guide below (Equipment column) to determine the value that must be added to the SL.



In this case with an equipment surcharge (ScL) of 3 the pocket guide tells you to add 3 to the Simple L-6 for a Total L (L) of 9.

SURCHARGE POCKET GUIDE

SURCHARGE (ScL)- Feet within Simple L (SL)				
SPOIL	Add to SL		EQUIP.	Add to SL
1	1		1	1
2	1		2	2
3	1		3	3
4	2		4	5
5	3		5	8
6	4		6	11
7	5		7	N/A
8	7		8	N/A
9	9		9	N/A
10	10		10	N/A
Note: Total L (L)=Simple L (SL) plus Surcharge L (ScL)				
Charts are valid for Total L of 20 or less				

A look at the Wale Charts tells us that with 8' spans the wales listed that can support a Total L-9 are the 7"x7" LVL (L≤12) and the Paratech (L≤10)

WALE CHART

4' Maximum Vertical Spacing

DISTRIBUTED LOAD CHART

Wale Type	8" Span	12' Span
6"x6"	Maximum Total L-2	Maximum TotalL-1
8"x8"	Maximum Total L-5	Maximum Total L-2
7"x7" LVL	Maximum Total L-12	Maximum Total L-4
Paratech	Maximum Total L-10	Maximum Total L-1

NOTES:

*Span is the distance between the struts supporting the wales

*Gaps between the wales and panels at the panel edges and both ends of the wales must be filled with spacers and/or wedges

*2' vertical Spacing will increase the capacity (Total L Value) of each wale by 150% (Total L x 1.5)

*6"x6" and 8"x8" timber capacities are based on #1 Douglas Fir/SPF

*7"x7" LVL capacity is based on bending strength of 3,100

STOP:

Complete Quiz #2 before continuing to Part 3.

PART 3

DEPTH to (SL) CONVERSION- In the unlikely event of a rescue in a trench that has not had a soil failure you need to measure the depth of the trench (measured in feet and rounded up) and refer to the Depth Conversion Pocket Guide to determine the Simple L (SL).

Example: A trench is 7 feet- 9 inches deep. Round that up to 8. The Depth Conversion Pocket Guide shows L-6 for trenches between 4'-8' deep. Use L-6 in the shoring charts. If a surcharge exists then surcharge rules apply as described above and would be added to L-6 if a surcharge exists.

DEPTH CONVERSION POCKET GUIDE

DEPTH TO SIMPLE L (SL) CONVERSION GUIDE	
Trench Depth	**SL Equivalent**
4- 8 feet	SL 6
9 feet	SL 7
10 feet	SL 7
11 feet	SL 8
12 feet	SL 9
13 feet	SL 10
14 feet	SL 10
15 feet	SL 11
16 feet	SL 12
17 feet	SL 12
18 feet	SL 13
19 feet	SL 14
20 feet	SL 14
Note: Total L (L)=Simple L (SL) plus Surcharge L (ScL)	

STOP: Complete Quiz #3

Send all completed quizzes to Aaron Osburn

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