1.1 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of the techniques, equipment, and documentation of surveys.

Supporting Knowledge and/or Skills

a. Discuss the mathematical basis for horizontal and vertical control.

During this century, professional surveyors have created several different systems of horizontal control. The first horizontal control system is called the North American Datum of 1927 (NAD 27)[1] This system selected an initial datum at Meades Ranch, Kansas, and then it generated latitudes and longitudes to some 25,000 stations around the continent based on this point. One will generally encounter this system on older surveys. Later, with more sophisticated astronomical observations, a system called the North American Datum of 1983 (NAD 83) was developed and based upon the center of mass of the earth. This system provides more accuracy and eliminates compounding errors encountered when choosing one reference point. Based on a sphere, however, the NAD 83 system greatly complicates the mathematics for the average surveyor, with very little to be gained in accuracy from the lengthy computations. Out of the need for approximations, the surveying industry created the Lambert conic projection and the Mercatur cylinder projection, both of which are closely tied into the NAD 83.

The Lambert projection uses a cone, with apex above the north pole, to approximate the earth's surface. Therefore, east-west measurements suffer no loss in accuracy, as the cone matches the curvature of the earth. In north-south direction, however, the curvature of the earth limits the range of accuracy. Therefore, if a state is longer in the east-west dimension, and the north-south dimension does not exceed 158 miles, the most significant error found in the state is 1/10,000. Indeed, Colorado uses a mesh of the Lambert system for this reason.

The Mercatur projection uses a cylinder to approximate the earth's surface in states with a long north-south dimension, like Mississippi. This cylinder can be extrapolated indefinitely north-south, but loses accuracy the further away east or west from the meridian through the center of the state. Again, as long as the east-west dimension does not exceed 158 miles, the accuracy remains within 1/10,000.

Some states use more than one grid of a given type. Initially, one might think that the Mercatur system would suit a state like California quite well. Upon closer inspection, however, California exceeds the 158 mile wide limit, and as such, the Mercatur system loses accuracy. Instead of the Mercatur projection, California chose to use seven grids of the Lambert system to cover the state. Alaska, New York and Florida do not lend themselves well to any one system, therefore, they use a combination of Lambert and Mercatur grids.

Sea level, as defined by the National Geodetic Vertical Datum of 1990 (NAVD-88) as mean elevation of the sea, defines vertical control for the engineering community.[1] 600,000 benchmarks comprise the vertical control system across the United States, and, for the most part, their installation is complete. On certain projects, maintaining a certain elevation is not equivalent to maintaining level. Each elevation represents a sphere, and over long distances, can be different than what level describes.

b. ***Discuss the different types of surveying equipment commonly used on a construction project including their applications and limitations.***

Electronic Distance Measuring Instrument

The Electronic Distance Measuring Instrument uses electromagnetic radiation to compute the distance to a prism.[1] The surveyor places the prism vertically over on the item in question. These instruments give a digital readout of the distance, some automatically record it for later downloading. As with any instrument, they are subject to many sources of error. The prisms should be kept clean, which is an involved process. The instrument may or may not automatically take into account temperature and humidity, both of which affect the speed of the light from instrument to prism, back to instrument. Some instruments require the operator to dial in the temperature and humidity to electronically compensate. Snow, fog, rain and dust all affect the range of the instrument, a knowledgeable surveyor will consult the instructions. Also, the surveyor should never point the instrument toward the sun, where background radiation can affect the reading. Because of the difference in index of refraction for the prism verse air, a calibration is built in at the factory for each prism. Use only the prism for which a particular instrument was designed and calibrated for.

Theodolite or Transit

The transit measures both vertical and horizontal angles, prolongs straight lines, determines magnetic bearings, measures approximate distances and can level to near the accuracy that a level can. Most theodolites can measure angles to the nearest minute, some to the nearest second, depending upon cost and quality. Old transits require experienced surveyors who have the skill to read the vernier, a mechanical device used to display the angles. Newer, optical transits have lit scales with magnification, but are still mechanical in nature. The most current device, called an electronic theodolite, gives the user a digital readout of the angle. These are popular with some surveyors, but require them to carry batteries to power the unit.

Level

There are two basic types of levels, the Dumpy level and the automatic level. The Dumpy level has a long level aligned with the axis of the telescope. The surveyor locates and levels the instrument, insuring that the bubble indicates level through 360 degrees of rotation. A reading is taken off a benchmark of known elevation, and the height measured on the rod is then added to obtain the height of the instrument. The surveyor can then sight any object, within reasonable optical sight, and then he can then identify the elevation

with the use of a rod. Some surveyors prefer an automatic level, though its basic function is the same. A self leveling instrument only requires placement near the horizontal plane, with the instruments electronics completing the fine adjustment.
The instrument can be used very accurately on short sights, even to a thousandth of a foot. As the surveyor allows the sights to get longer, he compromises accuracy. This range that it may be used varies and the manufacturer provides these specifications. The level describes a plane, not a sphere, and should not be used repetitively on long distances without checking benchmarks.

Rod

A rod is a stiff measuring device, usually collapsible, with black markings of distance clearly identified on the white face. Readings taken from a rod are in feet, tenths of a foot and hundredths of a foot. One side the scale ascends up from the bottom, the other side the scale descends from the top. The prime sources of error on rods come several different areas. The first source of error is because the rod man must rock the rod back and forth, and the instrument man must read the shortest distance that crosses his line of sight. This requires skill and experience on both surveyor's jobs. The second source of error comes from extending the rod for extra length. Often times, the rod slips from the locked position. This creates a higher reading because of the improper overlap of scales. A good rod man checks for slipping on every sight. Critical measurements should always be double checked, reversing the roles of the rod man and the instrument man.

Total Stations

There are three types of total stations, manual, semiautomatic and automatic. All total stations measure both angles and distances in both the horizontal and vertical planes, it is in the data collection that the differences appear. Manual stations require the user to read all data optically. Semi-automatic stations contain sensors for distance, but angles are still read optically. Automatic stations can send data directly to a recorder, without interpretation by the surveyor. The limitations of these instruments come from the fact that no field notes have to be generated, and it may be more difficult to review and check the work. It will, however, eliminate errors in reading the instrument. Also, they cannot be used for solar observations without additional filters.

c. Describe the methods for verifying proper survey equipment calibration.

Electronic Distance Measuring Instrument[1]

The EDMI may have a self calibration program which can compensate for atmospheric conditions. Other, less sophisticated EDMIs, require the user to input the calibration constants. If the surveyor thinks that the unit measures distances improperly with the correct calibration constants, the surveyor must consult the dealer.

Level

Levels are very durable instruments that can last a very long time with proper care. The professional surveyor calibrates the instrument before each use and frequently checks the settings during the data collection. Old levels have long bubbles that should remain level through 360 degrees of rotation. These bubbles must reside in a plane perpendicular to the vertical axis of the instrument. Newer ones have a bull's eye bubble that should remain centered during the leveling process. Simplicity governs construction and use of the level, and as a result it will last decades with proper care.

Theodolites and Transits

These instruments require leveling just like a level, but also centering over a sight. Older instruments used a plumb bob to achieve this, while newer instruments have an optical sight with cross hairs. Common adjustments that need to be made are described as follows:

- Plate bubble tubes must reside in a plane perpendicular to the vertical axis of the instrument;
- Cross hairs must lie in their respective planes. If not, the cross hair ring must be carefully adjusted until they lie in the horizontal and vertical planes;
- Horizontal and vertical axes of the instrument require adjustment such that they lie in their respective planes;
- The surveyor will then adjust the telescope bubble tube to parallel the line of sight axis of the scope; and,
- When the bubble tube reads level, and the telescope bubble tube reads level, the surveyor must calibrate the vertical scale to read zero.

Total Stations

Total Stations functionally combine theodolites and EDMIs. The combination of calibration procedures apply to the total station.

d. Discuss the care and handling of survey equipment.

The surveyor must follow the most important rule for protecting surveying equipment: avoid shocks.[1] Dropping the instrument, knocking over a tripod, and leaving the instrument in the vehicle without securing can lead to shocks that frequently damage surveying equipment. The surveyor will always utilize the designated box when transporting the instrument in a vehicle. The surveyor never picks up an instrument by the telescope. The surveyor always sets up the tripod first, securing the legs far apart in the ground. The surveyor never places the tripod on a hard surface unless he uses a triangular frame to hold the legs in place. The surveyor never uses excessive force to operate any knobs or levers, as threads can be stripped. The crew never leaves an instrument unattended. When carrying the instrument attached to a tripod, the surveyor always carries the instrument in front of him where a watchful eye can be kept on it. If it rains, snows or the fog is heavy, he puts the lens caps on, and if it hails, he puts the instrument in its case immediately. If the instrument gets wet, let it dry because wiping it can damage lenses. Lenses must be cleaned with the proper fluids and paper. The surveyor lubricates with only small amounts of graphite, never using oil, as oil collects dust. Also, the surveyor never puts the instrument back in the box without drying and dusting. An experienced crew member will make sure the telescope points down and all actions are loose when stored in case.

e. Describe standard practices for preparing survey field notes.

A professional surveyor will follow these basic practices when preparing field notes[1]:

- Name, address and phone number of the surveyor printed in ink on the inside cover of the notebook;
- Job title, date, weather and location recorded;
- Names of the survey party members should accompany each report in the book, including duties performed by each member;
- Standard field books with standard forms used;
- Immediately write down the measurements taken and observations made in the field. Nothing should be committed to memory. If data is copied, it should be noted on the copy;
- Sketches used frequently to describe the field measurement;
- Never erase entries in the field book. Always cross them out and write the new measurement elsewhere. The field book is a legal document and should not have erasures;
- Professional surveyor uses hard pencils so that the lines do not smear. The surveyor also does not use ink as it tends to bleed if moisture gets in the book;
- Marks made later should be of a different color, to distinguish from those made in the field;
- Always note which instrument was used for the survey; and,
- Number every page, include a table of contents in the front, indicate north on every sketch, and use a new page for each job.

f. Discuss the appropriate state requirements for preparing survey documentation, drawings, site plans, profiles, and contours.

To ensure compliance with all state regulations, consult a Registered Professional Land Surveyor in the state in question[1]. All states require an ink stamp and the surveyor's signature on every legitimate survey drawing produced. The state typically requires the same standards for documentation, drawings, site plans, profiles and contours. State law typically requires the name of the surveyor, title, scale, meridian, legend, north arrow, and ties into the state grid coordinate system. Also, items scaled on the drawings must be within a range of acceptable error. Again, the requirements vary from state to state, consult a local professional surveyor.

g. Read and interpret survey field notes.

An individual required to interpret survey field notes should familiarize themselves with standard note taking protocol. Some other pointers on reading notes are as follows[1]:

- Column on the far left typically contains the point referenced, or other identifying information;
- Series of columns after the identifier contain angle, distance and elevation information, as described by the headings at the top of the columns; and,
- Opposing page (on the right) is usually reserved for a sketch showing the basic arrangement of the measurements taken on the left page.

When a proficient surveyor writes the field notes, there is little difficulty or skill required to effectively interpret them.

h. Define and discuss error closure as it applies to surveying

Closure is defined as returning to the starting point at the end of the survey[1]. This allows the surveyor to mathematically check the series of distances and angles measured. As there will always be some error, the surveyor can then distribute a fraction of the error over each measurement. This will yield a mathematically perfect picture of the survey. The amount of acceptable error depends upon equipment, project, laws and the surveyor's own code of standards. Typical laws are 1/5000 in rural areas, 1/7500 for suburban areas, and 1/10,000 for urban land.

[1] McCormac, Jack C., "Surveying Fundamentals," 2nd edition, Prentice-Hall, Englewood Cliffs, New Jersey, 1991.

1.2 *Construction management and engineering personnel shall demonstrate the ability to establish other control points from a set of horizontal and vertical control points.*

Supporting Knowledge and/or Skills

a. Select the proper instruments for establishing control points.

The survey crew will require the following[1]

- Level and rod;
- Transit or theodolite, and an EDMI; and
- In place of Number 2, a total station.

The crew should establish the points from known references. The crew should also establish enough points on the job so that if construction destroys several control points, they can be easily replaced without an entire resurvey.

b. Discuss the procedure for measuring angles and distances.

To properly measure an angle, the surveyor must center the transit over the proper point and he must also properly level and calibrate the instrument.[1] The surveyor releases both upper and lower clamps and then the horizontal scale is clamped near zero. Once clamped, the fine adjustment tangent screw is turned until the vernier reads zero. The lower motion is then released and the telescope sighted on the first point. The lower motion clamp is then engaged and the tangent screw adjusted until the vertical cross hair is on the point. Next, the upper clamp is released and the telescope swung to the second point. The upper clamp is then tightened and the fine adjustment tangent screw turned until the vertical cross hair is on the second point. The angle can then be read from the vernier.

To properly measure distance with a tape requires skill and experience. The steel tape must be tensioned with a constant force every time, and the temperature noted. Corrections for sag and temperature are factored in once the measurement is taken. The rear tape man always holds the tape over a point on an integer of a foot while the head tape man reads the fraction of the foot.

The use of an Electronic Distance Measuring Instrument (EDMI) requires a tripod to be set up over the first point then leveled and centered. A prism with a bull's eye level or another tripod is sent to the other point where it is placed in the vertical position over the point. The EDMI is sighted to the prism. Calibrations are checked on the EDMI, if required, and the measurement is taken. The measurement is then recorded into a field book. For exact work, process should be repeated in the opposite direction.

c. ***Determine the proper route using known points.***

The surveyor will always use the route through the points that requires the shortest sights.[1] Using short sights will always reduce the amount of error introduced into the survey. The route will always return to the initial benchmark to check for any error introduced in the series of measurements.

d. ***Estimate turning points.***

Turning points should always be about halfway between back-sight and the fore-sight, and no greater than the equipment manufacturer specifies.[1] Sometimes, temporary benchmarks must be devised in order to achieve the range necessary, but the survey should always return to the first benchmark as an error checking procedure.

e. ***Define and discuss the following terms associated with control points:***[1]

- **Benchmark**: Monument of brass embedded in concrete set up by the U. S. Geological Survey whose elevation has been precisely determined.
- **Back-site**: Sight taken to the level rod held on a point of known elevation to determine the elevation of the instrument.
- **Temporary benchmark**: Convenient fixed point on the ground whose elevation is determined during the leveling process. It is marked so that it can be used again during the next few surveys but without a permanent marking locating it.
- **Turning point**: Temporary point whose elevation is determined in the process of leveling.
- **Latitudes**: Component of any line in the north-south direction.
- **Departure**: Component of any line in the east-west direction.
- **Instrument height**: Elevation of the horizontal plane in the line of sight of the telescope of the instrument
- **Bearings**: Direction of a line accompanied by the quadrant the line occupies. The quadrants are described NW, SW, NE and SE. For example, N 30° E, describes a line at a 30 degree angle with respect to north.
- **Grid coordinates**: Typically set up for each project, in X-Y fashion so that the X-axis coincides with east-west and the Y-axis coincides with north-south. The system is usually set up so that no negative coordinates are encountered in the project.

[1] McCormac, Jack C., “Surveying Fundamentals,” 2nd ed., Prentice-Hall, Englewood Cliffs, NJ, 1991.

1.3 Construction management and engineering personnel shall demonstrate a working level knowledge of the principles and construction methods associated with grading, paving, and drainage for site preparation.

Supporting Knowledge and/or Skills

a. Read and interpret a site plan drawing.

A site plan shows what the site looks like from above, and includes contours[i]. The site plan shows the boundary streets, property lines, easements, rights-of-ways, size and type of utilities, compass directions, trees, streams, lakes, swamps, benchmarks, transportation routes, zoning, jurisdictional requirements. These lines will have a direct impact upon excavation sequencing, haul road planning, safety, quality and production for the construction. Easements and rights-of-way may have a direct effect upon drainage, access during construction, crane erection and test borings.

Boundaries are represented by a line consisting of a long and two short dashes. Contours are continuous lines. Utilities are dashed lines. Building lines are solid lines.

No two sites are the same, and as a result all of the aspects of a given location must be considered as a whole, and general rules are difficult to apply. A professional Construction Manager should be consulted on complex projects.

b. Read and interpret a contour map.

Contours are the most common method of showing topography on a 2 dimensional map.[ii] Contours show a constant elevation. Usually each fifth contour, called an index contour, is darker and heavier, and is numbered to show elevation. The contours between index contours are divided equally and represent equal elevation increments. A few comments on reading contour lines:

- Equally spaced lines show a uniform slope;
- Lines very close together show steep slopes, even cliffs;
- Cross or “X” is usually accompanied by an elevation, showing the highest elevation on a peak or hill;
- Series of contours that abruptly bend uphill and then return are usually associated with a stream, river, or some past water flow;
- Contour lines of different elevations rarely cross (an overhanging cliff). Lines of equal elevation can cross and represents a geographic structure called a saddle;
- Contours are perpendicular to the direction of water flow; and,
- Contours are stopped at the edge of a building

With respect to grading, the contour maps should be used to analyze the grades over which construction equipment will cycle, yielding estimates for production. The paving subcontractor will be concerned with the contour maps to identify sequencing and alignment. The drainage engineer will identify watersheds, rainfall probabilities, and flow properties over the site.

c. ***Draw a site contour map from field notes and survey data.***

The field notes and the survey data will yield an X-Y plot of all the data points.[2] Identify these points with an elevation. Determine what contour intervals will yield an effective map, with the contours not too cluttered but not so far apart that they skip important features. Next, begin measuring between adjacent points, interpolate the position of the contour, and place a small mark. Continue this process between all adjacent points, then use a flexible straight edge to connect points of like elevation.

There are some software programs that exist that are much more efficient than doing this by hand. The programs typically take a spreadsheet input file and convert the points to a contour map in a computer aided drafting program.

d. ***Develop cross sections.***

To develop cross sections, draw a line on the contour map along the line that the profile is desired.[2] Take length measurements from this line at every point that the profile line crosses a contour line. Create a graph along the section line using the intersections of the profile line and the contour lines as the X coordinates. The Y coordinates are simply the contour elevations corresponding to the X coordinate intersections.

e. ***Use mathematical techniques to determine earth quantities.***

A very common technique used for computing earthwork volumes is the average end area method.[2] In this approach the volume of the earth between two cross sections is assumed to equal the average of the two end cross sections multiplied by the distance between them.

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All input variables are in feet, the output, volume, is in cubic yards.

f. ***Discuss field and lab soil compaction methodologies and utilization criteria.***

Compaction is the process of increasing the density of a soil by packing the particles closer together with a reduction in the volume of air: there is no significant change in the volume of water in the soil.[iii] In general, the higher degree of compaction the higher will be the shear strength and lower will be the compressibility of the soil. The degree of compaction of a soil is measured in terms of dry density, the mass of the solids only per unit volume. This dry density depends upon the water content and compactive effort.

In the Proctor test, the volume of the mold is 1 liter and the soil, with particles larger than 20 mm removed, is compacted by ramming a hammer consisting of a 2.5 kg mass falling freely through 300 mm: the soil is compacted in three equal layers, each receiving 27 blows. In the modified AASHTO test everything is the same except five layers are used and a hammer weighing 4.5 kg is used falling through 450 mm. In the vibrating hammer test, the soil, with particles larger than 37.5 mm removed, is compacted in three layers in a 2.3 liter mold, using a circular tamper fitted in the vibrating hammer, each layer being compacted for 60 seconds.
Once this test is performed, the sample is dried and the density determined. This should be repeated at least five times from each sample.

There is a particular value of the water content called the optimum water content. This is where the highest dry density can be achieved. At low values of water content, most soils are stiff and difficult to compact. At high water content the dry density decreases, as more of the volume is occupied by water.

Some specifications for field compaction require a certain dry density, while others just specify the weight and number of passes of a given piece of equipment. Lab tests should be performed on field compacted materials to insure a minimum dry density in the selected fill.

Smooth-wheeled rollers
These are weighted, hollow steel drums that produce a smooth finish and is suitable for most soils except uniform fines. It typically produces lamination between layers.

Pneumatic tired rollers
This equipment is suitable for a wide range of coarse and fine soils but not uniformly graded material. The spacing of the tires imparts a kneading action on the soil and the finished surface is relatively smooth.

Sheepsfoot roller
This type of roller consists of a large steel drum with numerous club shaped feet protruding from it. As a result of these feet, they impart a high pressure and cause significant mixing of the layers. They are excellent for fine material, both plastic and non-plastic. They are often used in soils where the desired permeability is very low.

Grid rollers
These rollers have a surface consisting of a network of steel bars forming a grid with square holes. Grid rollers provide high contact pressure but provide little kneading action. They are suitable for most coarse soils.

Vibratory rollers

These are smooth wheeled rollers fitted with a power driven vibration mechanism. They are used for most soil types but are more efficient if the water content is slightly wet of optimum. They are particularly good for coarse soils with little or no fines. The mass of the roller and frequency of vibration must be matched to the soil type and layer thickness. The lower the speed of the roller the fewer the number of passes required.

There is also an assortment of small tampers to be used in small confines and where a large machine is not cost effective.

g. Define the following terms as they relate to horizontal curves:

- Point of intersection (PI) -A curve is initially laid out by showing the two lines that the curve is to connect. Where these two lines meet is called the Point of Intersection;[2]
- Point of tangency (PT) -The end of the curve is called the Point of Tangency. This is the point where the curve ends and the tangent resumes; and,
- Point of curvature (PC) - The beginning of the curve is called the Point of Curvature. This is the point where the line intersects the curve.

h. Prepare a site grading plan.

To the engineer assigned to create a site grading plan, the same rules apply to the grading plan as to creating a contour map. The primary concern to the engineer, however, is location of the contours to provide adequate drainage away from building structures. Drainage away from buildings prevents unwanted shrinking and swelling of the soil surrounding the buildings. The engineer grades the contours on the map to cause the flow of run off to drain towards storm sewers. The engineer must also give special attention to the grading of parking lots, as pavement allows no seepage, whereas soil can store run off, thus not causing as much flooding as pavement and concrete. Secondary to the site grading process, balance of the cuts and fills will prevent the contractor from extra costs associated with fill purchase or waste disposal.

i. Define, compare, and contrast the following terms:

- Balance and cut-and-fill
- Shrink and swell

Balance and cut and fill

Cut is a term used to describe material that will have to be removed on a project. Fill describes an earthen embankment, usually one that must be installed on a project.

