EM-385-1-1 Section 25 Excavations, Section 26 Underground Construction
OSHA 1926, SUBPART “P”
TRENCHING EXCAVATION MISHAP STATISTICS

- 100-400 FATALITIES EACH YEAR FROM CAVE-INS.
- 1000-4000 INJURIES EACH YEAR!
- MOST INJURED/KILLED WORKERS WERE MALES AGE 20-30 WITH NO TRAINING
- 79% OF FATALITIES WERE IN TRENCHES 5 TO 14 FT. DEEP

Look On Page #15
An Excavation/ Trenching Plan will be submitted and accepted by the GDA prior to beginning operation.
TRENCHING & EXCAVATION SAFETY

Less than 5 ft. in depth, an AHA is required; plan is optional.

Greater than 5 ft. in depth an AHA and plan are required. Minimum plan shall include:

1) identification and credentials of Competent Person;
2) Diagram or sketch of the area where the work is to be done, with adjacent and nearby structures shown;
3) Projected depth of the excavation;
4) Projected soli type and method of testing to determine soil type;
5) Planned method of shoring, sloping and or benching;
6) Planned method for confined space entry, trench access and egress and atmospheric monitoring processes;
TRENCHING & EXCAVATION SAFETY

Less than 5 ft. in depth, an AHA is required; plan is optional
Greater than 5 ft. in depth an AHA and plan are required.

Minimum plan shall include:

7) Location of utility shut offs (if required)
8) Proposed method of preventing damage to overhead utility lines, trees designed to remain, and other man-made facilities or natural features designated to remain within or adjacent to the construction rights-of-way;
9) Plan for management of excavated soil/asphalt/concrete;
10) Digging Permits (Excavations Permits)
11) Certification for UXO (clearance by EOD personnel)
12) For cofferdam; Controlled flooding plan, Fall protection, access/egress; Evacuation procedures
CAVE-INS CAUSE DEATH. & INJURIES FROM

- SUDDEN DEATH
- SOFT TISSUE INJURIES
- CRUSHING
- LOSS OF CIRCULATION
- FALLING OBJECTS
EXCAVATION FATALITIES FROM CRUSHING

WEIGHT OF SOIL
1 CUBIC FOOT. = 90-140 LBS

1 CUBIC YARD. = 2340-3780 LBS
DID YOU KNOW?

The Average Pick Up Truck weighs about the same as ONE Cubic Yard of Soil?

SELDOM IS A CAVE IN ONLY 1 CUBIC YARD OF MATERIAL!
EXCAVATION CAVE-IN

A COLLAPSED TRENCH WALL OF 3-5 CUBIC YDS OF SOIL WEIGH FROM 8,000 - 14,000 LBS!

RESULTS:
CRUSHING INJURIES
SUFFOCATION &
LOSS OF CIRCULATION
EXCAVATION FATALITIES SUFFOCATION

WORKER BURIED IN ONLY A FEW FEET OF SOIL EXPERIENCES ENOUGH PRESSURE ON CHEST AREA TO PREVENT LUNGS FROM EXPANDING AND CONTRACTING. APPROX. TIME UNTIL SUFFOCATION IS 3 MINUTES!

RESULTS: SUFFOCATION!

10/25/2013
IS THIS WORKER SAFE?

NOTE:
This photo was copied from an internet site! It is not from a known Gvt. job

Imminent DANGER!
EXCAVATION & TRENCHING KEY DEFINITIONS

COMPETENT PERSON

ONE WHO CAN IDENTIFY EXISTING AND PREDICTABLE HAZARDS IN THE WORKING ENVIRONMENT OR WORKING CONDITIONS THAT ARE DANGEROUS TO PERSONNEL AND WHO HAS AUTHORIZATION TO TAKE PROMPT CORRECTIVE MEASURES TO ELIMINATE THEM!