Balance describes the equilibrium situation on an earth-moving project where the volume of the material excavated will equal the material required to fill the rest of the project.[iv]

The designer of an excavation project strives to balance the cuts and the fills. Balancing is important as shortages in fill material can be expensive, either from a borrow pit or purchased from off site. Even more rarely does an engineer want more cuts than fills, as this creates a disposal problem, unless the material has a market value.

Shrink and swell

Swell describes the increase in volume of a material as it is excavated. Shrink describes the volume loss as the material is placed and compacted. They are both used in earth moving projects and are usually not reciprocal. The swell factor is usually greater than one, as voids are added during excavation. The shrinkage factor is usually smaller than one, and describes the soil after placement and some compactive effort applied.

j. Discuss the characteristics of rigid and flexible pavement.

A rigid pavement is designed primarily on the basis of its resistance to bending and, essentially, portland cement concrete is the sole type of pavement in this category.[v] Concrete pavement design requires a knowledge of the mechanics of reinforced concrete and the mechanics and stability of the material used as a sub-grade to the rigid pavement. The rigid pavement acts like a series of small bridges carrying the load of the vehicle, and the pavement must be designed accordingly. Rigid pavements must also account for thermal qualities of the material through the use of expansion joints, much more so than flexible pavements.

A flexible pavement consists of a relatively thin wearing surface supported by layers of compacted subgrade. The strength of the pavement is derived from the distribution of the load over the subgrade through the subbase, base, and surface courses rather than the carrying capacity of the pavement as a whole. The most common threat to flexible pavement is the combination of heavy rains, long periods of cold with an abrupt spring can cause frost heaves, or buckling of the pavement at the wearing surface.

k. Discuss the hydraulics associated with drainage to include:

Open channel flow

The primary difference between flow in closed conduits and flow in open channels is that in open channels there is a free surface at atmospheric pressure, whereas in closed-conduit flow, there is no free surface.[vi] Open channel flow can be an extremely complex phenomenon to describe. The depth of the channel, configuration of the sides of the channel, material lining the channel and changes in the direction of flow all contribute to the velocity, and ultimately, the quantity of flow through a cross section. Gravity is usually the primary driving force in an open channel situation.

In any drainage situation, the maximum rainfall expected in the given life span of the project should be determined. With total inflow now determined, the drainage engineer will determine all divide lines on the project. These lines will separate the areas that will receive the predetermined estimate of rainfall. With these areas and rainfall estimates, the flow on a project can be determined using open channel flow equations. The drainage system at the outlet of the project needs to be designed to at least this criteria of flow quantity, sometimes another channel flow problem.

Flood zone determination

In a flood zone determination, much like the drainage situation, the engineer must estimate the total flow input to the drainage system.[vii] With this estimate complete, the engineer must then create a cross section of the flood plane, including river, banks, foliage, rocks, etc. The engineer then creates imaginary vertical surfaces which divide the main channel and the overbank areas. That part of the flood plane which is being flooded is called the overbank area.[viii] Each of these areas need to be correlated to a manning's number, which vary based on the frictional resistance of the material in the overbank area. For example, a flooded area of short crops yields a manning's number of 0.035, whereas a flood in dense willows yields a manning's number of 0.150. Since flow is inversely proportional to the resistance (manning's number), then more resistance the higher the flooding region, since the quantity of flow must remain approximately the same. This engineer then repeats this analysis at intervals along the main channel and then the engineer plots the height data on a contour map. The contour map graphically shows the zone that a flood of given magnitude affects.

l. Discuss the following elements of hydrostatics related to site preparation:

Hydrostatic pressure

Hydrostatic pressure is the force applied over an area in a depth of water.[8] This pressure is of importance to retaining wall designers, excavation contractors, caisson drillers, and foundation designers. Dewatering a site is the subject of numerous manuals and texts.

Flood routing

Flood routing is the management of peak water flows in and out of both natural and artificial water storage areas.[7] To properly evaluate the effect of these storage features and structures, it is necessary to develop the runoff hydrograph and route the hydrograph through the storage area. The following is a list of steps required to develop the hydrograph:

- Determine the drainage area of the watershed;
- Determine the design rainfall, both total amount and rainfall distribution;
- Determine the surface runoff volume, factor for ponding and soil absorption;
- Compute factors to adjust surface runoff volume into reservoir input; and
- Plot time verse quantity of flow.

With the input flow determined, the engineer must then use the continuity equation to describe the state of outflow of the reservoir. The engineer must take into account the elevation of the water in the reservoir, the degree of opening of the flood gates, how the storage of a reservoir changes as a function of depth and safety factors to determine by how much and when the flood gates need to be operated.

Hydraulic gradient

The hydraulic gradient is a summation of two of the three energy components of a body of water at any given point.[ix] The hydraulic gradient is the elevation energy and the pressure energy. This energy representation is usually per unit weight of the fluid. The hydraulic gradient does not include the velocity component of the total energy of the unit volume of water.

Seepage

Seepage describes a situation in a soil structure where a liquid, usually water, flows at either at a constant rate or at a transient rate.[x] The rate at which the liquid flows in the soil is called the seepage velocity. This seepage may or may not contain contaminants. Seepage does create an important force on the structure of the soil, called the "seepage pressure." The geotechnical engineer must consider these forces when designing a structure or excavation in a seepage environment.

m. Discuss the construction methods and requirements associated with earth work and trenching. Include the following elements in the discussion:

- Water pollution and soil erosion
- Noise pollution
- Traffic control measures
- Dust control

Earth work is typically achieved through some relatively generic processes. First, the soil is loosened, either by blasting, bull-dozer, back hoe, front end loader, drag line, trenching machine, mining machine or power shovel.[xi] In this initial stage, the equipment removes the topsoil. This top soil layer typically reduced erosion by wind and water. Once the equipment removes this top layer, any run off from the site picks up sediments from the newly exposed layer. Even if the sediment has no inherent danger, the run-off is no longer clean, and is considered water pollution. Wind can also erode the soil and create air pollution. Project engineers must manage run-off from the onset of excavation to prevent water pollution and keep the area covered or wet to help prevent air pollution. In some areas, engineers may request the use of dust suppressant systems where wind and fines often mix, such as conveyor systems and loading docks. Another consideration to the site engineer is the dewatering of a deep excavation. Water inflows typically require the installation of pumps, and the engineer must also manage the water quality of these pump discharges.

In areas where the engineer must manage traffic, all lane closures and haul routes usually must pass inspection from the local traffic governing bodies, including cities, counties, and state transportation departments. These entities will usually require an extra amount of earth work support if near public streets. Also, the excavation contractor should contact all utility companies, as utilities are typically buried along street right of way's. Also, the project must comply with all traffic sign requirements.

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[i] Merritt, Frederick S. and Ambrose, James, "Building Engineering and Systems Design," 2nd ed., Van Nostrand Reinhold, New York, NY, 1990.
[ii] McCormac, Jack C., "Surveying Fundamentals," 2nd ed., Prentice-Hall, Englewood Cliffs, NJ, 1991.
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1.4 Construction management and engineering personnel shall demonstrate a working level knowledge of techniques for preparing cost estimates.

Supporting Knowledge and/or Skills

a. Discuss how each of the following factors contributes to the development of cost estimates for a construction project:

Construction plans

Definition: The complete design package, including drawings, specifications, work plans, procedures, etc.

Construction plans provide the technical basis for the project to be estimated, as specified by the owner, designer, and engineer; and supplemented as appropriate by the contractor and the vendor. The bid package, consisting principally of the drawings and specifications, describes the end product (requirements), and may include site-specific (construction) requirements, quality assurance requirements, etc. that may impact how the end product is to be achieved and obtained. Work plans and /or management plans describe the specific methods to be used by the contractor to achieve the end product, and (eventually) the milestones, cost, schedule, and technical baselines.

The construction cost estimate uses the bid package for developing material take-offs to determine materials and labor costs, identification of construction equipment needed, identification of specific activities, and identification of construction impediments. Contractor work plans will identify construction equipment to be used, and perhaps crew size, composition, and methods.

Productivity rates

Definition: Factors used to estimate the labor hours required for a discrete element of work from a standard quantity measurement.

The process of preparing a “bottoms-up” cost estimate involves dividing the project into individual “generic” work elements, often by media or craft, and estimating the cost of materials and labor for that work element. To assist in developing cost and construction equipment productivity estimates, standard material costs and labor hours (productivity rates) have been developed based on average construction costs collected from numerous projects based on “generic” conditions; e.g., labor hours per cubic foot of concrete sidewalk, per pound of structural steel, etc. These standard costs and labor rates must be modified for job-specific conditions that vary from the generic conditions. This is sometimes accomplished by “productivity factors” (sometimes called “building factors” at a large, complex facility or site) that relate the costs in a given area or condition with the standard rates.

Specifications

Definition: Text information covering project requirements, such as quality of materials, acceptable vendors, codes, standards, and procedures that must be followed in construction, etc., which, along with the design drawings, comprise a typical bid package.

A designer and an engineer will create written specifications for a project detailing the project requirements. For a construction or manufactured product, these specifications are normally supplemented by design drawings. In the case of a conflict between the written specifications and the drawings, the specifications are the overriding document.

Crew composition

Definition: Crafts or disciplines required to perform a work element.

In the preparation of a bid, the cost estimating is generally performed together with certain other planning activities such as determining methods of construction, scheduling, and resource identification. For performing work elements that require more than a single individual, a crew composition (e.g., two carpenters, one sheetmetal worker, one rigger, and one radiological control technician) would be identified. The use of a crew allows the cost estimator to perform calculations support the development of resource requirements in the overall scheduling and planning process. Supervisory hours are generally not included in the crew composition, but are pro-rated or included as separate activities. In developing independent estimates, the estimator must generally assume a crew composition. Union bargaining agreements may impact crew composition.

Schedule interpretation and impacts

In the planning process, the development of schedule activities, durations, and resources is principally based on output from the cost estimating process. As the activities are sequenced (e.g., assembled into a CPM schedule), a "critical path" developed, and the schedule resource leveled, the scheduling process provides feedback to the cost estimating process. Typical examples might include identification of specific activities that might be shortened by application of more resources, decreases in efficiency due to crowded conditions, quantification of time for specific large equipment (such as cranes) to be rented, work element combined or divided, etc. For multi-year schedules, escalation and sometimes depreciation must be included in coat estimate calculations.

General and administrative rates

General and administrative rates (G&A) cover the costs of doing business, and are usually included in a cost estimate as a factor multiplied to the total cost estimate, along with profit and sometimes other overhead expenses. G&A typically includes corporate oversight, business development, home office overhead, etc. For government cost plus-type contracts, the G&A rates are subject to audit and retroactive adjustment.

Material prices

Material costs, along with labor and construction equipment costs, are the principal direct components of cost estimates. Material costs can be determined based on standard values (as adjusted for area of the country, required quality, etc.) or quotes from vendors. Typically, if a material or vendor-supplied component is a significant portion of the overall project cost, one or more vendor quotes (with expected delivery times) need to be obtained. Sometimes fixed-priced subcontracted services are handled as material costs in the estimate. If the equipment is to be furnished to the contractor at no cost to him (i.e., Government Furnished Equipment), the contractor's estimated material cost will be zero (although the GFE should still be listed, and may require installation labor and materials).

Equipment types and rates

Definition: "Equipment" in this context means rented construction equipment or tooling.

Many times estimates will include the cost of contractor-furnished construction equipment necessary to perform the contracted tasks (e.g. cranes, man-lifts, grading equipment, etc.). This equipment may be estimated based on rental costs or costs generated by an internal accounting system based on cost allocation or depreciation. In some cases for long-term projects, specific equipment may be bought and dedicated to the project, typically requiring a separate "lease-or-buy" analysis. Specification of equipment by relevant capacity (tonnage, bucket size, etc.) is necessary to determine the cost.

Known labor rates

Definition: Project or contract-specific labor rates (as opposed to generic rates).

Labor rates will vary based on the contracts, Davis-Bacon requirements, area of the country, tightness of the labor market for specific crafts, etc. For labor categories which constitute a significant portion of an estimate, an attempt should be made to identify the labor rates that will be used on the task, because they will probably be significantly different from the standard rates, especially if the work is Davis-Bacon covered.

For work to be "Davis-Bacon covered" means that the work falls under the provisions of the Davis-Bacon Act. This Act applies to all federal construction contracts greater than $2,000, and requires the government to pay the locally prevailing wage rates. Construction is defined as "altering, remodeling, installation (where appropriate) on the site of the work ... painting and decorating ... manufacturing or furnishing of materials, articles, supplies or equipment on the site of the building or work, and ... transportation between the actual construction location and a facility which is dedicated to such construction ..." The locally prevailing wage rates are minimums only (the government can pay more than these rates, but not less), and are determined for a given area by the Department of Labor. Specific requirements for determination of whether work is covered are in DEAR 922.4 and 970.2273, and 29 CFR 5.

b. Discuss the impact of job factors on productivity rates.

Productivity rates, being essentially averages of work under average, (unimpeded conditions), will vary based on the specifics of the job both on an overall basis and sometimes between work activity. In general the impacts of constraints and impediments will make the job more difficult in comparison to the standard productivity rates. These impacts reflect in the cost estimate in several ways. There may be a recognition that a specific task will involve greater than normal effort, in which case it will be estimated separately as a "lump sum" cost, based on the estimator's judgment. Alternatively, specific productivity factors may be applied. These may be increases based on height (scaffolding requirements, etc.), site conditions ("rock factors" for excavation), or area congestion. At some large, complex facilities or sites, specific "Building Factors" have been developed to relate Site work in a particular building to standard productivity rates. These building factors incorporate the impact of the difficulty of activities within a MAA (security), RCA (radiological entry and exit, contamination shutdowns), respirator or supplied-air area (PPE inefficiencies, stay time restrictions, external support requirements), as well as general Site requirements (training, bioassay, dosimetry, etc.).

c. Develop time, material, and labor estimates for a construction project.

This is a demonstration skill. The development of time, material, and labor estimates for a construction project proceeds through the following steps:

- Step 1 – Develop material takeoffs from drawings and specifications;
- Step 2 – Identify material costs, availability; identify items requiring vendor quotes, and obtain those quotes;
- Step 3 – Develop labor hours based on material takeoffs. Identify subcontracted items and obtain appropriate quotes. Incorporate productivity factor information;
- Step 4 – Establish crew composition and size;
- Step 5 – Provide input to scheduling function; receive feedback to optimize planning;
- Step 6 – Develop project-specific overhead and additional costs - overhead (supervision, management, quality, safety, contracts, project controls, etc.), fringes, G&A, profit, escalation, etc.; and
- Step 7 – Check estimate.

d. Discuss the effect of escalation and inflation factors on cost estimates.

<u>Definition</u>: Inflation is the decrease in the value of money over time. Inflation may be caused by aggregate demand exceeding aggregate supply, external pressures on the market such as droughts or cartels, wage-price spiral, an increase in the cost of labor or a decrease in the availability of goods or services. As applied to cost estimating, escalation is the factors applied to increase the cost

estimate costs over time to reflect future inflation in general, and sometimes also specific contractual and identified price increases.

Escalation is a factor typically multiplied to the direct and indirect costs on a cost estimate to reflect both the effects of general inflation and sometimes specific anticipated cost increases. Escalation that reflects general inflation is typically not included on current-year estimates, and is factored on costs expected to be incurred within a given year based on the activity midpoint in the resource loaded schedule. Escalation may also be used to correct historical data for the effects of inflation. Escalation indices are routinely published by DOE. It is difficult, if not impossible, for a single individual or group of individuals who are not trained economists to predict the future escalation with any reasonable degree of accuracy.

e. Discuss the purpose of contingency in cost estimating, including an explanation of how it is calculated.

<u>Definition</u>: Contingency is the factor applied to increase a cost to cover costs that may result for incomplete design, unforeseen and unpredictable conditions, and uncertainties within defined project scope. (Management Reserve is the account to which contingency funds are assigned during project execution to allow for management of project uncertainty.)

Contingency is related to the uncertainty of a project and is expressed as a percentage of the estimated cost. Contingency is larger for projects that are in the feasibility study and conceptual phases (30-40%) and becomes less as the project becomes more defined and can be estimated in greater detail in the definitive design phase (5-15%). Contingency is also larger for one-of-a kind projects, cutting-edge technologies, and fast-tracked projects; and smaller for routine, standard, or low-learning curve activities.

f. Prepare a cost and technical analysis of a contractor's proposal.

The development of a cost and technical analysis of a contractor’s proposal proceeds through the following steps:

- Step 1 – Prepare an independent estimate. [Prior to any Request for Proposal being issued by a site M&O Contractor, a Government Estimate (i.e., an engineer’s estimate used to determine the reasonableness of competitive bids received in connection with construction contracts and to serve as a control in evaluating cost estimates prepared by a prime construction contractor) must be prepared. This estimate will be based on the Title II estimate, but will include only those items in the bid package, not engineering, GFE, M&O Contractor support, etc.];
- Step 2 – Compare elements: assumptions, background conditions or data, estimate coverage, estimate methodology, and basis of estimate (these can also be

examined on a contractor's proposal even if no independent estimate is available);

- Step 3 – Identify and quantify discrepancies;
- Step 4 – If appropriate, discuss technical issues with the contractor's estimator to identify technical or scope disconnects or deficiencies; and
- Step 5 – Present results and conclusions.

g. Discuss funding authorization limits and their impact on the cost estimating process.

Definition: Funding authorization limits are funding limits distinguishing whether a project can be a General Plant Project (GPP) or must be a Line-Item Project ($1.2 million).

The impacts on the cost estimating process based on whether a construction project is Line Item or GPP is typically level of detail and expected level of scrutiny for the basis of estimate. The GPP will be evaluated at the field office level. A Line Item will need to support Congressional review and may be subject to an Independent Cost Estimate review from the DOE Office of Facility Management.

h. Develop recommendations for the contracting officer based on cost and technical analysis.

The development of recommendations for the contracting officer, based on cost and technical analysis, proceeds through the following steps. This in reality represents development of a negotiating position for a cost plus-type contract or change order since, although cost is part of the evaluation of a fixed price proposal, typically the estimate details are not available for review.

- Step 1 – Identify overall negotiation targets, based on results of the government estimate and analysis of contractor's proposal;
- Step 2 – Identify technical weaknesses of the contractor's cost estimate; and,
- Step 3 – Prepare supporting rationale for points of contention.

i. Describe the application and use of estimator tools.

The following estimator tools are described below:

Estimating Guides
Several estimating guides or estimating manuals are published, the most notable being Mean's and Richardson's. These manuals will provide standard rates for materials and labor based on material takeoffs.

Site-specific Cost Estimating System

For example, at some large, complex facilities or sites, engineering may utilize a cost estimating system which has collected data on past projects at the Site, including materials, labor hours, labor rates, and productivity ("Building") factors.

Alternative Estimating Models

Numerous commercial estimating computer models are available to provide generic construction cost estimating. Some systems have modules which cover decontamination and decommissioning and environmental restoration activities.

DOE Estimating Guideline
DOE has developed a document providing overall guidance for the preparation of cost estimates at DOE sites.

Contractor Estimating Manual
Each site contractor may have developed procedures for the preparation of cost estimates, for example, if the site has developed an Estimating Procedures Manual

1.5 Construction management and engineering personnel shall demonstrate a working level knowledge of techniques for scheduling construction projects.

Supporting Knowledge and/or Skills

a. Discuss construction project scheduling methods, including an explanation of critical path scheduling.

Construction project scheduling is done using two primary methods: Critical Path Method (CPM) and Project Evaluation Review Technique (PERT). The primary difference in these two methodologies is activity time estimation. CPM utilizes a single most likely estimate for activity duration. PERT utilizes a probabilistic model for time estimation.

Both techniques utilize a network methodology for scheduling. This methodology is broken up into six basic steps:

- Project Planning
- Time and Resource Estimation
- Basic Scheduling
- Time-cost Trade-offs
- Resource Allocation
- Project Control

Project Planning – The first step in Project Planning involves clearly defining the ultimate goal of the project. All activities necessary to complete the project must then be determined. Once these are known, the planner must determine logical relationships which exist between the activities (i.e., which activities must be completed in series, which may be completed in parallel, and which activities may start in the middle of another). These activities will then be mapped on a network diagram. Many techniques to perform this mapping exist. The three most common are arrow, node and precedence diagramming.

Time and Resource Estimation – Once the network diagram is developed, estimates of time required to perform each activity must be made. These estimates are based upon assumed manpower and equipment requirements and availability, and other assumptions that may have been made in planning the project. If utilized CPM then a best estimate time is employed. If utilizing PERT, three time estimates are used: best case (optimistic - O), worst case (pessimistic - P) and most likely (M). These three estimates are utilized to determine the mean time to complete the activity. Advanced statistical methods may be employed to determine the mean time to completion (Mean Activity Duration), but a simple approximation may be used as follows:

$$\text{Mean Activity Duration (T)} = (O + 4M + P)/6$$

Basic Scheduling – Once activity times have been estimated (CPM or PERT), scheduling of the activities will be conducted. This is done utilizing the network logic and the time estimates.

Terms associated with project scheduling include:

- Early Start - the earliest date an activity may begin as logically constrained by the network logic;
- Early Finish - the earliest date an activity may finish as logically constrained by the network logic;
- Late Start - the latest date an activity may begin as logically constrained by the network logic;
- Late Finish - the latest date an activity may finish as logically constrained by the network logic;
- Total Float (Path Float) - the amount of time an activity may be delayed from its early start or early finish without delaying the end date of the project;
- Free Float (Activity Float) - the amount of time that an activity can slip form its early finish date and not impact any successor early start date; and
- Critical Path - the path with the least total float.

The first step is to conduct a forward pass through the network logic. This is a calculation which determines the earliest dates an activity can occur. The durations of each activity are added left to right observing network logic dependencies to determine early start and early finish dates for each and any total float associated with each path.

Then a backward pass is made. This calculations determines the latest dates each activity must occur. An end date may be either assumed or determined using the forward pass critical path end date (this is known as the zero float convention). Utilizing this end date, each duration is subtracted right to left observing network logic dependencies to determine activity late start and late finish dates.

1.5-1 and 1.5-2 illustrate the process with a simple example. The zero float convention is assumed for the example.

Time-cost Trade-offs – Once the preliminary scheduling is completed, a decision will be made determining whether the completion date is satisfactory. If an accelerated completion is required, then time-cost trade-offs of activity performance times must be considered for those activities on the critical path and near the critical path.

Resource Allocation – The feasibility of each schedule must be checked with respect to manpower and equipment requirement, which may not have been explicitly considered in basic scheduling. The float determined in basic scheduling may be used to arrive at schedules which satisfy outside constraints placed on the quantity of resources available as a function of time.

For example, if a particular activity has a 10 day duration and a 10 days free float, it may be scheduled to start the day after its predecessor is completed up to 10 days after its predecessor is completed. If the crew which is to work on this task is also involve in a parallel path, it may be prudent to delay the start of the subject task so as not to require additional resources be brought in. In this example, the start may be delayed up to 10 days.

Project Control– Once the plan and schedule have been finalized, the project will then be tracked against the schedule. If changes occur in the schedule due to delays, the network must be revised and analyzed for its effect on the overall schedule.

Illustrative Example of Forward and Backward Pass

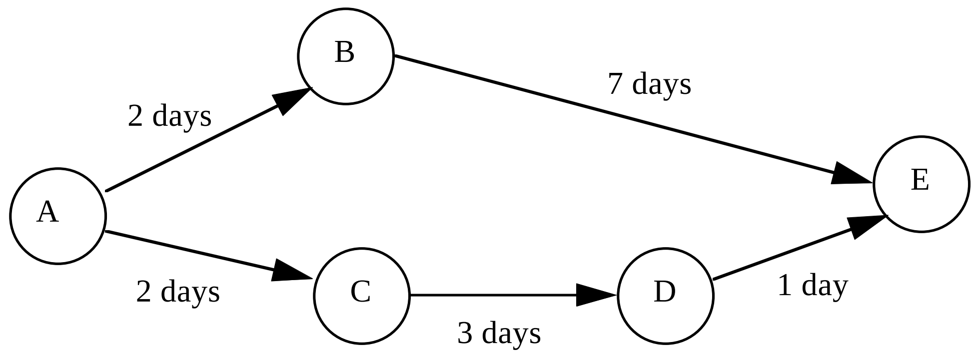


Figure 1.5.1

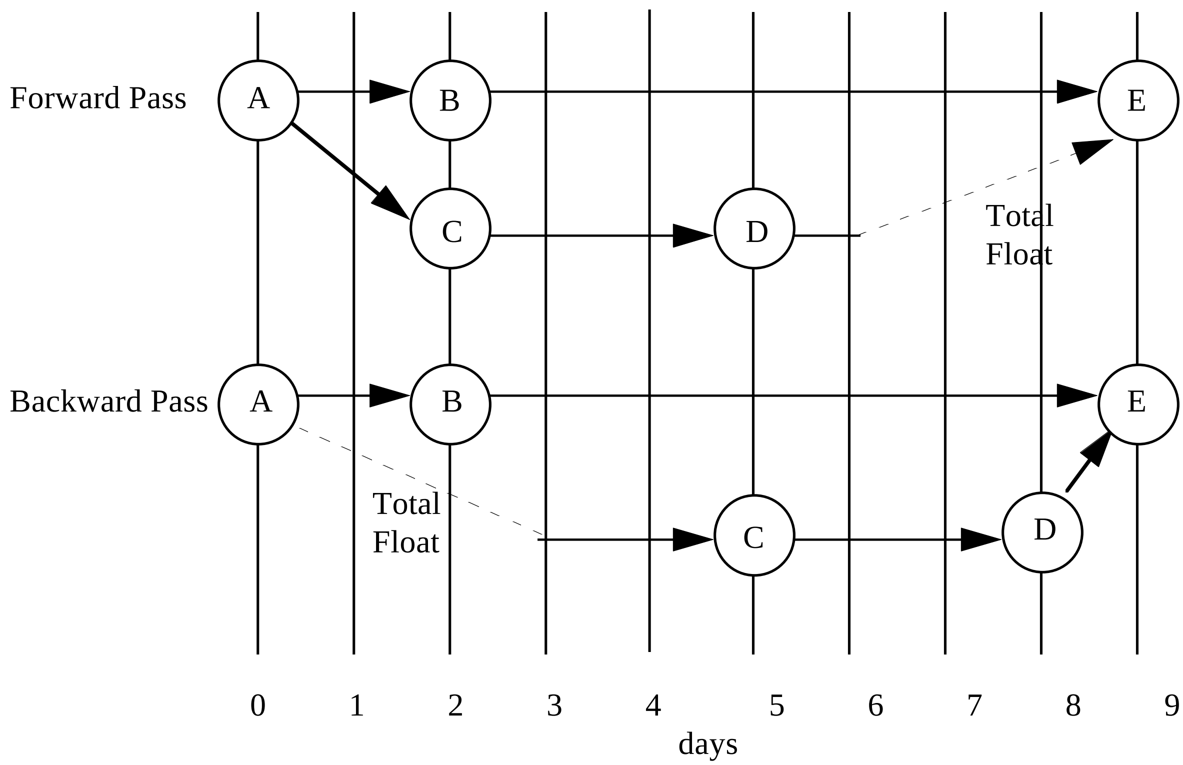


Figure 1.5-2

b. ***Discuss each of the following elements of construction project scheduling, including the factors of each that could impact the schedule:***

- Orderly delivery of equipment and materials in sequence with the installation schedule.

  The schedule needs to address equipment and material requirements. These items must be identified during the planning phase. The use of integrated material and equipment schedules is recommended to ensure that all equipment and materials are identified and at the construction site when needed. These schedules should include any contracting or manufacturing lead time necessary so that this may be done far enough in advance to ensure timely delivery. Changes in the overall schedule will affect the material schedule. If the schedule slips, additional cost will be incurred due to the staging and security costs associated with storing the material. If the schedule is moved forward, materials may not be ready for installation or additional cost may be incurred for early delivery.

- Construction equipment requirements.

  Like the materials, a detailed schedule of construction equipment must be prepared based on the project schedule. This is necessary to ensure all construction equipment needs are identified and contracted for, and to make the most efficient use of the equipment. For example, if crane services are necessary, perform as many lifts as possible during the period it is contracted for. This may also be a restriction placed on the project schedule. If parallel paths on the schedule require the same asset, then the activities must be sequenced in series with one having priority over the other. Any path float will be used to accomplish this if possible. If not, this linked sequence may affect the critical path.

- Manpower planning and scheduling

  Required manpower estimates are required for every project. These should be specific to what type and how many personnel are required for each activity. As with equipment, conflicts may arise with two activities requiring the same manpower. In this event, the activity must be adjusted utilizing any path float time available or more people must be hired.

  A useful tool identify potential manpower or equipment conflicts is a technique known as resource loading. In the network diagram, the various resources required are also listed with each activity. The total of each paths resource requirements are then plotted over time assuming both early start and late start assumptions. The result is a graphical presentation of each individual resource requirement for each day of the schedule. The schedule may be adjusted based on this resource loading.

- Bidding and award activities

A design and procurement schedule for each project should be developed. This will be used to track scheduled design, bid, and contract award and actual design, bid and contract award. This is then used to put for the project or construction manager to determine where pressure and assets are needed to speed the procurement process.

During this time frame, actual bids are compared to preliminary and fair-cost estimates to track bidder performance for future use.

c. Read, interpret, and develop the following construction project control aids[1,2]:

- **GANTT Charts (bar chart)**

Read: Bar charts show the corresponding schedule with activity bars positioned along a time-scale. Each activity is displayed according to the total time for completion and the start/end dates on the time-scale. Bar charts can be used to display resource usage, resource/cost data and work breakdown structure (WBS) outline.

Interpret: Information presented is activity duration and start/end dates for each activity.

Develop:

◊ Analyze the project and specify the basic approach to be used;

◊ Break the project down into a reasonable number of activities to be scheduled;

◊ Estimate the time required to perform each activity;

◊ Place the activities in sequence of time, taking into account the requirements that certain activities must be performed sequentially while others can be performed simultaneously; and

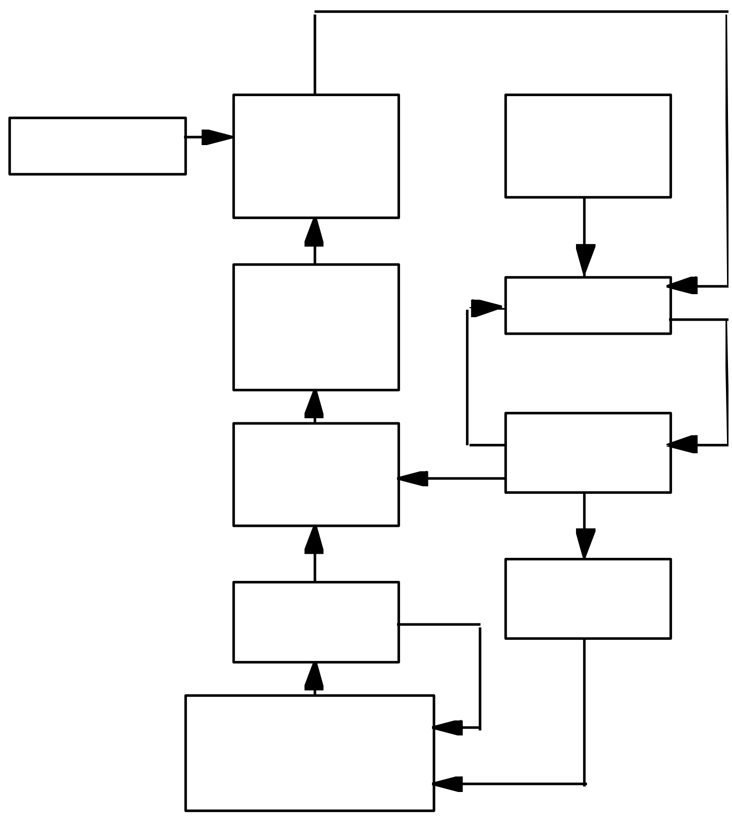
◊ If a completion date is specified, the diagram is adjusted until this constraint is satisfied.

- **Networking techniques (critical path method)**

Read: Networks show the corresponding schedule with activity dependencies or ties clearly displayed. Critical path method (CPM) is a graphical depiction of the shortest time period through the logical ties from project start to project finish.

Interpret: Network interpretation is simply reading the overall project with all the logical ties which results in an understanding of the critical path and the various start/end dates of each of the activities.

Develop:



- **Percentage completion curve (S curve)**

Read: Percentage completion curves graphically plot some measure of cumulative progress on the vertical axis against time on the horizontal axis. Progress can be measured in terms of money expended, man-hours expended or any other measure which makes sense in terms of actual units (dollars earned, dollars planned, dollars actual, man-hours etc.) or in percentage of estimated quantity to be measured.

Interpret: Percentage completion curve interpretation is accomplished by reading the horizontal and the vertical scale so that an understanding of overall project completion percentage is gained. On most projects resource expenditure starts slow (low slope in the beginning), builds to a peak (slope increases in the middle), then tapers off near the end (slope flattens near the top).

Develop: Percentage completion curves can be developed manually or by using the various software packages available. Calculate the each time-frame project completion percentage by dividing measure expended for each time-frame by overall project measure. Insert the various completion percentages over time into a graph so a line can be drawn from point to point to display the completion curve to date. The manual methodology is more labor intensive due to the fact that updating involves plotting the graph for the present time-frame. The computerized method of creating a percentage completion curve is usually an automatic function of the software as you input/update each of the activities.

- ***Labor schedules/Material schedules/Equipment schedules/Finance schedules***

  Read: Labor, material, equipment, and finance (resource loaded) schedules show the corresponding project schedule with labor, material, equipment, or financing requirement dependencies clearly displayed. By using these types of schedules the various requirements over the course of the project can be accessed as needed. This helps prevent beginning with the entire labor force, all required material, all needed equipment at project start, or all of the financing. This results in lower project cost by not having to carry the cost of man-power, material, construction equipment, or financing over the entire project.
  Interpret: Schedule interpretation is simply reading the overall project requirements (labor, material, equipment, or financing) with all the logical ties which results in an understanding of those particular requirements.
  Develop: Schedules can be developed manually or by using the various software packages available. Use time-scale graph paper to display each requirement at the time of need. Begin with the earliest starting requirement so that all later requirements will be tied to this date as the logic (predecessor/successor ties) of the work is used to drive the schedule. The manual methodology is much more labor intensive due to the fact that updating involves recreating the requirement network display. The computerized method of creating resource loaded schedules is usually an automatic function of the software as you input/update each of the activities.

d. Prepare and control project baseline using resource loaded, time based CPM schedules at a level and frequency that potential problems can be identified and solved before they become real problems.

GANTT Charts (bar chart)

- Networking techniques (critical path method)
- Percentage completion curve (S curve)
- Labor schedules
- Material schedules
- Equipment schedules

- Finance schedules

Prepare the above items, utilizing the "develop" sections in Part 1.5 (c) above.

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[1] Moder, J. J., Phillips and C. R., Davis, E.W.,*Project Management with CPM, PERT and Precedence Diagramming*,Third ed., New York, NY: Van Nostrand Reinhold, 1983.
[2] Barrie, D. S. and Paulson B. C.,*Professional Construction Management: Including CM, Design-Construct, and General Contracting.*

1.6 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of contract law applicable to contract specifications and drawings.

Supporting Knowledge and/or Skills

a. Discuss stop-work orders including responsibilities and authorities, and the impact of a stop-work order to project cost and schedule.

Contract clauses should give the owner (including his construction manager) and the engineer (includes the project engineer or professional engineer) the right to suspend the contract (via a stop-work order) if, in their opinion, an emergency or other unexpected development makes this necessary to protect the owner's interests. On the other hand, the right to suspend the contract should not be given to the contractor. The right is intended to protect the owner, but it should not be used in such a fashion as needlessly to injure the contractor. The suspension clause might read like this:

> If at any time the Owner considers it impracticable to start or to continue performance of the work or any portion thereof (whether or not for reasons beyond the control of the owner), the owner shall have authority to suspend performance until such time as he may believe it feasible or desirable to proceed. However, should such action suspending the work be taken, the owner shall take all appropriate steps to minimize the duration of the suspension of work, and the contractor shall be entitled to such compensation for the resultant unavoidable expenses to him as the owner may believe to be just and reasonable because of the suspension.

In the case of a contract with a definite time limit for completion, an extension of the time should be granted to the contractor to make up for the time lost because of the suspension. The extension should be a liberal one because a protracted interruption of work will almost always cause considerable further delay before the contractor can get adequate production under way again. Personnel cannot remain on hold indefinitely nor can the contractor keep the flow of materials to the site ready to be resumed at short notice.

Because of the actual time lost and remobilization delays, any stoppage of work can significantly add to the cost and negatively impact the construction project work schedule. Because of this, alternate methods of issue resolution should be used, and earliest consideration should be given to emergent issues. Actual stop works (contract suspensions) should be used only as a last resort.

In the DOE system, authority to stop work on a construction contract lies with the Contracting Officer. The Project Manager, who has line responsibility for the construction project, has the authority to stop work in an area if an imminent safety hazard is discovered. Otherwise, the Project Manager must work through the Contracting Officer to suspend the contract after all less severe courses of action are found to be insufficient.[1]

b. ***Describe what constitutes compliance with specifications and drawings.***

Specifications give detailed information regarding each and every thing and operation within the scope of the contract. They serve as the single and definitive basis for competitive bidding, and constitute the book of instructions for all concerned with the work. Compliance with specifications and drawings, as they are written, constitutes performance of the contract. See item "e." below for details of the degrees of performance under the contract.

Differing functions of drawings and specifications can be illustrated as follows:

- Drawings show lengths, elevations, sizes, thickness, spacing, and requirements such as waterproofing, joining, etc.; and,
- Specifications describe such things as the quality of the concrete or aggregates, workmanship for mixing, placing, and curing the concrete, quality of materials for waterproofing, materials and workmanship for expansion/ contraction joints, preparation of soil foundation, etc.

The engineer and the owner should understand that if the specifications fail to show all requirements adequately, then the contractor's obligation is limited to performance of what is actually called for in such incomplete specifications and/or drawings.

The contract should specify the procedure to follow if discrepancies are found between the drawings and specifications. This is called a contract integration clause. In general, when something is called for in the specifications but not included in the drawings, or vise versa, the contractor should furnish or perform the item in question as though it were covered in both. The contract documents must make this point clear. It is not legal for the contractor to knowingly ignore or show preference for conflicting information between the drawings and specifications.

There are two categories of specifications within a construction contract, namely workmanship and materials. Workmanship is intended to denote the contractor's *operations* in the shop or field, rather than the materials used by him in the performance of the contract.

Workmanship– An independent contractor must be free from dictation by the engineer (or anyone else) about how the work shall be done. When the contractor signs the contract, it becomes his duty to perform in accordance therewith, to follow carefully the plans and specifications, and to furnish proper materials and workmanship as required by them. Should the engineer or the contract documents specify exactly how the work is to be handled, then the engineer has largely assumed responsibility for securing the desired results.

There may be circumstances that make it necessary for the engineer to specify in detail just what is to be done and how it is to be accomplished, thereby deliberately assuming responsibility. (This may occur frequently in the highly technical requirements for a nuclear weapons facility.) In this case, the contractor agrees to build the system according to plans and specifications. Whether or not the finished product is adequate for its intended service would be the responsibility of the designers.

Materials– It is often both efficient and desirable to specify standard products by trade name, catalog number, or any suitable reference that is definite enough and is customary usage. (For government work, it is normally a requirement to designate three alternate, suitable articles, to secure adequate competition in bidding.) It is also helpful to refer to standard specifications where applicable ones are available. The American Society for Testing Materials (ASTM) has prepared volumes of specifications for most of the materials commonly used. Testing methods for these materials are also provided by ASTM.

Standard specifications are generally prepared for use in average or ordinary conditions. When special requirements are to be met, the engineer should not trust the adequacy of standard specifications. It is his responsibility to prepare complete and accurate specifications that meet the unique requirements of the particular job.[1]

c. Discuss the process for making changes and modifications to contract specifications or the scope of work.

It is often the case that revisions (changes) of plans prove expedient or imperative after a contract has been awarded. Decisions to revise should follow these principles:

- Any error should be corrected promptly;
- Matters involving safety of personnel, structures, and equipment should be given top priority;
- When something bearing upon satisfactory operation is found, the indicated changes should be made unless they entail undue hardship or expense. Additional trouble and expense during the construction process may be offset many times over by savings in operation;
- Modifications that are merely the result of differences of opinion, that will have little real consequence, should be avoided;

- Revisions that involve substantial changes in quality or quantity of work should not be effected until the contractor and the owner have agreed upon what is the allowable additional expense. This agreement should be confirmed in writing; and,
- If the revision constitutes so major a change that it greatly affects the scope or character of the work, the matter may have to be treated as requiring a negotiated modification of the original contract or the preparation of a new and separate contract covering the additional work.

All revisions should be in written form. Telephone notification may be an excellent way to pass along the information, but it should be followed up promptly by written confirmation of the instructions.

It is also desirable for the contract to contain a clause stating that the contractor is not to proceed with the execution of revisions until official data and instructions in writing have been received. Similarly, after having been notified that certain revisions are pending, he is not to proceed with work that will be affected thereby because doing so would probably result in even greater cost and trouble in carrying out the revisions later.

Extras are scope of work changes that increase the scope of work. The contract should make definite and adequate provisions for handling the "extra" costs, whether the contract is on a lump-sum or a unit-price basis. This matter is especially troublesome in the case of lump-sum contracts. Extra charges may result from ordinary changes made by the engineer, from a substantial increase in the quantity of work required, or from a real change in the quality of materials or workmanship from what was specified in the contract. Also, something unforeseen may be encountered, and the performance of unanticipated work may become essential. If so, the additional task simply has to be accomplished regardless of the costs involved.[1]

When major changes to the specifications and/or the scope of work are required, the Contracting Officer and the appropriate level Change Control Board must become involved.[2]

d. Describe the difference between expressed and implied warranties and how each is addressed in contract specifications.

In general, a <u>warranty</u> is the assumption of responsibility by the seller (constructor) for the quality, character, or suitability of the goods he or she has sold. When the seller assumes responsibility by agreement with the buyer (in the contract), the warranty is called an <u>express warranty</u>. In addition, certain responsibilities for the quality of the goods sold are imposed on the seller by the Uniform Commercial Code. These warranties arise whether or not the seller has made express promises as to the quality of the goods. The warranties imposed by law are known as <u>implied warranties</u>.

Only the expressed warranty is addressed in the contract as described above. Specified parameters invoking quality, character, performance, suitability, and ownership type features are included or referenced in the contract specifications. The critical elements for creating this express warranty are: a statement of fact or a promise made by the seller to the buyer concerning the goods that becomes part of the contract between the buyer and the seller. Note: Sellers who merely give an opinion or recommend the goods do not create an express warranty.[3]

e. ***Describe the process for expending funds for a project as it relates to contract law.***

Building or construction contracts commonly contain clauses making the payments due the building contractor conditional on the production of certificates to be issued by a named architect or engineer. These certificates are issued at each stage of completion after the architect or engineer has inspected the work done.

There are three recognizable degrees of performance: (1) complete or satisfactory performance, (2) substantial performance, and (3) material breech. Complete or satisfactory performance is performance up to accepted standards; substantial performance falls short of complete performance only in minor respects, and it does not deprive the promisee (buyer) of a material part of the consideration bargained for. The promisor (seller) is guilty of material breech if his or her performance is defective in some major respect.

If performance is complete or satisfactory, the promisor is entitled to the contract price; if the performance is substantial, the promisor is entitled to the contract price less damage resulting from defects. If the promisor has materially breached the contract, the promisor has no right of action (receiving payment) on the contract unless the promisee has accepted the defective performance without objection.[4]

In the event that a contractor fails to pay a portion or total of a subcontractor's price, public sector work does not fall under the lien laws of the United States. In response to this legality in bidding public work, the Miller Act requires performance and payment bonds of all contractors on government work. Therefore, upon contractor failure to pay, the recourse for the subcontractors is through the bonding agency.

f. ***Describe in general terms the process used to negotiate and establish a construction contract between the Department of Energy and the contractor.***

Per DOE O 4700.1, selection procedures for architect-engineers (for construction contracts) is to be in accordance with Department of Energy Acquisition Regulations (DEAR) part 936.6.[5]

DEAR 936.6 has the following sections:

- 936.601 Policy

- 936.602-2 Evaluation boards
- 936.602-3 Evaluation board functions
- 936.602-4 Selection authority
- 936.602-70 DOE selection criteria
- 936.603 Collecting data on and appraising firm's qualifications
- 936.605 Government cost estimate for architect-engineer work
- 936.606 Negotiations
- 936.609-3 Work oversight in architect-engineer contracts

Policy – In an effort to ensure the broadest publicity concerning DOE's interest in obtaining this type of services, a notice of intent to contract for architect-engineer (AE) services shall be published in accordance with the Federal Acquisition Regulations (FAR). Submissions received differ in substance from proposals received for other types of acquisitions (so they must be handled in accordance with guidelines in this section of the DEAR).