Yea! The key information is on page 7 & 8.
1. INSPECT PROTECTIVE SYSTEMS DAILY BEFORE EACH SHIFT, THROUGHOUT THE WORK SHIFTS AS DICTATED BY THE WORK BEING DONE, AFTER EVERY RAIN STORM, WHEN THERE IS A CHANGE IN SIZE, LOCATION OR PLACEMENT OF THE SPOIL PILE; AND WHERE THERE IS ANY INDICATION OR CHANGE IN ADJACENT STRUCTURES
EXCAVATION & TRENCHING KEY DEFINITIONS

COMPETENT PERSON

Shall be able to demonstrate the following:

1) Training, experience, and knowledge of.
   a. soil analysis
   b. Use of protective systems and;
   c. Requirements of this section, EM-385-1-1 and 29 CFR 1926 Subpart P

2) Ability to detect:
   a. Conditions that could result in cave-ins;
   b. Failures in protective systems;
   c. Hazardous atmospheres; and
   d. Other hazards including those associated with confined spaces

3) Have the authority to take prompt corrective measures to eliminate existing and predictable hazards and STOP WORK WHEN REQUIRED.
MAJOR CONSIDERATIONS

Surface Encumbrances
Underground Utilities
Access & Egress
Vehicular Traffic
Exposure to falling loads
Warning Systems for Mobile Equipment
Hazardous Atmosphere
Water Accumulation hazard protection
Adjacent Structure Stability
Employee protection
Fall Protection
Inspections

Can you think of any more items to consider?
SO WHAT ELSE DO I HAVE TO KNOW BEFORE I CAN START DIGGING?
Many contractors use heavy equipment besides cranes to install materials into an excavation. Example a large tracked backhoe installing large concrete pipe in a trench and moving a trench box.

A recent change to Em-385 Section 16.S covers this type of operations.
Hydraulic excavating equipment shall not be used to hoist personnel. Hydraulic excavating equipment used to hoist only if allowed by the manufacturer. Controls of equipment with folding arms shall not be operated from a ground position unless so designed. AHA specific to transporting or hoisting operation shall be prepared.

1) Written proof of qualifications of equipment operators, riggers, and others involved in the transporting and hoisting operations;
2) Performance of the operational test described in 16.F
   a. written reports of tests with hoisting equipment
   b. qualified person conduct operational tests IAW manufacturers recommendations
3) Load Testing
   IAW Manufactures recommendations, no manufacturer has no recommendations, a Registered Professional engineer must approve procedures, use Appendix I
HYDRAULIC EXCAVATORS, WHEEL/TRACK/BACKHOE LOADERS USED TO TRANSPORT/HOIST LOADS WITH RIGGING

4) Proper use of load charts
5) Proper use of rigging, including positive latching devices to secure load
6) Inspection of rigging
7) Use of tag lines to control load

Loads shall not be lifted over personnel

Adequate clearances shall be maintained from electrical sources.

An operational test with the selected hydraulic excavating equipment will be performed in the presence of the GDA, !6. S.03 a,b,c
ACCESS AND TRENCHES

Persons required to enter excavations over 4 feet in depth, stairways, ramps or ladders are required and lateral travel to these is not to exceed 25 feet.

Also, walkways or bridges are required with standard guardrail for persons required to cross over the excavation.
rough approximation: $P_v = \gamma h$, $P_v = 2P_h$

LOOK FOR CRACKS AND THE BOTTOM EDGE OF THE DITCH!

Vertical Soil Pressure = 500 lb/ft$^2$, horizontal pressure ~ 250 lb/ft$^2$ but only on one side creating instability
TYPICAL TRENCH FAILURE

A: CRACKS OCCUR 1/3 TO 2/3 BACK FROM EXCAVATION, USUALLY VERTICAL & MAY BE 1/2 THE DEPTH OF THE TRENCH. B. 1ST. FAILURE DUE TO WEIGHT OF COLUMN OF SOIL AT BOTTOM. C. 2ND FAILURE DUE TO LESS LATERAL FORCES HOLDING COLUMN OF SOIL. D. ULTIMATE CAVE IN DUE TO GREATER FORCES BOTH LATERALLY AND NO SHEAR FORCES HOLDING DUE TO CRACKS. E. SHOWS FIRST, SECOND, AND THIRD FAILURE ZONES. THESE ARE NOT THE ONLY REASON FOR FAILURES, ALSO WEATHER, WATER, VIBRATION, OTHER LOADS ON SOIL.