AE evaluation boards shall be used for the selection of professional AE services when the cost of the (construction) contract is over $500,000. They may also be used for contracts below this level.

Firms annually submit Forms 254/255 to indicate their interest in providing AE services. Supplemental information may also be requested.

After DOE Headquarters review, a Commerce Business Daily (CBD) announcement shall be prepared per the FAR, parts 5.205(d) and 5.207. This is the intention to contract for AE services discussed under the Policy section above.

Every opportunity and encouragement shall be given to small, small disadvantaged, and woman-owned businesses. Other factors such as project size and geographic area should be considered.

AE evaluation board reviews Forms and selects three or more firms for further discussions. Selection criteria such as experience, local resources, key personnel, etc. are listed in 936.602-70.

Discussions shall be held with the selected firms regarding "anticipated concepts and the relative utility alternative methods of approach for furnishing the required services."

The AE evaluation board finishes its work by submitting a report to the Source Selection Official with recommendations, as well as the solicitation, selection criteria, weights, and other relevant information and documents.

The Source Selection Official then selects the firm determined to be the most highly qualified. If this is not the firm selected by the AE evaluation board, complete documentation of the decision shall become part of the contract file.

Prior to entering negotiations, an independent Government cost estimate for the services will be prepared per the detailed requirements of 936.605. [Contract type should have been selected based upon the information available as to the scope of work. A fixed-price contract should be used whenever practicable. If insufficient project definition is available, a preliminary engineering (Title I Design) contract on a reimbursable or fixed-price basis should be used; this will then be followed by a fixed-price contract for the remaining portion of the AE services (Title II/III) based upon information developed under the first contract.]

The Contracting Officer requests a price proposal from the selected AE.

The Contracting Officer then negotiates a price considered fair and reasonable based upon a comparative study of the Government estimate and the AE's proposal.

The results of the negotiation become the cost basis for the contract. (Promptly at the conclusion of each negotiation, a memorandum documenting the principal elements of the negotiation is prepared and included in the contract file.)

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[1] *Contracts, Specifications, and Law for Engineers*, 4th edition, Bockrath, published by McGraw-Hill Book Company, 1986.
[2] DOE O 4700.1, *Project Management System*
[3] *Business Law and the Regulatory Environment*, 5th edition, Lusk, et al, published by Richard D. Irwin, Inc., 1982.
[4] *Contracts, Specifications, and Law for Engineers*, 4th edition, Bockrath, published by McGraw-Hill Book Company, 1986.
[5] *Department of Energy Acquisition Regulations (DEAR)*, Amendment 20

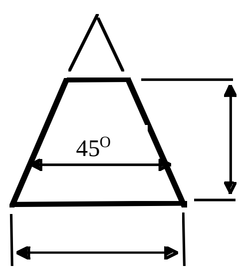
1.10 Construction management and engineering personnel shall demonstrate the ability to read and interpret engineering fabrication, construction, and architectural drawings.

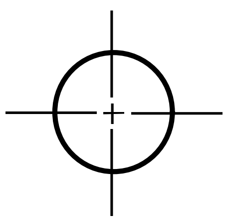
<u>Supporting Knowledge and/or Skills</u>

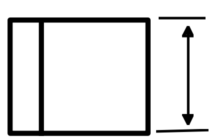
a. Given the above drawings, read and interpret the following symbology:

This is a demonstration requirement. The following tables are provided as examples of graphic symbology. Always check the legends on the controlled drawings that are applicable to the project, since different architects and software packages may use unique symbology.

- Basic dimensional and tolerance



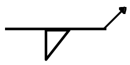
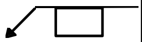
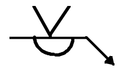
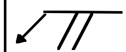
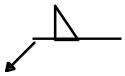
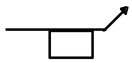
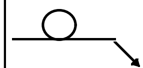
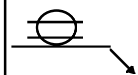
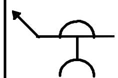
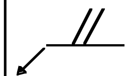
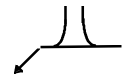
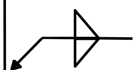
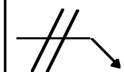
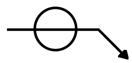
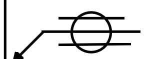




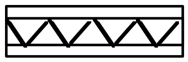
Geometric characteristic symbols

	Type of Tolerance	**Characteristic**	**Symbol**
For individual features	Form	Straightness Flatness Circularity (roundness) Cylindricity	— ▱ ○ /○/
For individual or related features	Profile	Profile of a line Profile of a surface	⌒ ⌓
For related features	Orientation	Angularity Perpendicularly Parallelism	∠ ⊥ //
	Location	Position Concentricity	⌖ ◎
	Runout	Circular runout Total runout	↗ ⌰ a

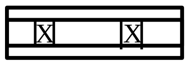
- Basic fabrication

Basic Welding Symbols and Their Location Significance								
	Fillet	Plug or Slot	Spot or Projection	Seam	Back or Backing	Surfacing	Scarf for Brazed Joint	Flange Edge
								
						Not used		
		Not used	Not used	Not used	Not used	Not used		Not used
	Not used	Not used			Not used	Not used	Not used	Not used

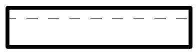
- Basic construction



STEEL STUD

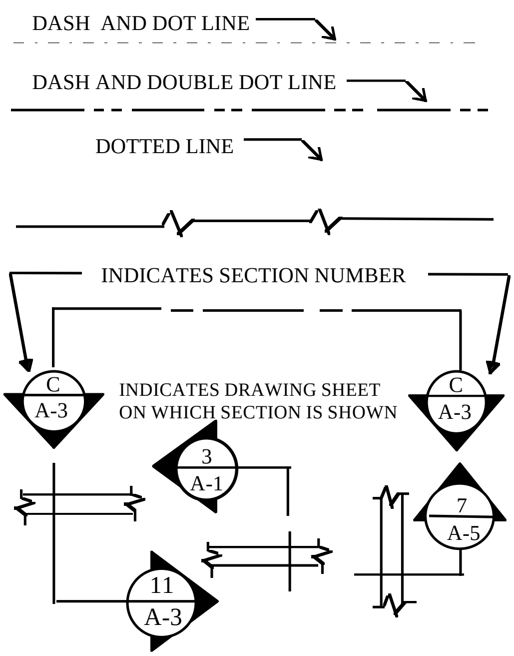


WOOD STUD



DASHED LINE DENOTES SPECIAL FINISH FACE - PLAN/SECTION

- Basic architecture



CENTER LINES, FLOOR LINES IN EXTERIOR ELEVATIONS, PROJECTED LINES

PROPERTY LINES, BOUNDARY LINES

CUT LINE OR HIDDEN LINE

TO BREAK OFF PARTS OF DRAWINGS

SECTION LINES AND SECTION REFERENCES

b. ***Given a drawing and a completed or partially completed product, compare the product against the specifications on the drawing.***

This is a demonstration skill.

Use the information represented on the drawings to check dimensions on all elevations and plans, sizes, shape, locations (if applicable), materials, assemblies, equipment, fabrication, finishing, tolerances, and any other information called out on the drawings.

c. ***Discuss the relationship between specifications and drawings.***

Architects and engineers communicate their concepts to others by a set of documents containing both words and graphics. Although words and graphics are combined in the drawings, words predominate in the bidding requirements, conditions of the contract, and specifications. Of these three, the one most closely related to the drawings is the specifications. In specifications, words describe in detail the qualities of products and installations illustrated and identified in the drawings. The two are intended to represent a coordinated and complementary set of documents.[1]

On drawings, the symbols, conventions, dimensions and words are combined with two-dimensional graphic representations in the form of plans, elevations, sections, and details to inform about quantities, location, relationships, sizes, shapes of buildings and/or components.[1]

In specifications, qualitative requirements are defined in words, as related to materials, assemblies, equipment, fabrication, and finishing; and for execution of the work, as related to installation, and application. Included in the specifications, are administrative and other procedures needed for quality control during construction. After a contract is awarded, the specifications provide the measure of quality by which the work is performed and judged.

d. Describe the process for resolving conflicts between specifications and drawings.

To resolve conflicts between specification and drawings, it must first be determined the nature of the conflict, whether it be lacking information or conflicting information. It must also be determined which documents, the specifications or the drawings, take precedent over the other. The contract may provide this answer. In most cases, the specifications take precedence. Contracting parties may not ignore one component of the contract in favor of another, conflicting, clause. This precedent is usually described in the general conditions of the contract under an Integration Clause. Negotiation between appropriate personnel would occur, leading to a revision.

[1] Wilkes, Joseph A., Robert T. Packard, *Encyclopedia of Architecture, Design, Engineering & Construction*, John Wiley & Sons, New York, NY, 1989.

1.13 Construction management and engineering personnel shall demonstrate a working level knowledge of construction methods and accepted construction practices for the following:

- Structural waterproofing
- Architectural finishes
- Roofing systems
- Mechanical and electrical equipment installation
- Material protection and storage
- Construction site tools, equipment, and materials

Supporting Knowledge and/or Skills

a. Discuss the requirements, materials, and methods for waterproofing walls, floors, or other building elements that are subject to hydrostatic pressure, are below the water table, or may be immersed in water.

Concrete alone is not waterproof, therefore, concrete requires special membranes, drains and flashing to prevent moisture seepage into the structure. Flashing is a metal material used at joints to prevent water from entering the structure by diverting the water to a drainage system. If the ground has only small quantities of water, a system of gravel or French drains can be incorporated around the structure. If the structure is submerged in a saturated soil of high permeability, a complete waterproofing membrane can be employed to prevent water infiltration. These membranes can be coatings to the structure or they can be a continuous membrane , both of which require protective coverings.

b. Discuss the construction methods and requirements associated with the following architectural finishes. Include the elements of fire protection, hazardous material contamination, and indoor air quality in the discussion.

Lath and plaster – System of wall finish that requires installation of a system of metal material and then application of a plaster coating, which is then smoothly finished. Lath and plaster generally has good fire retardation qualities, does not pose an indoor air quality problem, and is not a hazardous material.

Gypsum board – Consists of a gypsum core faced with paper. It provides a smooth finish, but the coverings burn at a lower temperature than the gypsum, poses a small dust problem upon installation, but is not a hazardous material.

Tiles – Generally set in a Portland cement bed or adhesive. They provide excellent wear and fire resistance, they create fine dust when ground or sawed, and certain adhesives require adequate ventilation upon installation. Most ceramic tiles are not a hazardous material, but always consult the manufacturer.

Acoustical treatment– Acoustics can be managed by several different methods. One method to reduce sound transmission is to use materials that absorb sound. These materials include carpets, drapery, and soft furniture which absorb many undesirable sounds. Another method is to use barriers to sound, usually a material placed inside a floor slab or ceiling to stop the transmission of sound from one room to the next. Walls with insulation also provide effective sound management. This insulation often has fine particles associated with it and the manufacturer may suggest the use of respirators during installation. Most acoustical treatments are not hazardous materials, but consult the manufacturer.

Resilient flooring– This type of floor covering is usually less than 1/4 inch thick and must be laid on a hard, smooth surface. They often require cements, latex glues, or other adhesives which require adequate ventilation. Different types of flooring systems are rated differently on fire retardation, consult Underwriters Laboratories for standards. Most resilient types of flooring are not hazardous, but consult the manufacturer.

Carpet – Type of resilient flooring. Even treated carpets generally have higher combustion ratios than other types of flooring. They also entrap dust and require extra cleaning efforts. Carpets are not a hazardous material.

Resinous flooring– Typically a substitute for concrete, it is used where the thickness required is less than 1/4 of an inch (a thickness to which concrete cannot be placed). Resinous flooring costs more than concrete, requires ventilation during placement, and is generally not a fire hazard. Some types of resin are considered hazardous, the manufacturers will indicate proper disposal techniques.

Conductive floors– Used to prevent electrostatic sparks in potentially explosive environments. Conductivity is usually achieved by adding a resinous mix during the manufacture of the concrete. This concrete additive always causes a black surface. This additive may nullify any concrete recycling effort during demolition. There are no specific indoor air quality concerns, as the additive is added during batching of the concrete.

Painting– Requires ventilation during and shortly after application. Depending upon type, they can promote or retard fires, check with the manufacturer. Paints should always be disposed of properly. Paint in older buildings may be of a lead base, which falls under specific guidelines for removal and disposal. Tests should be completed on the paint to determine the chemical composition.

Wall coverings– Numerous coatings exist for walls, such as wall paper. Consult the manufacturer and Underwriter's Laboratories for standardized information on fire qualities and application requirements and indoor air quality concerns and any hazardous material concerns.

Special coatings– There exists special coatings to retard fires from spreading, sparks from being generated, for waterproofing, heat and acoustical properties.

c. ***Discuss the construction methods and requirements of roofing systems. Include the following elements in the discussion:***

- Roofing tiles;
- Membrane roofing;
- Bituminous roofing;
- Sheet metal roofing;
- Single ply roofing;
- Roof mounted equipment; and
- Water retention.

Roofing tiles are a flexible method of roof covering. Tiles can be clay, asphalt, concrete, slate or wood. They are best suited for use on slopes, and require more skill on installation to achieve proper waterproofing.

Membrane roofing, a type of waterproofing, is a system usually used in conjunction with other roofing systems. The material is usually flexible, adaptable, and can easily be fused to other layers of membrane to effectively cover the roof. This usually requires a specialty sub-contractor.

A bituminous roofing system is installed in layers of felt and coal tar pitch or asphalt. Coal tar pitch melts at a much lower temperature and can flow in direct sunlight. Coal tar pitch is relatively self sealing because of this characteristic, but requires a layer of gravel to be placed on top to prevent excessive movement. Asphalt roofing tends to require more work, but because of its higher melting point can be installed on a high sloping roof.

Sheet metal roofing is utilized because of its ability to conform to a wide variety of roof shapes. Preventing water infiltration at the joints of the sheet metal requires soldering or an extra joint piece with complex configurations to cover the connection. Also, a single ply roofing material could be used, which often has a reinforcement cemented to the underside to allow for light foot traffic. This type should not be used, however, on roofs with intricate designs, as the roofers have high labor costs to cut, fit and seam many different sections together.

Any roof mounted equipment, such as transformers or HVAC components must be properly waterproofed at the point of attachment to the structure of the building. This may require a special layer of membrane, some custom flashing and some tar at the joint, depending upon the type of roofing system utilized.

Another concern to the designer of a structure with a flat roof is water retention. Flat roofs often sag and create ponds where water can collect. Ponding adds a considerable load component that can often cause failure. Frequent drains and yearly inspections can help prevent roof failures, better yet, design a sloped roof.

d. Discuss the construction methods and requirements for installing electrical and mechanical equipment. Include the following elements in the discussion:

- Clearances;
- Maintenance access and staging space;
- Spill consequences;
- Accessibility to cranes and hoists; and
- Bonding and grounding of equipment.

During the course of building construction, the various subcontractors will have to install different HVAC and electrical system components. This equipment usually requires a dry, covered place for storage until installation. This location should also provide easy access to the crane or hoist, as the number of movements of the equipment should be minimized. The schedule must be detailed enough to foresee constructability aspects when installing the equipment. Cranes will drop the material in vertically, and field engineers must check the clearances when the crane is in use for both the equipment being lowered into the structure and boom reach over the partially erected building. Once installed, the equipment often requires the use of an environmentally unfriendly material, such as oil or chlorofluorocarbons. The material is usually not placed into the equipment until the equipment is safely installed. The room which the material is installed in is usually designed to contain liquid leakage. Once installed, all equipment should be electrically grounded to help prevent shocks.

e. Discuss the methods and requirements for material protection and storage on the construction site. Include the following elements in the discussion:

- Theft protection;
- Moisture protection; and
- Temperature protection.

One of the first duties of the contractor upon arrival on site is usually the construction of a fence around the project. Most contractors also hire guards for off hour times on the site. The best method of material protection is to have the material delivered to the site just as the material is scheduled for construction. As this is not always possible, a warehouse, sometimes a trailer, is placed on site to store and protect them. Without indoor storage availability, the material should be placed on timbers, elevated from the ground, and covered with a waterproof tarp. A good quality plan will provide for the necessary care and maintenance of permanent equipment.

f. Describe the use and application of various tools and equipment used on a construction project. Include a discussion of specialty tools used for specific applications.

There are thousands of different tools that can be used on a construction project. The use and application of these tools is best left to the professional trades involved in their utilization. On a construction project, it is typically the responsibility of the individual tradesmen to provide these tools and to use them effectively and safely.

g. ***Discuss the characteristics, material strength properties, and service applications for the materials used on a construction project. Include the following elements in the discussion:***

- Sand and aggregate;
- Construction lumber;
- Concrete;
- Back-fill material; and
- Shoring.

Sand is a uniform material used as an ingredient in concrete and as a backfill material. Care must be taken on the storage of sand on the project to keep it dry and free of contamination. The use of wet sand can affect the strength properties of concrete batched on site. Sand is one of the primary ingredients in mortar, and of equal importance in concrete. Larger aggregates provide the main volumetric component in concrete. Larger aggregates can also be used as a backfill material where water drainage is desired.

Construction lumber refers to any wood on the site used for the construction of the project, but not including permanent structural lumber. Wood has a grain, and it follows that the strength properties of wood are dependent upon the loading directions. Wood is attractive and can be fashioned into almost any practical shape. Wood, however, is not as strong as concrete, aluminum, or steel, and thus has limited applications in a commercial or industrial environment as a structural material.

Concrete’s main ingredients are cement, aggregate (including either sand or gravel) and water, although many other items can be added for different requirements. Fly ash, accelerators, colors, fibers (both steel and plastic), and workability agents can be added. The ultimate strength of concrete can range from 1000 pounds per square inch easily up to 5000 pounds per square inch. Some high strength concretes can reach 15,000 ponds per square inch, but quality control is tougher and the material is more expensive.

Shoring is a generic term used to describe any type of structure used to prevent the movement of earth into an excavation. Types of shoring include concrete walls, soil nails, geosynthetics, soldier pile walls, sheet pile walls and shotcrete. The strength depends upon the type of material used and the configuration of the design.

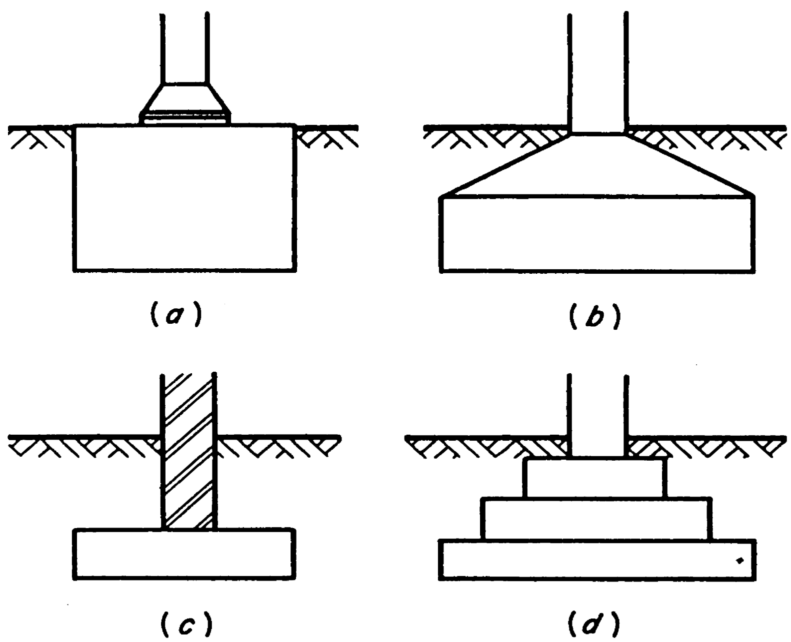
1.16 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of the basic principles and concepts of geoscience as applied to soil, erosion, foundations, and earth embankments.

<u>Supporting Knowledge and/or Skills</u>

a. Identify and describe examples of shallow and deep foundations.[1]

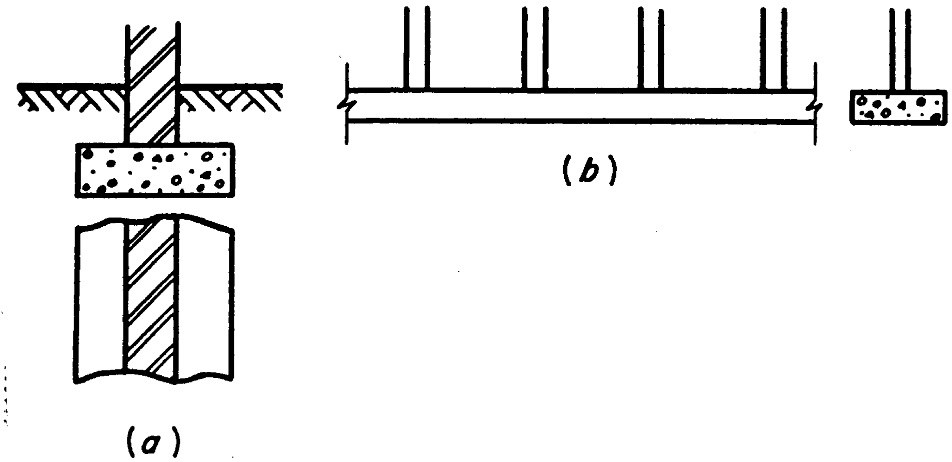
Shallow foundations are those where loads are transmitted to the soil at a depth adjacent to the lowest part of the functional structure. They are grouped into three major categories:

- <u>Pad foundations</u> Pad foundations typically provide support to structural columns. They may consist of a simple circular, square, or rectangular slab of uniform thickness, or they may be stepped or haunched to distribute the load from a heavy column.