Figure 2. Mechanics of a trench failure (Abstrected from Mickle, 1991)

You’ll find this On Page #5 !!
SOIL CLASSIFICATION SYSTEM

WHAT IS THE **ONLY PURPOSE**
TO **CLASSIFY SOIL TYPE**?

To determine the protection to be used for employees working in the excavation!

Mandatory Knowledge for Competent Person
SOIL CLASSIFICATION SYSTEM

A METHOD OF CATEGORIZING SOIL AND ROCK DEPOSITS IN A HIERARCHY OF: STABLE ROCK and THREE TYPES!

TYPE “A”
TYPE “B”
TYPE “C”

DECREASING ORDER OF STABILITY
TRENCH & EXCAVATIONS
MAY BE A CONFINED SPACE

“UNDERGROUND UTILITY VAULTS, TUNNELS, PIPELINES, AND OPEN TOP SPACES MORE THAT 4 FEET IN DEPTH SUCH AS PITS, TUBS, VAULTS, AND VESSELS”

THE ABOVE IS QUOTED AS PART OF THE OSHA DEFINITION OF A CONFINED SPACE
MAXIMUM ALLOWABLE SLOPE

THE STEEPEST INCLINE OF AN EXCAVATION

FACE THAT IS ACCEPTABLE FOR THE MOST

FAVORABLE SITE CONDITIONS AS PROTECTION

AGAINST A CAVE IN. EXPRESSED AS THE RATIO

OF HORIZONTAL DISTANCE TO VERTICAL RISE.

(H:V)
TYPE “A”

MOST STABLE: CLAY, SILT CLAY, & HARDPAN (RESISTS PENETRATION) SUCH AS CALICHES HAS A COMPRESSIVE STRENGTH OF 1.5 TSF OR GREATER

TYPE “A” SOIL IS NOT FISSURED, SUBJECT TO VIBRATION, PREVIOUSLY BEEN DISTURBED, OR HAS SEEPING WATER.
TYPE “B” SOIL CLASSIFICATION

COHESIVE SOIL WITH A UNCONFINED COMPRESSIVE STRENGTH < .5 TSF BUT LESS THAN 1.5 TSF, GRANULAR COHESION LESS SOILS INCLUDING ANGULAR GRAVEL, SILT, SILT LOAM, AND SANDY LOAM, SOIL THAT HAS BEEN PREVIOUSLY DISTURBED (EXCEPT TYPE “C”) SOIL THAT MEETS TYPE “A” REQUIREMENTS EXCEPT IS FISSURED OR SUBJECT TO VIBRATION AND DRY ROCK THAT IS UNSTABLE.
TYPE “C” SOIL CLASSIFICATION

COHESIVE SOIL WITH AN UNCONFINED COMPRESSIVE STRENGTH OF .5 TSF OR LESS GRANULAR SOILS INCLUDING GRAVEL, SAND, LOAMY SAND, SUBMERGED SOIL OR SOIL FROM WHICH WATER IS FREELY SEEPING, AND SUBMERGED ROCK THAT IS NOT STABLE.
HOW COMPETENT PERSON CLASSIFIES SOIL TYPE.

TWO FIELD TESTS:
ONE VISUAL AND ONE MANUAL TEST

1. VISUAL ANALYSIS (OBSERVATION)
2. MANUAL ANALYSIS

Why does he classify the soil?

TO DETERMINE STABILITY!
SOIL CONTENTS
CLAY  SILT  SAND

THE DEGREE OF COHESIVENESS & PLASTICITY DEPEND ON THE AMOUNT OF ALL THREE OF PLUS WATER.

Soooo….the major factor in the stability is the water content!
SOIL VISUAL TEST

IS EXCAVATED SOIL IN CLUMPS?

YES............IT IS COHESIVE
NO............. NOT COHESIVE
& BREAKS UP EASILY

IS THE SOIL FISSURED?