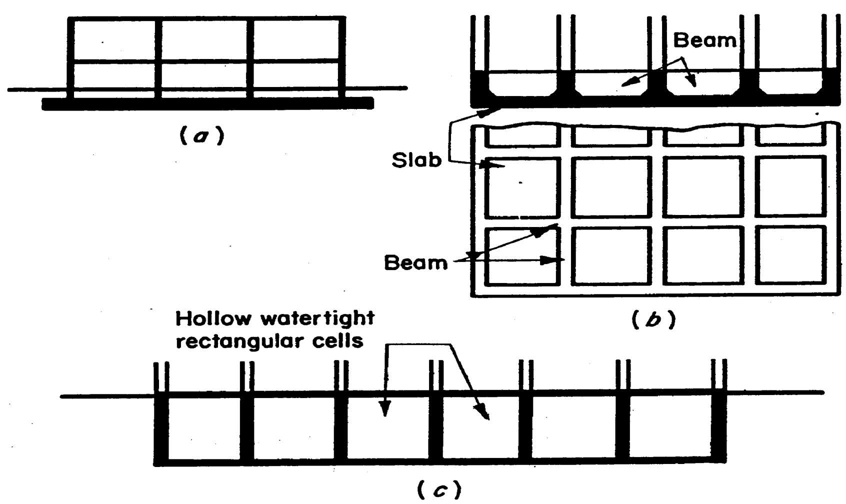
Types of pad foundation. (*a*) Mass concrete for steel column. (*b*) Reinforced concrete with sloping upper face. (*c*) Plain reinforced concrete. (*d*) Stepped reinforced concrete.

- Strip foundations This type of foundation is normally used for load bearing walls and for rows of columns which are spaced so closely that pad foundations would nearly touch each other. This type of foundation typically consists of a strip of concrete which supports a load bearing wall or row of columns.



Types of strip foundation. (*a*) Strip foundation to load-bearing wall. (*b*) Strip foundation to a row of close-spaced columns.

- Raft foundations This type of foundation is required on soils of low bearing capacity, or where structural columns are close in both directions that pads would touch or nearly touch. This type of foundation typically consists of a slab of concrete which supports a load bearing walls or rows of columns.



Types of raft foundation. (*a*) Plain slab. (*b*) Slab and beam. (*c*) Cellular (or buoyancy) raft.

Deep foundation are typically required where the soil at shallow foundation level cannot support ordinary pad, strip, or raft foundations or where structures have the potential to settle under their own weight because they are sited on deep layers which are compressible. Deep foundations are grouped into two major categories:

- Bearing Piles This type consists of long slender columns of wood, steel or concrete driven into the soil.
- Drilled Shafts, Piers, or Caissons This type is typically concrete columns constructed in drilled holes.

b. ***Discuss the basic elements of embankment design.*** [2, 3]

Embankment design incorporates the following major steps:

- Extensive ground investigation to determine foundation and abutment conditions is the first step. Both compressibility of the foundation and embankment materials and shear strength of the foundation and abutment materials must be determined.
- The quality and quantity of available material in potential borrow areas must also be determined. Cost of excavation and transportation of the materials must be considered.
- Design of the embankment foundation is another step in the overall design of the embankment. Based on the analysis of the foundation material, several different approaches may be used. If the foundation is slightly compressible, then monitoring during construction to ensure the proper compression is occurring may be the only action necessary. If compression or shear is more of a potential problem, sand drainage may be provided to greatly accelerate compaction during construction. Finally, relocation or removal of the offensive materials may be required.
- The embankment itself may be designed as a homogenous unit or it may be designed in layers with alternate layers of good compacting material and good draining material. The economics of getting the material to the embankment is a major driver in the design. This will dictate what materials will be used and this in turn dictates the overall construction of the embankment. For example, a poor compacting soil will require a much wider base and more gentle slope than a good compacting soil.

c. ***Define erosion and describe the characteristics and effects of water and wind erosion.*** [2]

Erosion is the process of wind or water wearing away a particular substance.

- Water Erosion. Water erosion results in gullies which have three basic shapes based on the type of ground material. V-shaped gullies typically appear in rock or course textured sediments with fines that impart some cohesiveness. U-shaped gullies will form in materials which cave in easily such as silt or sand deposits.

Finally, saucer shaped gullies are characteristic of cohesive materials containing considerable amounts of clay.

- Wind Erosion. Wind erosion results in the removal of thin sheets of material. This may result in wind scoured depressions, called blowouts. Wind can remove medium and fine sand or silt. Sand can typically only be carried a short distance by the wind while silt may be carried a long way.

d. Describe the types of tests used to determine the strength and dynamic properties of soils.[3]

Strength and dynamic property tests for soils fall into two basic types. Tests for determining the compaction characteristics of the soil and tests which determine the shear strength of soil.

- Compaction testing In general, these tests consist of compacting a number of soil layers with a rammer or vibrating hammer. The number of soil layers, weight of the rammer or vibrating hammer, and number of compacting blows or duration of the hammer test vary from test to test. These tests are performed several times at each set of conditions and then the conditions are varies. The independent variable is typically water content of the soil and the dependent variable is resulting dry density (the density of the soil if all water were removed). The results of dry density versus water content are plotted to obtain the optimum water content value. At low water content most soils tend to be stiff and difficult to compact. As water content increases, soil becomes more workable, facilitating compaction and resulting in higher dry densities up to the point of the optimum water content. As more water is added, the dry density lowers because the water is now a larger portion of the soil volume.
- Shear testing These tests measure the shear strength of soils. One general test is the triaxial test. This test involves placing the specimen under axial load in a rubber sleeve. This results in equal all around pressure on the sides of the specimen, and a deviator stress is applied to the top and bottom of the specimen. The loading is increased until specimen failure occurs. The test can also be run with drainage from the specimen. The goal is to best simulate the field conditions of the soil in the applications which it will be used. Other shear tests have been designed specific materials such as clay or sand. These tests also determine at what point the material will fail under a given set of conditions.

e. Describe the unified soil classification system.

This system is a method for classification of soils. It consists of a two letter code as detailed below. The corresponding letter codes have a qualitative descriptor and a quantitative laboratory criteria.

Primary Letter	Secondary letter
G: Gravel	W: Well graded
S: Sand	P: Poorly graded
M: Silt	M: With non-plastic fines
C: Clay	C: With plastic fines
O: Organic Soil	L: Of low plasticity ($w_L < 50$)
Pt: Peat	H: Of high plasticity ($w_L > 50$)

f. ***Discuss the applicability of active, passive, and at-rest pressures to earth retaining structures.***

An at-rest earth retaining wall structure describes a situation in the field where a retaining structure has not allowed the soil to move. Without movement of the soil, failure criterion do not apply to describe the state of stress. The soil structure can be described, however, by the effective stress of the soil factored by an experimentally determine constant, K_o. Thus, pressures on a earth retaining structure are a factor times the in situ state of stress.

When an earth retaining structure is installed, but not completely rigidly, and the soil is allowed to deform in the direction of the wall, this is called the active pressure state. The active state involves using gravity on the soil mass to contribute to the deformation. Thus, all retaining walls designed through this criteria must be strong enough to overcome the effects of gravity and prevent failure along a surface in the soil stretcher.

The passive state is just the opposite. Gravity, in this deformation situation, is contributing against the direction of strain. This situation is less frequent than the active state, but is a concern when using highly tensioned soil nails to pull the wall toward the soil mass. Because of the effects of gravity, the force required to fail a soil structure in the passive state is much, much higher than the force required in the active state.

[1] Tomlinson, M. J., *Foundation Design and Construction*, 5th Edition, New York, NY.: John Wiley & Sons, Inc., 1991

[2] Woods, Kenneth B., *Highway Engineering Handbook,* First Edition, New York, NY: McGraw-Hill Book Company, Inc., 1960.

[3] Craig, R. F., *Soil Mechanics,* Fifth Edition, London: Chapman and Hall, 1992.

1.18 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of the Department of Energy's design and construction processes.

Supporting Knowledge and/or Skills

a. Discuss the following elements of the Department design process:

•Congressional project approval process (Table 1.18-1)

Table 1.18-1
SUMMARY OF DOE BUDGET FORMULATION/JUSTIFICATION PROCESS

November	Field begins budget preparation
January	Unicall issued to field. Operations Offices issue field b budget guidance to their reporting entities.
March/April	Field reporting entities submit budgets to Operations Offices Operations Offices review budget submissions Field Budget Submissions prepared by all offices that submit this budget to HQ.
April/May	Field Budget Submission due to HQ (AS/CFO). As review Field Budget Submissions, prepare Internal Review Budget (IRB) Submission.
Mid June Through August	Internal Review Budget Submission due to DOE CFO. DOE CFO works with AS to refine and balance the budget within OMB targets. DOE Secretary or designee make final decisions on budget. OMB Budget Submission prepared by CFO/AS.
September 1	OMB Budget Submission due to OMB. OMB works with DOE to refine DOE budget, and balance federal budget within overall targets. President makes final decision on budget. Congressional (a.k.a. President's) budget prepared by DOE/OMB.
Early February	Congressional budget due to Congress.
February-June	Congress holds hearings on the budget.
September 30	Congress appropriates funding or passes continuing resolution.

- **Actual preparation of a conceptual design report**

  CONTENTS. Arrangements, format, and content of the conceptual design report shall be determined by Heads of Field Elements. The following items shall be included as applicable:

  - ◊ Official project number and title;
  - ◊ Project justification;
  - ◊ Detailed description of the project scope;
  - ◊ Performance requirements for the project system or process;
  - ◊ Total estimated cost including individual estimates for each title of design (I, II, and III), construction, standard equipment, uncertainties, and contingencies. Cost estimate methodology and backup details shall be included;
  - ◊ Project design, procurement, construction, and environmental compliance schedules (critical path method schedule is recommended);
  - ◊ Methods of performance for design, procurement, and construction with backup details;
  - ◊ Work breakdown structure;
  - ◊ Requirements and assessments for:

    - Safeguards and security;
    - Energy conservation;
    - Health and safety;
    - Environmental protection (detailed schedule for compliance with National Environmental Protection Act and other environmental review requirements as appropriate);
    - Decontamination and decommissioning;
    - Quality assurance;
    - Maintenance and operation;
    - Telecommunications;
    - Computer equipment; and,
    - Provision for handicapped and fallout shelters.

  - ◊ Analysis of uncertainties, contingencies, and effort required to resolve uncertainties; and,
  - ◊ Conceptual drawings and outline specifications.
  - ◊ Applicable codes, standards, and quality levels.

- **Architect/engineer selection process**

  Architect-Engineer Selection – Selection procedures for architect-engineers (A-Es) shall be in accordance with subpart 936.6, "Architect-Engineer Services," of the Department of Energy Acquisition Regulations. It is emphasized that, prior to the selection procedures, the professional experience and qualifications required for each project are accurately identified, and the evaluation criteria and prerequisites that are developed for each A-E services procurement adequately reflect these requirements. Prior to A-E selection, field office managers must ensure that the project design criteria package is complete and complies with DOE 6430.1.

Traditional Engineering Services - These services which encompass Titles I and II as defined above, are normally performed by architect-engineer firms under DOE prime or subcontract arrangements. To obtain the highest qualified professional services available, Departmental Elements shall comply with the policy and procedure set forth by the Brooks Bill, (40 U.S.C. 471, et seq.); DOE implementing regulations; and OMB Circular A-76. Operating contractors may perform Titles I and II work when it is determined by the field office manager to be in the best interest of the Government and is not a violation of the policy and procedures set forth by the references cited above.

Projects for which the operating contractor might perform design services include those for which the design involves a high degree of interfacing with existing equipment, operations and/or facilities; work is closely tied to ongoing research and development; and/or special expertise and knowledge is required which is generally only available to the operating contractor.

- **Design approval process**

The scheduling of definitive design shall be based upon a detailed analysis of a project and its component parts. Engineering work involved in defining equipment and materials having long-lead procurement time shall be scheduled for early completion, in order that procurement can be initiated prior to the construction contracting when timing would make inclusion of the procurement as part of the contract infeasible. When construction is to be performed under a number of fixed-price contracts or under a cost-plus-fixed-fee contract, construction drawings and related documents should be scheduled in the sequence required for construction operations.

Of major assistance in scheduling the performance of definitive design is the early establishment of detailed schedules of the need for drawings and specifications to support construction and procurement. Such detailed schedules assist in determining engineering manpower requirements and assure that completion of individual documents meet procurement and construction schedules.

Periodic and Final Design Reviews. As a vital part of the overall management of the project, periodic design reviews need to be performed during the preliminary (Title I) and definitive (Title II) design to assure that project development and design are proceeding in an orderly manner; assure that the project will satisfy program and operating objectives; review performance, schedules, and costs; identify potential and real problem areas; and initiate action for timely solutions and corrective measures. Procedures for conducting, monitoring, and controlling these necessary design reviews must be developed by the Heads of the Field Elements. In addition to procedures for design review, Heads of the Field Element shall develop procedures for the distribution and approval of design documents.

Design and Construction Scheduling and Methods of Performance.

(A) Scheduling.

Considerations Pertaining to Performance Time of Contractors and Effects on Cost To the extent possible, schedules for engineering, procurement, and construction services shall be established concurrently to assure assignment of adequate time for performance and to properly coordinate the accomplishment of the services. Construction completion of project elements shall satisfy operating requirements, including time for tests and adjustments prior to operation. If required completion dates do not permit normal performance periods, the available time must be allocated to achieve maximum overall economy, based on a careful determination of the feasibility and cost of performance of each service in less than normal time (i.e., with premium time). Sometimes the total time available may not, by any reasonable allocation, allow completion of all design prior to starting construction. Under such conditions, the design shall be scheduled so that logically separable portions of the work, such as sitework, foundations, superstructure, mechanical, and equipment installation can be awarded as separate contracts, bearing in mind that for maximum effectiveness a contractor should have, subject to security limitations, full control of the area in which he is working. However, it may be necessary to perform both engineering and construction on a cost-plus-fixed-fee basis so that both can proceed concurrently. Where plans involve use of more than one fixed-price contract for construction, special care should be taken to assure that the plans and specifications clearly and completely define the scope of work to be accomplished under each contract. Sequential fixed-price contracts should be scheduled to permit orderly progress and timely completion.

Considerations Pertaining to Performance Times Required to Accomplish Administrative Actions Past experience indicates that schedule delays have occurred on many projects due to the insufficient allowance for the time required to accomplish the administrative functions on the project. In scheduling the work, proper consideration shall be given to the time required for such activities as the selection of the architect-engineer selection of a cost-plus-fixed-fee construction contractor, administrative approval requirements, and bidding and award of fixed-price construction or procurement contract(s). The field office manager shall determine the type and number of architect-engineer contracts to be used and the most appropriate type of contractual arrangements required. During the course of preliminary and definitive design, the field office manager reviews and firms up the preliminary determination as to the type and number of construction-contracts to be used. Field office managers should ensure that realistic times are scheduled for selection of architect-engineer and construction managers, appropriate administrative approvals, and award of procurement and construction contracts. Appropriate procedures and controls shall be established and utilized for the accomplishment of these administrative functions that will ensure on-time completion of these actions.

Use of Logic Diagrams. During the entire process of scheduling, the use of logic diagrams can be extremely helpful to the planner or scheduler to recognize the relationships between the various actions required on a particular project. It must be recognized that perhaps the largest benefit from the use of the performance evaluation review technique (PERT) or critical path method (CPM) can be gained during the early phases of project design. Design decisions and regulatory requirements during the design phase may create considerable changes to the project logic. In some cases, a design or other decisions may have such an effect on the project cost and schedule to require a modification or reversal of the decision. For this reason, the project manager must continually revise and utilize the logic diagram.

(B) Methods of Performance.

General. In determining the manner and method of performance, consideration should be given to constantly evolving innovations which may result in improvements in the traditional methods of design and construction of buildings and facilities required for accomplishment of programs. New techniques and new ways of doing things may provide solutions to new challenges and problems which may arise. New practices should be adopted which will reduce design and construction time; use of other cost saving techniques should be maximized; and new methods of contracting should be considered which will produce economies in construction costs. Use of performance-type specifications may permit the application of new technology and produce improved designs to meet requirements. In adopting any new techniques or methods, care should be exercised to assure that the design criteria are satisfied, and that the results will be achieved without any decrease in desired quality and without any sacrifice in essential requirements. Methods of performance and scheduling must be considered together, comparing the advantages of a method with the effect it has on the schedule and cost. During the design phase of a project, this interaction between these two important actions must be continually considered. Construction contracting and erection methods can greatly affect the design method and sequence and should be determined early in the design phase. Field office managers must ensure that provisions for the above considerations are included in the project management plan.

Cost Estimates. The importance of continual development of the project cost cannot be overemphasized particularly under the current market conditions of rapidly rising costs. Inclusion of "nice to have" features in the design, and failure to consider improved construction methods will contribute to excessive project cost growth. Consideration of cost during design evaluations can limit this growth, as well as facilitate the preparation of the formal cost estimates required during the life of a project. Further information and guidance on cost estimates is contained in Chapter II of this Order and DOE 5700.2C.

b. ***Discuss the Department's construction process following a project's certification for construction. Include in the discussion the difference between direct hire and indirect hire construction contracts, and the role of Department construction management and engineering personnel in the construction process.***

Direct hire construction contract is a contract directly with DOE for construction. Indirect hire construction contract is one which the construction contract is made with a subcontractor to DOE. In either case, department personnel are involved in a management oversight capacity. Direct contact, the issuing of orders or any other contact activity of an official nature would be through the Contracting Officer or Project Manager if granted appropriate authority by the Contracting Officer.

<u>Note</u>: The terms direct hire and indirect hire construction contracts are not defined in any DOE documentation. The terms may not be used at all DOE facilities.

1.26 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of computer applications used in construction management.

Supporting Knowledge and/or Skills

a. Describe the project scheduling system used to track and report project status.

One way to track project status visually would be to plot the completed activities on a gantt bar chart as solid black.[1] The activities yet to be completed will remain in their original colors showing criticality, resources, etc. The computer will then draw a vertical line on the date the report is generated. All the activities to the left of the line should be black, all the activities ahead of the line should be in their original colors. If the black bars surpass the vertical line, the project is ahead of schedule. If some of the bars do not meet the report date's line, the activities described are behind schedule.

Also, the schedule should be cost loaded to a level of detail that matches the level of detail in the construction activities and the original detailed construction estimate. With the cost loaded schedule in hand, the field personnel; will track installed quantities and input them into the schedule as percent completes on each activity. With this data, an earned value report can be created to compare the percentage of the money actually spent with the percentage of the work completed. Only with this level of information, can a project truly be controlled on a proactive basis. The project manager will have instant knowledge of activities that are in both schedule trouble and cost trouble. Without the earned value component, the manager has no way of knowing if the money spent on a given activity relates properly to the amount of work completed.

b. Read and interpret computer generated project reports.

To effectively read computer generated project reports, one has to be familiar with the software that generated the reports.[2]

- Gantt bar charts depict each activity as a bar on a time scaled graph. The bars can be colored to show criticality, and arrows connect them to show logic flow;
- Project networks show each activity as a node, and the arrows that connect the activity have no specified length, but a number is associated with each arrow to show the time estimate for the node preceding it; and
- Time scaled network is much like the project network, but the arrows are time scaled to give a visual element to the chart.
- A time-scaled chart that shows the budgeted cost of work scheduled, the budgeted cost of work performed, and the actual cost of work performed by period. This report should be closely tied with cash flow on the entire project.
- A project health report should be included, showing the Cost Performance Index and the Schedule Performance Index.

There are any number of variations on this theme, as total man-hours can be graphed simultaneously on the chart to show manpower allocation throughout the project. A cost graph can be scaled onto the schedule to show how fast and when the money will be spent to complete the job. One must investigate the power and capabilities of each scheduling program to fully understand every type of output available from such programs.

c. Describe the applications of computer aided design (CAD) and computer aided engineering (CAE) tools.

Almost all drawings generated by designers in today's market are electronic, using either AutoCAD® or Microstation®. These programs provide both a two dimensional environment and a three dimensional environment for design purposes. After market programs give these standard drafting programs the ability to input topographical information, structural information, etc. Computer aided design programs allow the designers to quickly change designs, value engineer and check for clearances. The same programs allow the contractor to evaluate equipment selection, improve safety, and complete constructability reviews.

d. Describe the use of computers in the scheduling of construction projects, including a discussion of what the computer applications can do for the Construction Manager as well as what they cannot do.

Computers and scheduling programs are a potent weapon in the arsenal of project management. The typical construction scheduling program can structure all the time and production and cost data regarding a project. These programs allow the construction manager to impose external dates on the schedule of a project. The programs show effective use of resources such as crews and equipment. The programs can generate intelligent and effective visuals of the schedule. The programs allow the construction manager to play scenarios on the schedule to determine other impacts on the schedule.

Scheduling programs will not, however, solve problems in the schedule. It will not guarantee that a project will get completed on time and on budget. The scheduling program is as good as those who use the program.

e. Describe how the project schedule is used to control cost and schedule as well as track it.

The project schedule is an excellent tool for tracking costs. Every schedule item has associated with it an estimated or budgeted cost, which is linked to the schedule item inside the scheduling software. When the time sheets are submitted from the field and the material costs are submitted from the procurement department, the hard costs of the schedule activity can then be placed into the budget data linked within the scheduling program. This process is repeated for every activity, throughout the duration of the activity. With this data linked in the scheduling program, a good scheduling program can generate graphical outputs which show the relationship of budgeted schedule, actual schedule, budgeted cost and actual cost. The items the scheduling program will plot are

Actual Cost of Work Performed, Budgeted Cost of Work Performed, and Budgeted Cost of Work Scheduled. It is important to include all these items on the graph for it allows informed management decisions to be made for the following reasons:

- Project can be ahead of schedule, below budget. This situation is by far the best situation;
- Project can be ahead of schedule, above budget. The project may not be in jeopardy yet, as more work has been completed than expected, so more money could have been spent to achieve this extra work. What the graphical representation that a scheduling program can generate can do for the cost control engineer, is tell him if the project has spent too much to achieve the faster schedule; and,
- Project can be behind in the schedule, above budget. The project schedule will tell by how much the project is in jeopardy.

[1] Primavera Project Planner: *Getting to Know P3*, *Primavera Systems*, Bala Cynwyd, PA, 1991.
[2] Moder, Joseph J., Phillips, Cecil R., Davis, Edward W., *Project Management with CPM, PERT and Precedence Diagramming*, 3rd ed., Van Nostrand Reinhold, New York, NY, 1983.

1.27 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of the systems for industrial waste treatment, storm drains, and sanitary waste treatment.

Supporting Knowledge and/or Skills

a. Describe the basicdesign for a sanitary waste treatment system.

Basic Design for a Sanitary Waste Treatment System:

- Screening to remove large floating debris;
- Settling tank to allow heavier material to settle out of water;
- Aeration filter to convert organic waste into stabilized sludge;
- A second settling tank is then used to allow the raw sludge to settle out, the raw sludge is removed for disposal;
- A chlorinator is used on the effluent from this second settling tank to eliminate pathogens;
- The sludge is put through an anaerobic digester to stabilize the sludge; and
- The sludge is then dewatered prior to disposal.

b. Discuss the following methods of waste water treatment:

- Primary
- Secondary
- Tertiary

Primary Waste Water Treatment - Screening removes the large floating debris. The sedimentation or clarifier removes the sludge and heavier solids.

Secondary Waste Water Treatment - Aeration stabilizes the waste stream. Sedimentation a second time removes the remainder of the sludge. Chlorination treats the effluent to meet disposal limitations. Trickling filter or anaerobic digester stabilizes the sludge stream. The final step is dewatering sludge prior to disposal.

Tertiary Waste Water Treatment - Considered advanced treatment. Nitrogen and Phosphorus removal systems.

c. Discuss the functions of the following components:

- Clarifier
- Trickling filters
- Pumping station
- Wet well

Clarifier – Clarifier or sedimentation tank is to allow heavier material and raw sludge to settle out of the waste stream, oil/grease is skimmed off the top.

Trickling Filters – Liquid wastewater is sprayed over a bed of rocks or other media to allow a layer of biological slime (mainly bacteria) to absorb and consume the waste.

Pumping Station – The nexus where all sources of the waste water meet to enter the waste water treatment system.

Wet Well – A well in close proximity to a disposal system to ensure that no untreated sewage is entering the groundwater system.

d. Discuss the methods and requirements for solid waste disposal associated with sanitary waste treatment systems.

The digested and dewatered sludge is potentially useful as a soil conditioner, that is a fertilizer. It is commonly disposed of in a sanitary waste landfill as solid waste.

e. Discuss the construction and installation requirements for sewers and force mains.

Sewers and force mains shall be either clay or concrete. All sewer pipe shall be perforated, except where the pipe is imbedded in concrete and where otherwise specified. Perforated pipe drains shall be placed on a lean concrete pad and shall be covered with a crushed-rock or gravel bedding and sand filter material.

f. Discuss the installation and construction requirements for storm drain and sewer main piping that pass under a security barrier.

A security barrier may be constructed of metal bars or grates preventing ingress into the sewer piping. The piping must be reinforced to be able to hold the metal barrier as well as the increased force of the water due to increased obstruction.

g. Discuss the hydraulics associated with the following:

- Runoff into storm sewers
- Open channels
- Street drainage

Runoff into storm sewers – Streamlines of flow of runoff into storm sewers are turbulent and vertical to the flow in the enclosed conduits receiving the runoff, creating non-steady state flow velocities. The static head of the flow entering the storm sewers is converted to kinetic energy, which manifests as high velocities, which if impeded result in large pressures.

Open channels– Streamlines of flow in an open channel are parallel and velocities at all points in a cross-section are equal to the mean velocity. Depending on the depth of the open channel, certain relationships exist between the specific energy at the bottom of the channel and the depth as well as between that energy and the discharge, varying between critical and subcritical flow.

Street drainage– Streamlines of flow in street drainage tend to be similar to open channels, depending on depth of the drainage.

2.1 Construction management and engineering personnel shall demonstrate the ability to evaluate contractor compliance with Department of Energy (DOE) Order 6430.1A, General Design Criteria.

a. Discuss the use of the General Design Criteria in the identification of construction design requirements at defense nuclear facilities.

These criteria provide mandatory, minimally acceptable requirements for facility design. The predominant model building code in the region shall govern on issues not covered in these criteria.

State, municipal, county, and other local building and zoning codes and ordinances should be reviewed for possible conflicts with these criteria. While it is not mandatory that DOE projects comply with such local codes and regulations, the design professional is encouraged to cooperate with local officials and DOE personnel to accommodate the intent of local codes and regulations as much as possible.

b. Discuss the purpose, scope and application of the construction requirements detailed in the General Design Criteria.

The purpose is to provide General Design Criteria (GDC) for use in the acquisition of the Department's facilities and to establish responsibilities and authorities for the development and maintenance of these criteria.

The provisions of General Design Criteria apply to all Departmental Elements except as otherwise provided by statute or by specific delegation of authority from the Secretary of Energy, and all contractors and subcontractors performing work for the Department whose contract may involve planning, design, or facility acquisitions. This includes DOE-owned, -leased, or -controlled sites where Federal funds are used totally or in part, except where otherwise authorized by separate statute or where specific exemptions are granted by the Secretary or his designee.

The GDC is applicable to all facilities which are to be reported in the Department's Real Property Inventory System (RPIS), or in the General Services Administration's annual "Summary Report of Real Owned by the United States Throughout the World." The GDC is not intended to provide complete coverage for the diverse facilities in the DOE Complex. Specific project criteria and/or specifications need to be developed to satisfy the needs for a particular facility, incorporating applicable requirements of these general design criteria and supplemented with required criteria from applicable codes and standards. There is no intent that the GDC take precedence over other criteria, where those criteria meet or exceed the GDC requirements. Where there exists a conflict between those criteria and the GDC provided by this Order, however, the GDC governs.

c. Discuss what constitutes acceptable contractor performance in the General Design Criteria.

Contractor performance is considered acceptable if applicable Executive Orders, Federal laws, and regulations are satisfied. Best industry practices are used as a basis as well as a graded approach to ensure value and cost are balanced with the risks.

Determinations regarding the acceptability of design should include comparison with existing safety basis information, if available. All new construction shall, as a minimum, conform to the Model Building Codes applicable for the state or region, supplemented with additional safety requirements associated with the hazards in the facility in a graded manner.

Guidance associated with the Orders are not mandatory requirements. The guidance provided in implementation guides and standards referenced therein are acceptable methods to satisfy the requirements of this Order. Alternative methods that satisfy the requirements of the Order are also acceptable. Any implementation method selected must be justified to ensure that an adequate level of safety commensurate with the identified hazards is achieved.

d. Discuss the relationship between industry construction standards and the General Design Criteria.

There is a direct relationship between the General Design Criteria and recognized industry standards. Whenever possible, no changes in these standards were made and the standards were referenced as the requirements. The GDC is essentially a reference document to identify what the requirements are or what source document should be used as the standard.

e. Using the design packagefor a system, civil or structural application, determine the design criteria requirements for the system, components or structure.

DOE Order 6430.1A, General Design Criteria, identifies the requirements. The following types of requirements are used in the order:

- Regulatory requirements (CFRs, Congressional Acts, DOE Orders and Directives; and Executive Orders)
- Recognized national consensus standards such as ACI, ANS, ASHRAE, ASME, NFPA, UL etc.

The main topics are:

- Site and Civil Engineering;
- Concrete;
- Masonry;
- Metals;
- Wood and Plastics;

- Thermal and Moisture Protection;
- Doors and Windows;
- Finishes;
- Specialties;
- Equipment;
- Furnishings;
- Special Facilities;
- Conveying Systems;
- Mechanical Systems; and
- Electrical Systems.

The applicable sections identified above as well as section 1 of the order should be reviewed as a starting point. The sections in the order will provide specific guidance and in most cases refers the requirements to the industry standard. When the industry standard is referenced, the most recent version is to be used.

In addition, per DOE O 420.1, all new construction shall, as a minimum, conform to the Model Building Codes applicable for the state or region, supplemented with additional safety requirements associated with the hazards in the facility in a graded manner.

f. Discuss what constitutes a safety-class item as defined in the General Design Criteria.

Safety class items are systems, components, and structures, including portions of process systems, whose failure could adversely affect the environment or the safety and health of the public. Specifically, safety class items are those systems, components, and structures with the following characteristics:

- Those whose failure would produce exposure consequences that would exceed the guidelines in Section 1300-1.4, Guidance on Limiting Exposure of the Public, at the site boundary or nearest point of public access;
- Those required to maintain operating parameters within the safety limits specified in the OSRs during normal operations and anticipated operational occurrences;
- Those required for nuclear criticality safety;
- Those required to monitor the release of radioactive materials to the environment during and after a Design Basis Accident (DBA);
- Those required to achieve and maintain the facility in a safe shutdown condition; and,
- Those that control the safety class items described above.

There are three Safety Class levels that are assigned to items (components, systems, or structures) that must be designed to provide specific functions to protect operators, the public, or the environment. These levels are as follows:

SC-1: Provides function and/or structural integrity for mitigation of event severities up to and including DBAs.

SC-2: Provides function and/or structural integrity for mitigation of event severities up to and including Operating Basis Accidents (OBAs).

SC-3: Provides function and/or structural integrity for mitigation of event severities up to and including Uniform Building Code (UBC) and those that are industrial safety related.

g. Evaluate local compliance with the following construction site preparation criteria in the General Design Criteria.

- Site development;
- Surveying;
- Site preparation; and
- Earthwork.

The following information was taken out of DOE Order 6430.1A, General Design Criteria.

Site Development

The selection of sites for new facilities shall comply with DOE O 430.1, LIFE-CYCLE ASSET MANAGEMENT. Site development and facility utilization planning shall comply with DOE O 430.1. Site development planning for energy management shall comply with DOE/MA 0129. A site development plan shall be used to locate new facilities on existing or new sites to assure effective site utilization and to preclude future conflicts between existing and new facilities.

During site selection for new facilities the following conditions and requirements shall be considered:

- Programmatic and operating efficiency;
- Natural topographic and geologic conditions;
- Existing cultural, historic, and archeological resources;
- Endemic plant and animal species;
- Existence of known RCRA and/or CERCLA sites;
- Special siting requirements for facilities containing, using, or processing hazardous materials;
- Health, safety and environmental protection requirement;s
- Indoor air quality impacts (e.g., presence of radon in foundation soils, building materials that off-gas irritating chemical vapors and the need to "bake out" new buildings prior to occupancy);
- Hazardous operations and consequences of potential accidents in adjacent facilities;
- Natural hazards including seismic activity, wind, hurricane, tornado, flood, hail, volcanic ash, lightning and snow;
- Wave action within any natural or man-made body of water (in accordance with CERC Shore Protection Manual);
- Physical protection requirements;
- Security and safeguard requirements;
- Adequacy of existing or planned support and service facilities, including utilities, roads, and parking areas;
- Interrelationships between facilities and aesthetic compatibility;
- Energy conservation requirements; and
- Impact of site selection.

Location analyses performed during the preparation of Conceptual Design Reports (CDR)s shall consider but not be limited to these same criteria. The NEPA/DOE O 451.1 require the preparation of an environmental assessment prior to the initiation of a government action that may significantly affect the environment. These requirements shall be considered during facility siting.

To the extent possible, facility siting shall preclude the use of floodplains or areas subject to flash floods and shall minimize destruction, loss, or degradation of wetlands.

Radiological Siting Requirements

Radiological siting requirements shall be considered during site selection and facility planning efforts.

For those facilities in which radioactive materials are processed, used, or stored, or those facilities that incorporate radiation-producing machines, the acceptability of the site shall be evaluated in terms of potential radiological consequences. The accidents to be considered are those attributable to both operational events (determined by using a deterministic and/or a probabilistic approach) and natural phenomena as applicable to the facility and the site.

For a deterministic analysis, events to be analyzed are those judged to have maximum consequences based on technical review of the specific facility design and related radiological processes. For a probabilistic analysis, events to be considered are those events whose annual probability of occurrence exceeds 10^{-6} These analyses provide the basis of judgment for selection of one site over alternative sites and for overall risk of operation of the facility.

Radiation dose to an off-site individual receiving maximum exposure shall be evaluated. For both on-site and off-site individuals, emergency response planning shall be an important criterion in determining the acceptability of a site. Dose refers to dose equivalent in rem from exposure to radiation directly received by the body from an external source and/or from radioactive materials taken into the body by inhalation or ingestion. Dose shall be calculated and compared to the dose guidelines established below. Comparisons shall be based on a 50-year committed effective dose-equivalent. The off-site individual receiving the maximum dose shall be assumed to be located at the point of highest concentration (or highest exposure rate) outside the boundary controlled by the site. Meteorological conditions used in dose calculations shall be representative of unfavorable dispersion, determined by comparing the 0.5 percent dispersion factors (X/Q) for each sector to the 5-percent overall site X/Q and selecting the highest value. The dose assessment shall consider both the duration of the event and, consistent with emergency response capability to control or evacuate individuals, the duration of exposure. The duration of exposure should not exceed two hours. The dose calculated shall be compared to the numerical guidelines below.

Consideration shall be given to on-site individuals. Prudent measures associated with the radiological protection of on-site personnel and in conjunction with the on-site emergency response planning, as required through implementation of DOE O 151.1, shall be incorporated into the design and siting of a new facility.

Information on the siting evaluation, including the models, parameters, and assumptions used in the dose calculations shall be documented for use in the facility's SAR and emergency response plans. See O 451.1 and DOE 5481.1B.

Radiological Siting Guidelines

The following siting guidelines apply to off-site individuals receiving maximum dose from exposure to internally-deposited radioactive materials and/or to radiation from external sources. Guidelines are based on a 50-year committed dose equivalent.

The maximum calculated dose shall not exceed 25 rem to the whole body, 300 rem to the thyroid, 300 rem to the bone surface, 75 rem to the lung, or 150 rem to any other organ. If multiple organs receive doses from the same exposure, the effective dose equivalent from all sources shall not exceed 25 rem when calculated by using the International Commission on Radiological Protection (ICRP) Report No. 26 weighting factors.

These siting guidelines apply to nonreactor nuclear facilities. Siting and design criteria for nuclear reactors appear in DOE 5480.6.

The use of doses as set forth in these guides is not intended to imply that these doses constitute acceptable limits for emergency doses to the public under accident conditions. Rather, these are reference values that can be used in the evaluation of facility design in combination with the suitability of the site with respect to accidents having a low probability of occurrence and low risk of public exposure to radiation.

When calculating these doses, degraded performance of Engineered Safety Feature (ESF) and administrative controls shall be assumed unless they can be clearly shown to be unaffected by the accident (capable of performing their safety function) by proper design, installation, testing, and maintenance according to prescribed standards.

Guidance for implementing the criteria of the Radiological Siting Requirements, is available in LANL LA-10294-MS. However, this guidance does not apply to high-level waste repositories with respect to earthquake siting and design.

Surveying

Construction, control, property and topographic surveys shall be coordinated with the cognizant DOE authority. Where feasible, surveying support available from DOE contractors shall be used. Survey field notes shall be legibly recorded on standardized (8-1/2 inch x 11 inch) field note forms. Field notes and final plots of surveys shall be furnished to the cognizant DOE authority. Any boundary surveys and recorded maps shall be forwarded to the DOE Operations Office.

The degree of accuracy for construction, control, property, and topographic surveys shall be consistent with the nature and importance of each survey. Where required by law (i.e., applicable State statutes) all control and property surveys at DOE sites shall be performed by, or under the supervision of, a professional land surveyor registered in the State in which the subject site is situated.

Horizontal And Vertical Control

Each DOE Facilities Engineering Group shall be responsible for establishing, recording, and perpetuating primary on-site horizontal and vertical control monumentation. Each DOE Operations Office shall also be responsible for correlating primary site-specific horizontal and vertical control monumentation with that of other agencies such as the National Geodetic Survey (NGS, formerly the U.S. Coast and Geodetic Survey [C&GS]). Primary horizontal control monumentation shall comply with National Oceanic and Atmospheric Administration (NOAA) NGS Special Publication 247. Primary vertical control monumentation shall comply with NOAA Manual NOS NGS 1 and NOAA Manual NOS NGS 3. All geodetic control networks and surveys shall comply with Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks.

Temporary on-site horizontal and vertical control monumentation shall comply with American Congress on Surveying and Mapping (ACSM) Horizontal Control as Applied to Local Surveying Needs and with NOAA Manual NOS NGS 3.

Temporary Control Monuments

Where the scope and complexity of the project warrants, the placement, number and location of temporary horizontal and vertical control monuments in new development areas shall be coordinated with and approved by the cognizant DOE Facilities Engineering Group.

A minimum of two inter-visible control monuments shall be placed along or adjacent to right-of-way lines. These temporary control monuments shall be tied by a Grid Bearing, ground distance and elevation to a third permanent survey monument or temporary control monument. The surveyor setting such monumentation shall submit legible notes, drawings, and reproducible documentation to the DOE Facilities Engineering Group. The location and description of all temporary control monuments in the immediate vicinity of new construction shall be provided on construction drawings.

Temporary control monuments shall be 5/8-inch diameter mild steel bars or 3/4-in diameter iron pipe with a minimum length of 2 feet. In loose sand or unstable soil, such temporary control monuments shall have a minimum length of 3 feet. With written approval from the cognizant DOE Facilities Engineering Group, manhole rims, markings chiseled in concrete, PK nails in asphalt, and lead and tack in bedrock or concrete shall be suitable alternative temporary control monuments.

Temporary control monuments shall be set flush or within 0.2 feet of the ground surface.

All temporary control monuments shall have a cap or permanent tag bearing the assigned monument identification numbers as identified in the survey field notes and as shown on the design drawings or other related documents.

Three guard posts with reflective paint striping shall be installed adjacent to temporary control monuments in high traffic areas to preclude vehicular damage.

Temporary control monuments shall be set in conformance with the accuracy standards and specifications for Class 3 surveys or more accurately (Table 2.1-1).

This table is taken from ASCM Horizontal Control as Applied to Local Surveying Needs. These standards and specifications apply to surveys in areas where control is closely spaced (one or two miles, or less); however, these standards and specifications may be applied to surveys where control is more widely spaced with precision field operations.

Table 2.1-1 Suggested Standards and Specifications for Local Surveys***			
	Class 1	**Class 2**	**Class 3**
Position Closure	1:15,000	1:10,000	1:5,000
Angles Accurate to	5 sec.	7 sec.	14 sec.
Distances Accurate to	0.002 ft.	0.004 ft.	0.007 ft.
(per 100 feet)	(1:50,000)	(1:25,000)	(1:15,000)
Rejection limit or spreads between D & R and sets	5 sec.	5 sec.	10 sec.
Number of positions or sets			
1" Instrument	4 Pos.	4 Pos.	2 Pos.
10" Instrument	1 Set 6DR	1 Set 6DR	1 Set 2DR
20" Instrument	2 Sets 6DR	2 Sets 6DR	2 Sets 4DR
30" Instrument	3 Sets 6DR	3 Sets 6DR	1 Sets 6DR
1' Instrument		1 Set 8DR	
Azimuth Closure	8" N* 1/2	10" N* 1/2	30" N* 1/2
Azimuth Closure per angle point	3 Sec	5 Sec	10 Sec
Number of Repetitions (distance measurements)	1	1	1
Taping Criteria Temperature	Accurate to +2 degrees F	Accurate to +3 degrees F	Accurate to +6 degrees F
Tension	Accurate to +1# of standard	Accurate to +1# of standard	Accurate to +1# of standard
Calibration	**	**	**
Type of Target	Fixed	Fixed or Fixed	Plumb Bob String

(1) It is recommended that 30" transits not be used for Class 1 and 2 surveys.
(2) *N = Number of angle stations carrying azimuth. The smallest value for the azimuth closure criteria will apply;
(3) Fractions of a full tape length must be checked;
(4) Properly calibrated electronic distance measuring equipment may be used in place of metal tapes;
(5) Points observed from primary traverses shall conform within reason to the required accuracy for the primary traverse. The accuracy of the observations will depend on the type of point observed. Whenever indefinite points, such as fence corners, tree stumps, etc., are involved, the best approximation of the center or specific point previously described should be observed. Each angle should be observed 2DR, and the spread between the D and R observations should not exceed +20"; and,
(6) Tension applied should be same used to standardize or calibrate tape.

**Standardized tape or one calibrated with a standardized tape.

***Horizontal Control at Applied to Local Surveying Needs, American Congress on Surveying and Mapping 5200. Permanent survey monuments shall be considered to have zero positional error when used as reference for the placement of control monuments for construction, but should be checked with at least one other monument at the time construction control is set.

Permanent Survey Monuments

The placement, number and location of permanent survey monuments for horizontal and vertical control shall be coordinated with and approved by the cognizant DOE authority. The location and description of the nearest permanent survey monument shall be provided on construction drawings. These monuments shall be tied by Grid Bearing, ground distance and elevation to the applicable State Plane Coordinate System and referenced to National American Datum (NAD) of 1983 and the National Geodetic Vertical Datum (NGVD) of 1929.

Any surveyor that sets a permanent survey monument shall submit legible notes, sketches, or other reproducible documentation that show the location of the new monument relative to the on-site horizontal and vertical control network, to the applicable State Plane Coordinate System, to the NAD of 1983 and to the NGVD of 1929. The convergence, scale factor, and elevation at the monument shall also be provided.

A description of the surveying equipment and procedures used to establish the new monument shall accompany copies of all field notes, calculations, reductions, and closures. Similar information shall be submitted for any found monuments. Permanent survey monuments shall be considered properly positioned and represented only after the DOE Operations Office has approved all survey procedures and calculations and has verified conformance to standards and specifications for Class 2 surveys (see Table 2.1-1 above) or greater.

Table 2.1-1 shall apply to surveys in areas where control is closely spaced (one or two miles or less); however, these standards and specifications may be applied to surveys where control is more widely spaced with precision field operations. Permanent survey monuments shall be identified with a metal cap or disk set in a 2-inch diameter pipe with flared ends at the bottom. Identification numbers, as approved by the DOE Operations Office, shall be permanently stamped into the metal cap or disk.

These identification numbers shall be documented within the survey field notes and shown on the design drawings and within related documents. Tentative point identification for permanent survey monuments may be assigned by the surveyor; however, permanent point identification shall only be assigned to such monuments by the DOE Operations Office.

Permanent survey monuments shall not be removed without prior authorization from the cognizant DOE Operations Office.

Bench Marks

A minimum of one permanent bench mark for vertical control shall be established in each new development area. A minimum of three bench marks shall be established if there are no existing bench marks within a 3-mile radius of each new development area. Additional bench marks may be established, as necessary, with prior approval of the cognizant DOE

Facilities Engineering Group. Bench marks may coincide with permanent survey monuments or temporary control monuments.

Bench mark elevations shall be referenced to the NGVD of 1929.

Level section misclosures between fixed bench mark elevations shall equal or exceed Third Order Accuracy, as defined in FGCC Standards and Specifications for Geodetic Control Networks (Table 2.1-2).

Table 2.1-2
Accuracy Standards for Level Closures

First Order*	Second Older*	Third Order*
0.017 ft M 1/2	0.035 ft M 1/2	0.05 ft M 1/2

* M is the distance in miles of the total level route running forward and back between fixed elevations or along a level loop.

Source: Standards and Specifications for Geodetic Control Networks, Federal Geodetic Control Committee, 1984.