MANUAL SOIL TESTS/ THREE TYPES

1. WET MANUAL TEST

2. DRY STRENGTH TEST

3. THUMB PENETRATION TEST
WET MANUAL TEST

WITH WET FINGERS WORK SOIL BETWEEN THEM.

- CLAY WILL FORM A SLICK PASTE
- CLUMPS FALL APART IN GRAINS
  IT IS GRANULAR NOT COHESIVE.
DRY STRENGTH TEST

CRUMBLE SAMPLE IN HAND

- CLAY WILL NOT CRUMBLE INTO GRAINS BUT SMALL CHUNKS

- GRANULAR WILL CRUMBLE INTO GRAINS….IE: NOT COHESIVE
UNCONFINED COMPRESSIVE STRENGTH TESTS

POCKET PENETROMETER TEST
UNCONFINED COMPRESSIVE STRENGTH TESTS

SHEARVANE TEST

USED FOR
SATURATED SOILS

RESULTS TONS
PER SQ. FOOT
(TSF)
SOURCES OF VIBRATION

- EQUIPMENT
- NEARBY TRAFFIC
- RAILROADS
- JACKHAMMERS
- COMPACTION OPERATIONS
- PILEDIVING OPERATIONS
- AIRCRAFT OPERATIONS
REVIEW QUESTIONS?

1. What designated person is required for Excavation/Trenching Operations?

2. What is the sole purpose of classifying the type of soil for excavation/trenching?

3. How does the designated person determine the soil type classification?
EXCAVATION PROTECTIVE SYSTEMS

SLOPING & BENCHING

SHORING

SHIELDING (TRENCH BOX)
SLOPING & BENCHING

BASED ON SOIL CLASSIFICATION

TYPE “A” SOIL IS NOT FISSURED, NOT SUBJECT TO VIBRATION, NOT PREVIOUSLY BEEN DISTURBED.

IS COHESIVE, WITH UNCONFINED COMPRESSION STRENGTH OF 1.5 TONS PER SQUARE FT OR GREATER

THE EXCLUSIONS FOR TYPE ‘A’ GENERALLY ELIMINATE IT FROM MOST CONSTRUCTION SITUATIONS

SLOPE FOR TYPE “A” IS 1/2 : 1
TYPE B AND C SOIL SLOPING OPTIONS

TYPE "B" SOIL

Simple Slope

20' Max

TYPE "C" SOIL

Simple Slope

20' Max

LAYERED SOILS

C OVER B

B OVER C
MULTIPLE BENCHING

This bench allowed in cohesive soil only.

TYPE "B" SOIL

Single Bench

20' Max

4' Max.

Multiple Bench

This bench allowed in cohesive soil only

TYPE "B" SOIL

20' Max

3' Max

4' Max
WHAT IS THE REASON ON ALL THE DIAGRAMS FOR SLOPING & BENCHING FOR ANY TYPE OF SOIL, THERE IS A FIGURE OF 20 FOOT MAX. DEPTH SHOWN?
THE SLOPING & BENCHING SYSTEMS SHALL BE DESIGNED BY A REGISTERED PROFESSIONAL ENGINEER (PE) AT LEAST ONE COPY OF THE DESIGN SHALL BE MAINTAINED AT THE JOB SITE DURING CONSTRUCTION. 25.C.01c

REMEMBER: For all Hydraulic shoring, and Trench Boxes, the tabulated data must be on the site.
SHORING SYSTEMS

SUPPORT SYSTEMS: A STRUCTURAL MEANS OF SUPPORTING THE WALLS OF AN EXCAVATION TO PREVENT CAVE-INS; INCLUDES SHIELDS, SHORING, UNDERPINNING, ROCK BOLTS. Etc.

SHORING IS A FRAMEWORK OF VERTICAL MEMBERS (UPRIGHTS), HORIZONTAL MEMBERS (WHALES), AND CROSS BRACES TO SUPPORT THE SIDES OF AN EXCAVATION TO PREVENT A CAVE IN.
TYPES OF SHORING

TIMBER SHORING
TIMBER SHORING

1. INSTALLED ACCORDING TO SPECIFIC TIMBER SHORING TABLES
2. TABLES SPECIFY:
   MATERIAL TYPE  SIZE & SPACING FOR CROSS BRACES,
   WHALES & UPRIGHTS.
3. BASED ON SOIL CLASSIFICATION
   AND EXCAVATION DEPTH

TABLES ARE IN 1926, SUBPART “P” APPENDIX “C”
Sample for Type "C" Soil on page # 18
ALUMINUM SHORING

ALUMINUM HYDRAULIC SHORING
ALUMINUM HYDRAULIC SHORING ADVANTAGES

- WORKERS DO NOT HAVE TO GET INTO TRENCH TO INSTALL...SAFER!
- LIGHT IN WEIGHT...1 MAN INSTALL
- USED ON VARIOUS TRENCH WIDTHS
- EQUAL DISTRIBUTION..PRESSURE
ALUMINUM HYDRAULIC SHORING SAFETY

1. INSTALLED TOP DOWN
2. REMOVED BOTTOM UP
3. TOP CYLINDER MAX. 18” FROM TOP
4. BOTTOM NO MORE THAN 4’ FROM BOTTOM OF THE TRENCH
5. 2’ FEET EXPOSURE AT BOTTOM IF PLYWOOD SHEETING IS USED
6. MINIMUM 3 VERTICAL SHORES TO FORM A SYSTEM
7. MANUFACTURE DATA AT SITE OSHA 1926. SUBPART P, APPENDIX D.
VARIOUS SIZES OF ALUMINUM SHORING
ALUMINUM HYDRAULIC SHORING

Figure 1. Aluminum Hydraulic Shoring
ALUMINUM STACKED HYDRAULIC SHORING

Don't forget to take the manufacturers data page to the job site...ok???
ALUMINUM SHORING WHALER SYSTEM
ALUMINUM HYDRAULIC WITH PLYWOOD

PLYWOOD MUST BE 1 1/8” THICK SOFTWOOD OR 3/4” 14 PLY!
PLYWOOD IN SHORING

IS NOT INTENDED AS A STRUCTURAL MEMBER, ONLY FOR PREVENTION OF LOCAL RAVELING FROM THE SIDES OF THE TRENCH BETWEEN SHORES.

TYPE “C” SOIL ALWAYS REQUIRE SHEETING BEHIND SHORING MEMBER
QUICK QUESTION???

HOW DO WE KNOW THAT THE CONTRACTOR IS CORRECTLY INSTALLING A TRENCH SHIELD, TRENCH BOX OR ANY TYPE OF SHORING???
ANSWER
WRITTEN TABULATED DATA
FOR ANY TYPE SHORING SYSTEM
IS REQUIRED TO BE AT THE JOB SITE

Hydraulic Shoring Operation & Use
SHIELD OR TRENCH BOX SHORING

SHIELD OR TRENCH BOX
STEEL TRENCH BOX

Can we use these and sloping?

Figure 3. Trench Jacks (Screw Jacks)

Figure 4. Trench Shields
ALUMINUM TRENCH BOX
OTHER MAJOR SAFETY ISSUES

- EXCAVATED MATERIAL (OVERBURDEN) TO BE PLACED MINIMUM OF 24” FROM EDGE OF TRENCH.

- ACCESS INTO TRENCH REQUIRED FOR TRENCHES GREATER THAN 4 FOOT IN DEPTH.

- AT LEAST TWO MEANS OF EXIT SHALL BE PROVIDED, TRAVEL DISTANCE TO EXIT NOT TO EXCEED 25 FOOT IN ANY DIRECTION. LADDERS MUST EXTEND 3’ ABOVE TRENCH
DISCUSSION QUESTION

DOES AN TRENCH LESS THAN 5 FEET IN DEPTH REQUIRE ANY TYPE OF PROTECTION FROM A CAVE-IN?
ANSWER

Excavations less than 5 ft. in depth and which a competent person examines and determines there to be no potential for a cave-in do not require protective systems.

Word of Caution: Trenching conditions change very rapidly!