Legible level notes and calculations shall be submitted to the cognizant DOE Facilities Engineering Group for approval.

Permanent bench marks shall be identified with a metal cap or disk as specified in Permanent Survey Monuments above.

Permanent bench marks shall not be removed without prior authorization of the cognizant DOE Operations Office. The location and description of all bench marks in the immediate vicinity of new construction shall be provided on construction drawings.

Surveys For Utilities, Roads, And Parking Areas

Coordinates and elevations shall be determined for utilities, roads and parking areas at their principal points of definition. This information shall be provided on the construction drawings. The principal points of definition for utility systems shall include utility poles, obstructions, manholes, valve boxes and other appurtenances for heating and cooling lines, sewers, and overhead and underground power and telephone systems. Principal points of definition for potable water and natural gas distribution systems shall be valve boxes, main line intersects and fire hydrants.

The principal points of definition for roads shall be roadway centerline intersects. Road alignment surveys shall include stationing, bearings and curve information tied to these principal points of definition. Where applicable, the following information shall also be provided on the construction drawings:

- Stations and deflection angles for each point of intersection Right-of-way lines and markers;
- Spot elevations (centerline, edge of pavement, and at intersects) at minimum intervals of 100 feet;
- Pavement width;
- Other improvements (e.g., drainage inlets, wheelchair ramps, fire hydrants, sidewalk, curb and gutter);
- Topographic features within the project limits;
- Elevation contours;
- Overhead and underground utility crossings (plan and profile);
- Roadway drainage crossings; and,
- Location and description of underground utility witness markers.

Surveys For Existing Underground Utilities

Where exact routes of underground utilities are not defined within record drawings and such information is essential to subsequent design efforts, the cognizant DOE Facilities Engineering Group shall coordinate necessary electronic line detection and exploratory excavation activities. Such utilities shall be located by survey and documented on the construction drawings.

Site Preparation

Local topography shall be considered during project and facility design efforts. New facilities shall be planned to fit with the local topography and require a minimum amount of grading.

Design shall include provisions for erosion control and soil stabilization in ditches, fill slopes, embankments, and denuded areas, and restoration of areas disturbed by the project to original or improved conditions.

Site preparation design shall comply with the following criteria:

- Site drainage design shall comply with Section 0270 of DOE Order 6430.1A, Sanitary Wastewater Collection and Storm water Management Systems;
- Vehicle parking, sidewalks, and road requirements shall comply with Section 0250 of DOE Order 6430.1A, Paving and Surfacing;
- Landscaping shall comply with Section 0290 of DOE Order 6430.1A, Landscaping;
- Site grading design shall comply with Section 0250, Paving and Surfacing, and Section 0270 of DOE Order 6430.1A, Sanitary Wastewater Collection and Storm

water Management Systems;
- Site power and lighting shall comply with Section 0276 of DOE Order 6430.1A, Power and Lighting; and,
- Security requirements shall be taken into account and provided for in accordance with the requirements set forth in the DOE 5632 series. See Section 0261 of DOE Order 6430.1A, Physical Protection, for additional requirements.

Earthwork

Earthwork includes excavating, filling, stabilizing, and compacting earth at the site. Earthwork includes the addition of borrow and disposal of excavated material.

Subsurface Data

Prior to earthwork design, the design engineer shall confer with the soils engineer to define subsurface investigation recommendations required in accordance with Section 0201 of DOE Order 6430.1A, Subsurface Investigations. Subsurface investigations shall be performed under the direction of a qualified soils engineer. In earthquake-prone areas, appropriate geological investigations shall be made to determine the contribution of the foundation (subsurface) to the earthquake loads imposed on the structure and shall include, but not be limited to, a recommendation of foundation type, determinations of allowable soil bearing design capacity, and the possible effects of seismic activity on the soil mass. A settlement analysis under differential design loads shall be performed where differential settlement may cause structural or architectural damage.

Design

The earthwork design and specification shall comply with the recommendations in the project subsurface investigation.

h. Evaluate local compliance with the following construction project structural criteria in the General Design Criteria.

- Shoring and underpinning
- Building foundations
- Concrete
- Structural steel
- Wood structures
- Thermal and moisture protection

The following information was taken out of DOE Order 6430.1A, General Design Criteria.

Shoring and Underpinning

All shoring and underpinning shall comply with the safety requirements of 29 CFR 1926, Subpart P.

Shoring Systems

Tiebacks analysis of plastic yielding in strutted excavations, analysis of the stability of the bottom of excavations, and shoring for deep excavations shall comply with Scaffolding, Shoring, and Framing Institute (SSFI) SH 300.

Underpinning

Remedial underpinning shall be performed where existing foundations are inadequate. Precautionary underpinning shall be performed where new construction adjacent to an existing structure requires deeper excavation.

The services of a structural engineer specializing in underpinning shall be used to perform any underpinning design, which shall comply with the principles in Winterkorn and Fang, Foundation Engineering Handbook.

Building Foundations

Building foundations shall be designed in accordance with the requirements of the UBC and ACI 318.

Foundation Design Criteria

General

Based on preliminary information concerning the purpose of the structure, foundation loads, and subsurface soil conditions, the design professional shall consider alternative types of foundations for the bearing capacity and total and differential settlements.

Adverse Subsurface Conditions

One of the following procedures shall be used to ensure satisfactory foundation performance where poor soil conditions are encountered:

- Bypass the poor soil by means of deep foundations extending to or into a suitable bearing material;
- Design structure foundations to accommodate anticipated differential settlements;
- Remove the poor material, and either treat and replace it or substitute good compacted fill material; and,
- Treat the soil in place before construction to improve its properties.

Where reasonable alternative design foundation types are possible, preliminary designs shall be prepared for the purpose of detailed cost comparisons. These preliminary designs shall be sufficiently complete to determine the approximate size of footings, length and number of piles required, etc. The behavior of existing foundation types in the immediate vicinity to those proposed shall be ascertained during preliminary design. The long-term effects of subsurface conditions (bearing capacity and settlement) on each foundation type shall be considered.

Cost Estimates And Final Selection

Final foundation design shall not be initiated until the evaluation and cost comparison of the proposed alternatives have been completed. On the basis of tentative designs, the cost of each promising alternative shall be estimated. Estimate sheets shall include items, dimensions, quantities, unit material and labor costs.

Concrete

Concrete for building foundations shall be designed in accordance with Section 0330 of DOE Order 6430.1A, Cast-In-Place Concrete.

Cast-In-Place Concrete

Coverage

This section covers the selection of materials, proportioning of mixes, mixing, placing, testing, and quality control of cast-in-place concrete.

Materials, Testing, And Quality Control

Materials, testing, and quality control for cast-in-place concrete shall comply with ACI 318 for buildings and other structures, with the AASHTO HB-13 for highway structures, with the AREA Manual for Railway Engineering (Fixed Properties) for railway structures, and with ACI 349 for special facilities.

Tolerances for formed concrete shall be as suggested in ACI 347.

Selecting Proportions For Concrete Mixes

Normal, Heavyweight, and Mass Concrete

The selection of proportions for concrete mixes for normal, heavyweight, and mass concrete shall comply with ACI 211.1.

Structural Lightweight Concrete

The selection of proportions for structural lightweight concrete shall comply with ACI 211.2.

Mixing, Transporting, And Placing

The mixing, transporting, and placing of cast-in-place concrete shall comply with ACI 304.

Climatic Considerations

Hot weather concreting shall comply with ACI 305R. Cold weather concreting shall comply with ACI 306R.

Post-Tensioned Construction

In addition to the provisions of Section 0330-2, Materials, Testing, and Quality Control, the PTI Post-Tensioning Manual may be used for the design and construction of post-tensioned concrete structures.

Pier-And-Beam Foundations

Grade beams shall comply with ACI 318. Piers shall comply with ACI 336.3R.

Pile Foundations

Pile foundations shall comply with the UBC and ACI 543R.

Ribbed-Mat Slab Foundations

Ribbed-mat slabs shall comply with ACI 336.2R.

Structural Steel

Buildings And Other Structures

Structural steel for buildings and other structures shall comply with the following:

- Uniform Building Code (UBC)
- American Institute of Steel Construction (AISC) S326
- AISC M011

Light-Gauge Steel

Light-gauge steel shall comply with American Iron and Steel Institute (AISI) Specifications for the Design of Cold-Formed Steel Structural Members.

Pre-Engineered Metal Buildings

Pre-engineered buildings shall comply with MBMA Metal Building Systems Manual and Section 0111, Structural Design Requirements.

Where the use of the design loadings specified in Section 0111, Structural Design Requirements, would prevent procurement of pre-engineered metal buildings, consideration may be given to deviation from said loadings. Such consideration shall be based on review of the type of occupancy and functional requirements of the particular building and a determination as to whether such deviation could be justified and permissible in accordance with, Criteria Deviations.

Steel Cables

Steel cables shall comply with AISI Manual for Structural Applications of Steel Cables for Buildings.

Steel Water Tanks, Standpipes And Reservoirs

Steel water tanks, standpipes and reservoirs shall comply with NEPA 22 and American Water Works Association (AWWA) D100.

Fuel Storage Tanks

Fuel storage tanks shall comply with American Petroleum Institute (API) 650.

Highway And Railway Structures

Steel highway structures shall comply with the American Association of State Highway and Transportation Officials (AASHTO) HB-13.

Steel railway structures shall comply with the American Railway Engineering Association (AREA) Manual for Railway Engineering (Fixed Properties).

Transmission Towers

Transmission towers for electrical power lines shall comply with American Society of Civil Engineers (ASCE) 52.

Antenna Towers

Antenna towers shall comply with the National Telecommunications and Information Administration (NTIA) Manual, Chapter 5. Towers not covered in that manual shall comply with Electronic Industries Association (EIA)-222-D.

Transmission Pole Structures

Transmission pole structures shall comply with ASCE 1978-1.

Antenna Poles And Masts

Antenna poles and masts shall comply with TM 11-486-5.

Wood Structures

Buildings And Other Structures

Wooden buildings and other structures shall meet the requirements of the UBC.

Highway And Railway Structures

Wooden highway structures shall meet the requirements of the AASHTO HB-13.

Wooden railway structures shall meet the requirements of the AREA Manual for Railway Engineering (Fixed Properties).

Thermal and moisture protection

Section 7 of DOE Order 6430.1A provides detailed guidance on thermal and moisture protection.

Waterproofing shall be used at walls, floors, or other building elements that at any time are subject to hydrostatic pressure, are below the water table, or are liable to be immersed in water.

Waterproofing shall also be used at walls, floors, and other building elements to prevent water leakage from showers, built-in refrigerators and freezers, areas using water wash-down containment areas, and other types of water basins.

Where water is to be contained, waterproofing shall extend up walls to above the expected high water level.

Where water wash-down is used, waterproofing shall extend to fully cover the expected wall areas to be washed.

Wall, floor, slab-at-grade, and other building element waterproofing shall meet base course and through-the-wall flashings, and shall make a bond with these flashings.

Besides waterproofing, capillary water barriers such as sand, gravel or crushed stone courses shall be provided.

Penetrations below grade though slabs-at-grade and other horizontal building elements shall be limited to drains and structural elements. Positive drainage away from the facility shall be provided.

Insulation shall comply with UBC Chapter 17.

Thermal insulation shall be installed above and below grade between the exterior and interior of a facility where the exterior temperature differs significantly from the required interior temperature, e.g., such as where heated spaces are adjacent to exterior walls at slab-at-grade construction and at floors above grade, and where heated spaces are adjacent to roofs.

Thermal insulation shall be installed between interior spaces where significantly different temperatures are required.

Loose-fill insulation shall not be used where future remodeling, renovation, or expansion can reasonably be expected to occur and to require removal of portions of insulated walls.

The thermal resistance of insulation and the degradation of thermal resistance over time shall be considered as a part of the energy conservation analysis and the design of mechanical systems .

i. Evaluate local compliance with the criteria in the General Design Criteria related to the proper handling, site storage, and installation of mechanical and electrical equipment.

Some of the items to consider with the handling, site storage, and installation of equipment are as follows:

DBA's, and OBA's such as fire, explosion, criticality and natural phenomena shall be considered into the design and installation location of equipment.

When equipment are stored, adequate care should be exercised to prevent damage, contamination, and deterioration from handling or environmental exposure.

The ALARA (As Low As Reasonably Achievable) concept for radiological and other hazardous material shall be considered in the design and location of equipment.

Accessibility for maintenance, removal, and replacement of equipment shall be considered in the installation location. OSHA, NEC, UBC and NEPA codes at a minimum, will affect the location of the equipment and should be reviewed to ensure compliance.

Besides the equipment themselves, power sources for the equipment may affect the location of the equipment. Normally, this may be overcome by the addition of additional circuits, however, it should be considered.

2.11 Construction management and engineering personnel shall demonstrate a working level knowledge of the Uniform Building Code (UBC) industry standards for construction management and engineering.

a. Discuss the purpose, scope, and application of the Uniform Building Code industry standards. Include in this discussion key terms, essential elements, and personnel responsibilities and authorities.

There are at least three Model Codes that have been widely accepted. They are:

- Building Officials and Code Administrators International, Inc. (BOCA);
- International Conference of Building Officials (ICBO);
- Southern Building Code Congress International, Inc. (SBCCI)

Most state, county, local, or other jurisdictional building ordinances have adopted these codes without significant revisions.

The Uniform Building Code (UBC) and UBC Standards are published by the ICBO. The purpose of the UBC and Standards is to provide a uniform set of requirements that provide the minimum standards to safeguard public safety, health, property and welfare. This is accomplished by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of buildings and structures. The code is founded on broad-based performance principles so as new materials, construction systems and technology become available, they are easy to implement or include.

The UBC is applicable to the construction, alteration, moving, demolition, repair and use of any building or structure within the jurisdiction which has adopted them, except work located primarily in a public way, public utility towers and poles, mechanical equipment not specifically regulated by the UBC and hydraulic flood control structures.

Additions, alterations, or repairs may be made to buildings or structures without requiring the existing buildings or structures to comply with the current codes provided that the addition, alteration, or repair complies to the requirements for a new building or structure and will not result in an unsafe condition in the existing building or structure.

Alternate materials and methods of construction are allowed, provided they are approved by the building official. Evidence and documentation of the equivalency of the alternate material or method meeting the requirements of the code must be maintained.

On a case-by-case basis, modifications to the provisions of the code may be granted when practical difficulties exist. The modification can not lessen any fire protection requirements or lower any degree of structural integrity.

An enforcement agency to uphold the enforcement of the UBC should exist. As a part of this agency, the building official has the powers of a law enforcement officer. The building official or authorized representative has the right of entry whenever necessary to make an inspection to enforce the code or when there is a reasonable cause to believe that any condition or code violation exists such that the premises or buildings are unsafe, dangerous or hazardous. Entry should be at a reasonable time and every effort to request entry or contact the owner or persons in charge should be made. If entry is refused, the building official is authorized recourse to every remedy provided by law to secure entry.

The building official has the authority to stop work in writing whenever any work is being done contrary to the provisions of the code. Whenever a building, structure, or equipment are being used for other than the provisions allowed by the code, the building official is authorized to serve notice to vacate the area until the requirements of the code are complied with.

Buildings or structures regulated by the code which are structurally unsafe or not provided with adequate egress, or which constitute a fire hazard, or are otherwise dangerous to human life are considered unsafe public nuisances. The building official has the authority to abate the hazard by repair, rehabilitation, demolition or removal in accordance with approved procedures.

When required by the code, a building permit shall be obtained prior to commencement of work for the coverage of the permit.

b. During the actual management of a construction project, identify the Uniform Building Code industry standards necessary to evaluate the appropriate elements of the project.

Besides the Uniform Building Code and its associated standards that are referenced in the code book, additional standards should be referred to. Some of the additional standards that should be reviewed are:

- Uniform Mechanical Code;
- Uniform Plumbing Code;
- Uniform Sign Code;
- Uniform Building Security Code;
- Uniform Fire Code;
- CABO (Council of American Building Officials) Model Energy Code;
- National Electric Code; and,
- National Fire Code.

c. Determine contractor compliance with the requirements of the Uniform Building Code industry standards as they apply to contract design requirements and construction activities at a defense nuclear facility.

Per DOE Order 420.1, Facility Safety, all new construction shall, as a minimum, conform to the Model Building Codes applicable for the state or region, supplemented with additional safety requirements associated with the hazards in the facility in a graded manner. As mentioned in Part 2.11(a), there are at least three recognized Model Codes. The applicable building code for the area should be used.

In addition to the Uniform Building Codes, DOE Order 6430.1A, General Design Criteria should also be used reviewed for additional requirements that may not be in the UBC due to facility specific requirements.

The general process of determining contractor compliance with any type of requirement is as follows:

- Review the source documents. This will consist of at least the building codes, but may also include DOE Order 6430.1A, DOE O 420.1, and other DOE directives. These building codes and DOE orders are excellent starting points and will in most cases, identify requirements in other industry standards;

- Observe the area, plans, drawings, activity, etc.; and
- Interview individuals performing the work as well as those who have designed the system.

This process will validate that the requirements are being met on paper, in supervision and on site.

2.12 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of the Prestressed Concrete Institute (PCI) industry standards for construction management and engineering.

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, and application of the Prestressed Concrete Institute industry standards. Include in this discussion key terms, essential elements, and personnel responsibilities and authorities.

The primary reasons for utilizing prestressed concrete construction are to accelerate construction schedules and reduce construction costs by using off site mass production facilities in lieu of on site stick built processes. The purpose of the Prestressed Concrete Institute standards are to provide a uniform methodology for evaluating and monitoring the use of the prestressed concrete construction processes. From a construction management perspective, the primary concerns are suitability of the structure to fulfill its intended purpose and the ability of the structure to assimilate the installation of necessary sub-systems such as HVAC, electrical service, communications, utilities, and material/personnel movement. In evaluating the suitability of the structure, the use and location of the completed facility needs to be taken in to account. Factors to be considered are occupancy (residential, commercial, industrial, manufacturing, laboratory) and location influences (urban, rural, flood plain, high wind, seismic).

From an engineering perspective, the intended use of the facility has a significant bearing on the design elements to be considered. Most important is the ability of the structure to carry the loads to be imposed by the use category (residential, commercial, industrial). Evaluation of the load imposed on the structure will dictate the allowable members to be used (double tee, single tee, solid slab, hollow core slab, joists, girders, posts, piers, beam type, column type). Next, the impact of environmental factors such as temperature, humidity, sound isolation, seismic activity, and fire loading need to be evaluated. Once these more global factors have been addressed, the engineer should evaluate the design of structures and connections for strength, torsion, expansion, shear, moment resistance, diaphragm flexure, and constructability. Another important element is the adaptability of the structure to accept the installation of mechanical, electrical, and other sub-systems.

The Prestressed Concrete Institute standards are standards that have been prepared by individuals and companies who are actively employed and involved in the specification, design, and construction of prestressed concrete structures. The institute provides guidance in the design and construction of such structures. These standards are invoked as requirements for a project to the extent that is expressly stated in contract documents. The design engineer is fully responsible for the adequacy of his design and the constructor is responsible for construction of the structure in accordance with building codes that are imposed contractually.

b. During the actual management of a construction project, identify the Prestressed Concrete Institute industry standards necessary to evaluate the appropriate elements of the project.

During the construction of a prestressed concrete structure, the primary concern is the correct sequencing of the assembly process in order to preclude the over stressing of any single pre cast element. The elements should be handled properly to preclude damage. Some elements must be specifically designed to accommodate crane picks, pile driving, etc.

Additionally, if required by contract, the owner (owner's representative) should review manufacturer's test records as required by the Prestressed Concrete Institute quality control manuals MNL-116 and MNL-117. Materials must be in accordance with applicable ASTM requirements.

2.13 Construction management and engineering personnel shall demonstrate a working level knowledge of construction methods and accepted construction practices associated with reinforced concrete design as described in the following American Concrete Institute (ACI) documents:

- ACI-318, Building Code Requirements for Reinforced Concrete
- ACI-349, Code Requirements for Nuclear Safety Related Concrete Structures
- ACI-311.4R, Guide for Concrete Inspection
- ACI-311.5R, Batch Plant Inspection and Field Testing of Ready-Mixed Concrete
- ACI-305R, Hot Weather Concreting
- ACI-306R, Cold Weather Concreting

Supporting Knowledge and/or Skills

a. Discuss the standard construction methods for plain, reinforced, or prestressed concrete structures. Include a discussion of the concrete materials, design, and construction of the following:

- Sanitary engineering structures
- Concrete forms
- Concrete reinforcement
- Cast-in-place concrete
- Pre-cast concrete
- Cementitious decks for buildings
- Mass concrete
- Post tension concrete
- Tilt-up concrete

In sanitary engineering structures, consideration should be given to chemical resistance for chlorides, sulfates, and similar substances. Different types of cements are utilized in concrete formulation to resist chemical attack as well as assure sufficient structural strength.

Concrete forms can be made of any non-porous material with sufficient strength to support the load imposed by freshly placed concrete until the concrete has set up. In common practice, wooden forms are the most common due to the cost and workability of wood. Wood for forms should be moderately seasoned and non-staining. Extra care needs to be taken when constructing wooden forms such that the forms are sufficiently supported and reinforced to preclude displacement under the load of placed concrete and workman. Forms surfaces should be smooth, mortar-tight, and free from holes and seams which would permit appreciable amounts of mortar to escape, particularly if the concrete is to be vibrated. Prior to placement of concrete, clean form surfaces should be wetted, oiled, or coated with materials specifically designed for the purpose. If oil or similar coatings are used, these coatings should be applied prior to placement of reinforcing steel so that the bonding surface of the reinforcing steel is not impaired. All foreign materials such as chips, blocks, sawdust, dried mortar, and ice should be removed, preferably by air and water.

Concrete reinforcement should be checked for size, bending, horizontal and vertical spacing, location, firmness of installation, and surface condition. Guidance for placement of reinforcing is available in the “Manual of Standard Practice” by the Concrete Reinforcing Steel Institute. The size and location of reinforcing steel should be shown in detail on prints. The surface of the steel should be free of objectionable coatings, particularly heavy corrosion caused by outdoor storage. A thin film of adherent rust of mill scale in not considered detrimental. Reinforcing steel should be embedded a given minimum distance from the surface of the concrete, to prevent buckling under certain conditions of compressive load, rusting under exposure of the concrete to weather, or deterioration under exposure of the concrete to fire. All reinforcing steel should be sufficiently supported to precluded displacement by workmen during placement. All splices or overlaps should be staggered whenever possible.