Especially after a rain storm!!
EQUIPMENT/MOTORIZED VEHICLE SAFETY PRECAUTIONS

- STOP LOGS OR BARRICADES
- NO WORKERS UNDER MATERIAL BEING PLACED IN TRENCH
- BACK-UP/SIGNAL PERSON
- HIGH VISIBILITY VESTS/TRAFFIC
HAZARDOUS POTENTIAL IN A CONFINED SPACE

- A TRENCH/EXCAVATION 4 FEET OR DEEPER ARE CONFINED SPACES

- COMPETENT PERSON MUST TEST FOR OXYGEN AND GASEOUS CONDITIONS

- DAILY LOG TEST RESULTS AT SITE

IF A TRENCH IS 4 FOOT DEEP AND IS CLASSIFIED AS A CONFINED SPACE DOES A WORKER WEAR A HARNESS AND LIFELINE IN THE TRENCH?
Employees shall wear a harness with a lifeline securely attached to it when entering excavations classified as confined spaces or that otherwise present a potential for emergency rescue.

25.A.11

See also COE 5.F
EXCAVATION PROTECTION

PROTECTION REQUIRED TO KEEP PERSONNEL, VEHICLES, & EQUIPMENT FROM FALLING INTO EXCAVATION

SEE SAFE ACCESS 25.B.01 & Appendix “Q” for perimeter protection requirements.

THREE CLASSES OF PROTECTION BASED ON POTENTIAL EXPOSURE
EXCAVATION PROTECTION
MOST STRINGENT

CLASS 1: MEMBERS OF PUBLIC, (NOT CONTRACTOR) OR VEHICLES, OR EQUIPMENT THAT ARE EXPOSED TO AN EXCAVATION MUST HAVE GUARD RAIL SYSTEM, TOPRAIL, MIDRAIL, AND TOE BOARD AND GUARD AGAINST TRAFFIC FALLING INTO EXCAVATION
EXCAVATION PROTECTION

CLASS II

DOES NOT MEET CLASS I REQUIREMENTS BUT
(1) CONTRACTOR EMPLOYEES ARE ROUTINELY
EXPOSED OR (2) IS DEEPER THAN 6 FEET OR
CONTAINS IMPALEMENT HAZARDS

CONSISTS OF WARNING BARRICADES
OR FLAGS PLACED NOT CLOSER THAN 6 FOOT
FROM THE EDGE OF THE EXCAVATION AND AT AN
ELEVATION OF 3 FEET TO 4 FEET ABOVE GROUND LEVEL.
EXCAVATION PROTECTION
CLASS III

CLASS III: EXCAVATION LOCATIONS THAT DO NOT MEET CLASS I OR CLASS II PROTECTION WARNING LINES OR FLAGGING PLACED A DISTANCE NOT CLOSER THAN 6 IN. NOR MORE THAN 6 FOOT FROM THE EDGE OF THE EXCAVATION AND DISPLAYED AT AN ELEVATION OF 3 FEET TO 4 FEET ABOVE GROUND LEVEL
EXCAVATION AHA CONSIDERATIONS

1. COMPETENT PERSON
2. SURFACE ENCUMBERANCES
3. UNDERGROUND UTILITIES
4. ACCESS AND EGRESS
5. EXPOSURE TO TRAFFIC
6. EXPOSURE TO FALLING LOADS
7. MOBIL EQUIPMENT WARNING SYSTEM
8. HAZARDOUS ATMOSPHERES
9. WATER ACCUMULATION
10. EMERGENCY POWER
11. ADJACENT STRUCTURES STABILITY
12. EMPLOYEE PROTECTION
13. INSPECTIONS- DAILY
14. FALL PROTECTION

ALSO CHECK OUT PAGE #16!
SAFE ACCESS  FALL PROTECTION

WALKWAYS OR BRIDGES WITH STANDARD GUARDRAILS SHALL BE PROVIDED WHERE PEOPLE OR EQUIPMENT ARE REQUIRED OR PERMITTED TO CROSS OVER EXCAVATIONS

See 25. B. 04

IS THERE A PARTICULAR DEPTH OF TRENCH THAT IT IS MANDATORY TO HAVE A WALKWAY ACROSS THE DITCH?

21.A.15