Cast-in-place concrete is utilized for those installations where custom form work is constructed. Pre-cast concrete is utilized for those installations that lend themselves to standard shapes that can be assembly line manufactured such as blocks, beams, columns, and slabs. The advantages of pre-cast shapes are lower cost, enhanced quality control of the process, and increased safety by virtue of minimizing work site labor hours.

Cementitious decks for buildings lend themselves to the use of prestressed concrete slabs. The slabs can be fabricated off site and can include hollow slabs to reduce dead load and facilitate installation of utilities in cores.

Mass concrete is a concern in those concrete structures where the rise in temperature caused by the hydration of cement could be excessive. On large jobs, specifications usually state in detail the depth of lifts and the time interval between lifts. In the absence of specific instructions, every opportunity should be taken to promote the avoidance of high peak temperatures - through the use of lowest cement content consistent with strength requirements, cool materials, low placement temperatures of concrete, and provision for the maximum amount of heat dissipation at early ages.

Prestressed concrete structures can be fabricated by two methods; pre-tensioned or post-tensioned. In post-tensioning, the concrete is cast and allowed to cure. The concrete is cast with preformed voids of ducts in which bonded or unbonded tendons are then elongated. Bonded construction entails the filling of tendon ducts with a grout after tensioning; unbonded construction entails wrapping the greased tendons with asphalt impregnated paper or plastic.

In tilt-up construction, typically a wall section is formed up and cast in the horizontal plane. After the slab has cured sufficiently, it is lifted and tilted in to position. The casting process is reasonably straight forward except for bond prevention between the slab and the surface upon which it is cast. Bond breakers can be liquids, canvas, impregnated paper, felt, or other similar materials. Some bond breaking materials can be quite difficult to remove and/or can stain the tilt-up slab. If surface finish is a major concern, special emphasis must be given to the bond breaking method and the lower form material.

b. ***Discuss the construction climatic considerations for hot and cold weather concreting including the code requirements in ACI-305R and ACI-306R.***

In cold weather concreting, it is imperative that newly placed concrete not be allowed to freeze. It is highly recommended that concrete not be placed if the ambient temperature is below 40° F unless provisions have been made to heat the concrete until it has cured. At low temperatures, the time required for strength development and curing is prolonged. For air temperatures below 30° F when aggregates are free of ice and frozen lumps, the desired temperature of the concrete can usually be obtained by heating the mix ingredients. Detailed guidance for heating of ingredients is available in ACI-306. If heating is utilized due to cold weather placement of concrete, the concrete should be maintained at a temperature of 55° F for 4 to 6 days depending upon the type of cement used in the mix formula. Because heated air is likely to be very dry, all concrete surfaces should be kept continuously moist.

In hot weather concreting, the accelerating effects of higher concrete temperatures result in an increased water demand for a given consistency, increased evaporation of mixing water, rapid slump loss, decreased setting times, and an increase in the tendency toward plastic shrinkage cracking. In addition, the early strengths of the hardened concrete are increased and the 28 day strengths are reduced. Placement temperatures may be held at a minimum by concreting at night, using ice in cold mixing water, sprinkling or covering the aggregate, and avoiding cement with temperatures exceeding 170°F. Additionally, all forms and contacting surfaces should be well wetted in advance of concrete placement and placed concrete can be protected from hot dry winds through the use of spraying, ponding, wet sand, or wet coverings. Guidance for concreting in hot weather can be obtained in ACI-305.

c. ***Identify and discuss the minimum building code requirements for reinforced concrete in ACI-318.***

The requirements contained in ACI-318 cover the full spectrum of reinforced concrete construction from design through placement. The code specifies minimum requirements for structural evaluation and design, materials standards, quality control of mixing process, formwork design and installation, reinforcement design and installation, concrete placement, environmental parameters, and testing.

d. ***Identify and discuss the requirements for concrete construction in ACI-349.***

The requirements for concrete structure design and concrete construction are similar to those contained in ACI-318 with the addition of more rigorous and conservative design parameters and increased emphasis on testing and the documentation of quality control testing. This more rigorous approach is driven by the potential for more serious consequences if failure of a structure were to occur.

e. Discuss the longitudinal and shear reinforcement requirements for beam design.

Unlike idealized structural materials such as steel, concrete has a much lower tensile strength than compressive strength. Therefore, concrete beams must be reinforced in those areas of the beam that would be subjected to tensile stresses caused by shear and/or longitudinal loading. Tensile stresses as a result of shear loading are maximum at the neutral surface and tensile stresses as a result of bending that impose longitudinal loading are a maximum at the outer surface. As a result, reinforcement requirements have to be evaluated at the neutral surface and the outer surface most subject to tension. The vector sum of the shear and bending tensile stresses act at an angle to the horizontal and is known as diagonal tension. It is necessary to provide reinforcement in concrete beams to resist this diagonal tension.

f. Describe the inspection methods used for concrete.

Assuming that the structural design has been confirmed and the formwork has been satisfactorily installed, the remaining inspection primarily involves the materials to be placed. First, the inspector would inspect the completed forms for cleanliness and absence of extraneous materials. The inspector should check the trip sheet from batch plant for proper mix formula and batching time. The inspector should note the time of commencement of placement of concrete to assure that mixing time and/or rotation cycle limit has not been exceeded. Based upon a sampling plan per ACI guidance, a sample of concrete should be drawn and a slump test and entrained air test should be performed. The temperature of the concrete should be measured. All test results should meet the parameters as specified by the job.

2.14 Construction management and engineering personnel shall demonstrate a familiarity level knowledge of welding, weld testing and inspection, and the criteria in the following American Welding Society (AWS) codes:

- AWS D1.1, Structural Welding Code -Steel
- AWS D1.2, Structural Welding Code - Aluminum
- AWS D1.3, Structural Welding Code - Sheet Steel
- AWS D5.2, Standard for Welded Steel, Elevated Tanks, Standpipes, and Reservoirs for Water Storage

Supporting Knowledge and/or Skills

a. Describe the welding techniques, materials, and equipment used for different metals and applications.

Welding can be defined as the joining of two or more pieces of metal by heating the base metal to its melting point and allowing the pieces to fuse together with or without the addition of filler metal. The base materials and filler metals can be different, but compatible, materials. The means of heating can be gas flame or electric arc resistance heating. The electrical arc resistance welding power source may generate AC or DC welding current with DC being the most common. In most cases the molten metal must be protected from oxygen and nitrogen to prevent the formation of oxides and nitrides that are detrimental to the integrity of the joint. Shielding of oxygen from the molten metal can be achieved by utilizing an inert cover gas such as argon in heliarc welding or using flux coated electrodes that emit a cover gas as they are consumed in the welding process.

The two most common welding processes are shielded metal arc welding (SMAW - stick welding) and gas tungsten arc welding (TIG - heliarc welding). In SMAW welding, one electrical lead is attached to the work. The other lead contains a clamp holder that is used to hold a flux coated consumable electrode. To initiate the process, the electrode is scratched across the work to complete the circuit and then retracted slightly to establish an arc.. Upon establishment of the arc, the electrode is manipulated to maintain an arc as the electrode is consumed. In TIG welding, one lead is attached to the work and the other lead is a holder for a tungsten electrode. To initiate the process, the tungsten electrode is touched to the work and withdrawn to establish an arc. As the arc is maintained and the base metal is melted, filler metal is added to the molten puddle to build up the weld.

These welding processed are used to joint ferrous and non-ferrous metals with the deposited weld metal being as strong, if not stronger, that the base metal.

b. Describe the welding techniques, materials, and equipment used for nonmetals.

Nonmetals, such as plastics, are joined by heating the pieces of material to be joined to their melting point and then forcing the pieces together for fusion. This process is commonly used in the gas distribution industry to join underground plastic pipe.

The fixturing utilized to accomplish this process consists of two opposed colletts that grip the pipe ends and force the ends against an electrically heated plate to melt the ends. After melting, the heater plate is removed and the colletts are actuated to hold the melted pipe ends together until they solidify.

c. ***Discuss the requirements for welder qualification and the methods for ensuring that qualifications are current.***

The purpose of welder qualification is to assure that the welder can perform sound welds in accordance with the parameters specified in the welding procedure. The weld procedure specifies the equipment, process, and materials to used to qualify a weld type. The welder qualification is used to verify that the operator has the knowledge and manual dexterity to manipulate the equipment in the required position in a satisfactory manner. Welding experience records are maintained for each operator to document experience with a particular procedure for a given employer. Typically, the operator must have welded to the parameters of a particular weld procedure within the most recent six month period.

d. ***Describe the techniques and requirements for destructive testing of welds.***

Destructive testing for weld soundness is typically done by cutting out a portion of the weld profile (know as a strap), polishing the weld area, and bending the strap 180° The weld area is then examined under a 10X glass for evidence of failure.

Another method used is to cut out a weld strap and machine it such that the minimum cross sectional area is in the actual weld and the specimen is tensile tested to failure. The failure load is recorded and the cross sectional area is measured. With this, the strength of the can be determined.

f. ***Discuss the following methods of weld inspection:***

- Visual
- Radiographing
- Dye penetrant
- Ultrasonic

Visual inspection, either with the naked eye or with the assistance of a 10X glass, is used to check a weld for cracking, slag inclusion, undercutting, arc strikes, reinforcement, and profile. This process can locate discontinues open to the surface only. Acceptance criteria are typically found in code documents such as the ASME Code or contract documents.

Radiographic inspection is used to check for cracks, inclusions, lack of fusion, reinforcement, and thickness. The geometry of the weld joint must lend itself to radiography such as a butt weld of similar thickness materials. The process consists of exposing one side of the joint to an x-ray or radioisotope source and placing a film on the other side of the joint to record an image as seen through the joint material. This process can locate discontinuities throughout the thickness of the material. Acceptance criteria are typically found in code documents such as the ASME Code or contract documents.

Dye penetrant testing consists of applying a colored dye with a very low surface tension coefficient to the weld joint and allowing it to penetrate into any discontinuity open to the surface. Excess dye on the surface is removed and a white developer with an affinity for the dye is applied. The developer draws the dye out of any discontinuity where the dye had penetrated. This process can locate discontinues open to the surface only. Acceptance criteria are typically found in code documents such as the ASME Code or contract documents.

Ultrasonic testing consists of using an ultrasonic signal that is pulsed through the weld material where any discontinuity would result in an echo indication. This process can locate discontinuities throughout the thickness of the material. Acceptance criteria are typically found in code documents such as the ASME Code or contract documents.

2.15 Construction management and engineering personnel shall demonstrate a working level knowledge of construction methods and accepted construction practices associated with structural steel as described in the following documents:

- American Institute of Steel Construction AISC-M011, Manual of Steel Construction;
- American Institute of Steel Construction AISC-N690, Nuclear Facilities: Steel Safety-Related Structures for Design, Fabrication, and Erection;
- American Institute of Steel Construction AISC-S326, Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings; and,
- Uniform Building Code (UBC).

Supporting Knowledge and/or Skills

a. Discuss the structural design requirements and standard construction methods associated with the following:

- Light gauge steel;
- Pre-engineered metal buildings;
- Steel water tanks;
- Transmission towers;
- Steel joists;
- Steel decks; and,
- Structural steel connections and fastening.

Light gauge steel is generally defined as sheet steel up to 0.25” in thickness. This gauge material can be cut into strips and cold formed in to various structural shapes for use in framing of light duty structures. These light duty structures are typically used for single story structures where weather protection is the primary criteria. Therefore, the critical loads to be imposed on such a structure would be wind and snow loads.

Pre-engineered metal buildings typically consist of a structural steel frame on a concrete foundation with light gauge sheet metal siding. Structures can be insulated and multi-story floors can be concrete placed over corrugated sheet steel decking. The roof can be of trusses or purlins supporting lapped sheet metal. Aside from the load imposed by equipment and personnel in the building, the primary load factors are wind, snow, and seismic. Buildings are usually rectangular and have a shear wall to accommodate horizontal loading.

Steel water tanks are typically round in order to support internal hydraulic pressure and can be based at ground level on a concrete foundation of above ground supported on an open structural steel frame. The primary structural loading concerns are wind, internal hydraulic pressure, and seismic. Use of a grade of steel that is resistant to low temperature embrittlement is important. In those instances where the above ground support tower is tall in comparison to the diameter of the tank, the buckling mode of failure can be controlling.

Transmission towers are typically tall in relation to their footprint and; therefore, subject to failure in the buckling mode. Wind and seismic loading are the primary loads of concern. Use of a grade of steel that is resistant to low temperature embrittlement is important. Guying of towers is a method to minimize the size of the structure yet still resist the forces of wind and earthquake.

Steel joists are typically closely spaced beams that support roofs and floors of buildings. The structural analysis of joists would be via beam loading analysis as found in standard textbooks and the American Institute of Steel Construction's *Manual of Steel Construction.*

Steel decking is commonly used in floor construction for buildings that are not heavily loaded such as office buildings, hotels, and apartment buildings. The steel decking serves the dual purpose of providing a self supporting work platform plus serving as a form for the placement of concrete. Since the steel provides considerable structural support, the concrete layer on top of the steel can be thinner and/or allow the use of light weight concrete. The bottom side of corrugated steel decking also provides a convenient location to run utilities.

The process of connecting structural steel pieces has evolved over the years through a series of changes. Initially, connecting joints were riveted. However, riveting was a difficult process to control to the extent that uniform clamping forces could be replicated. Rivets were replaced with bolted connections that were more economical to make and, by controlling torque values, were capable of being controlled from a uniform clamping force perspective. Bolting, while still quite common, has been superseded by welding. As welding process control has improved, the duplication of sound welded joints has improved. Welding is a very economical and versatile way to make connections in structural steel.

b. Define the following:

- Minimum edge distance
- Unbraced length
- Beam bearing plate
- Web crippling

Minimum edge distance is the minimum distance allowed from the centerline of the bolt to the edge of the plate. The minimum edge distance is usually two diameters of the bolt, unless the bolt steel is of lower quality than the surrouding plate steel, then the minimum edge distance may be less.

Unbraced length is the distance in a member between points that are braced.

Beam bearing plate is a plate of steel placed upon a masonry surface that supports the end of a steel beam restraining vertical movement but allowing horizontal movement. They are typically used in the connection of steel beams and girder to masonry or concrete structural components.

Web crippling is the failure of the web of a member near a concentrated force.

c. Given data and the appropriate equations, calculate the following for a steel member:

- Average shear stress;
- Parabolic shear stress;
- Bending stress;
- Axial stress; and,
- Torsional shear stress.

Equations for calculating the parameters listed above will vary depending upon the loading profile imposed upon the member (uniform loading with simple end supports, single point loading with simple supports, etc.).

d. List the causes of buckling of load bearing columns and beams.

When a beam or column is not fully braced laterally, it may fail due to buckling laterally about the weaker axis between the points of lateral bracing. This will occur even though the beam is loaded so that it supposedly will bend about the stronger axis. The beam will initially about the stronger axis until a certain critical moment is reached. At that tune it will buckle laterally about its weaker axis. As it bends laterally the tension in the other flange will try to keep the beam straight. As a result the buckling of the beam will be a combination of lateral bending and a twisting (or torsion) of the beam cross section.

e. Describe the following types of connections:

- Friction
- Bearing
- Tension
- Rigid
- Non-rigid
- Semi-rigid

A friction connection is a bolted connection where the frictional resistance to angular movement can be varied depending upon the torque applied to the bolted connection.

A bearing connection is a connection where the load is constrained in one dimension and allowed to move in a normal direction.

A tension connection is a connection where the load is applied in tension as opposed to compression or torsion.

A rigid or continuous frame connection is a connection that, for evaluation purposes, is considered to maintain the original angle between members under load.

A non-rigid or simple connection is a connection that, for evaluation purposes, is considered to be flexible and free to rotate.

A semi-rigid connection is a connection that, for evaluation purposes, is considered to offer resistance to angular change that is between a rigid and a simple connection.

f. Evaluate scaffolding and temporary work platform arrangements for structural integrity and stability.

Scaffolding, although temporary, needs to be evaluated for the loads imposed upon it in the performance of its intended purpose. Scaffolding may not only be intended to be a platform for supporting workers but also may provide support for materials and equipment. All loads, including environmental loads, must be accounted for just as all loads being imposed on the structure being constructed must be accounted for.

4.2 *Construction management and engineering personnel shall demonstrate the ability to apply construction management principles in the execution of construction methods, constructibility reviews, planning, and performance measurement for a construction project.*

Supporting Knowledge and/or Skills

In general, application of construction management principles is a challenge that lies between dealing with detailed technical requirements and possessing a gut feel for the project and the local conditions in the construction industry. Since a construction project is resource intensive, the local availability of materials and qualified workers will many times become more critical to project success than the project details that are on paper. The construction manager also plays a key role in integrating the interests of the owner, the efforts of the design team, and the resources of the suppliers (both crafts and materials/equipment). Only a well qualified and currently active construction manager can evaluate those parts of a construction project that begin where the design documentation ends.[1]

a. Determine whether a construction project execution plan can be implemented safely and cost-effectively and still meet the project specifications.

Safety and Health– Safety and health are a key part of effective project planning and control, and in many ways equally significant with costs, schedules, and quality. But the attention safety receives on a construction project is frequently much less than its significance. The construction manager needs to have an awareness that safety is important on several levels, such as humanitarian, economic, legal and regulatory, liability, and organizational reputation, and control the project accordingly.

Safety concerns are those that pose an imminent danger to the personnel, equipment, or structures. These result from the sheer scale of the work compared to the frailty of the people performing it, as well as, from human factors throughout the project's duration. Falls, impacts, fires, electricity, and numerous other hazards must each be considered and mitigated in construction planning, as well as, on the construction site. Project plans must be reviewed for consideration of each of these hazards and the feasibility of implementing the planned mitigating actions throughout the project duration.

Health concerns are those such as heat, radiation, noise, dust, shocks and vibrations, and toxic chemicals. Since the effects of these concerns are not always immediately felt, the use of protective clothing and equipment is often seen as a nuisance and is disregarded if not routinely enforced. Project planning needs to include provision for adequate protection, such as hard hats, earplugs, respirators, and shock absorbers, and requirements and resources for enforcing the application of these protective devices.

OSHA regulations require that the employer supply a workplace that is free of safety and health hazards, and that the employee to comply with the applicable safety and health rules, regulations, and orders. Also, beyond the minimum requirements of the law, tort negligence considerations must be considered. A safety plan must be written by the construction manager in oder to protect against these types of law suits.

Cost Effectiveness– A sound project plan is based upon detailed cost estimates. Reviewing and validating the accuracy and completeness of the cost estimates is one of the most important responsibilities of the construction manager. Many intangibles must be accounted for in the estimates along with the obvious mass of technical details. Labor costs are a key area of concern because they constitute a major portion of the project cost and are the most subject to intangible factors[2]. Work force productivity can be affected by labor relations and local work practices, competition from other major resource consuming projects in the area, proper sequencing of crafts in different parts of the project, and the timely arrival of supplies and materials. In most cases, it is to the advantage of the owner and the construction manager to obtain fixed-price bids on work scope from each of the subcontractors, based upon thoroughly understood and documented project designs. The construction manager must evaluate all bids for completeness and the bidders for their ability to deliver the quality and quantity of work that they bid at the agreed upon price.

b. Determine the availability of the resources, equipment, and qualified subcontractors necessary to implement a construction project execution plan.

As described above, it is the construction manager’s responsibility to convert the design and cost estimates into the actual resources at the construction site when they are needed. Local conditions play a key role in this process. Demonstrated knowledge of the local marketplace for these materials and services is an essential part of this capability.

Early completion of the design package allows the construction manager to obtain commitment for resources, equipment, and qualified subcontractors. Significant project schedule and/or scope changes may place the existing commitments at risk. Before committing to any change in the construction project execution plan, availability of resources, equipment, and subcontractors must be verified, not assumed.

c. Evaluate a contractor decision to make or buy.

A make-or-buy decision involves the choice of procuring a good or service instead of obtaining it within one’s own organization. In many ways, this decision is similar to the evaluation of one subcontractor over another; that is, the cost as well as the ability to deliver the needed quality and quantity of work is the determining factor.

The make-or-buy decision is commonly used in the manufacturing world when deciding the source of a component to be used in manufacturing or assembling a product. In many cases, it is cost effective to purchase the component from a specialty vendor rather than to manufacture it internally. A pure make-or-buy decision is an economic one; in the real world, though, it can become a labor relations, public relations, or other "politically" driven decision.

The make-or-buy decision is not used frequently in the construction management world. In most cases, it is far better to purchase a "manufactured" component, such as a skid-mounted system or a steel truss than it is to "manufacture" it on the construction site. Quality control, labor expertise and efficiencies, and testing capabilities are among the technical barriers to on-site manufacturing of construction components.

Too often, an internal profit motive overrides the fact that a construction manager must obtain the quality and quantity of work needed, when it is needed. Subcontractors can be penalized for not meeting their commitments; internal organizational elements are rarely subject to the same degree of control. So, in evaluating a contractor make or buy decision, the organizational advantages and disadvantages should also be considered along with the more straight-forward technical and financial aspects of the decision.

d. ***Evaluate construction project execution plans and schedules for feasibility.***

A feasibility study is performed early in a project's conceptual design phase (Title I) as one of the parts of the broad-scale planning of the project. Economic and technical feasibility studies, as well as conceptual analyses and environmental impact reports should be done long before designers start preparing drawings, and certainly before field construction can commence.

Among the considerations in a feasibility study for an industrial facility are such questions as:

- What is the availability of skilled and productive workers?
- What is the local business climate?
- What is the availability of appropriate and economical forms of transportation?
- Where are the sources of raw materials and the markets?
- Are there adequate and economic sources of energy, such as gas, oil, and electricity?
- What will the environmental impact be?
- What do these factors, taken as a whole, mean for the technical and economic feasibility of the project?

Assuming a favorable answer to the above type questions for the planned construction project, the project design can proceed. After the definitive design (Title II) is finished, project execution plans and schedules should be reviewed. At this point in project development, actual planning of cash flow, basic construction schedules, environmental planning and permitting restraints, seasonal weather conditions, corporate necessities, and similar broad considerations can be analyzed to ensure the plans and schedules are feasible.

A constructibility review is a technical review of the facility design itself, usually by the construction manager or engineer(s) who are independent of the design agency. This review determines whether the facility can be constructed as designed, or whether it is cost-effective to use the design approach. A constructibility review can be done at any time before the field work begins, but it makes the most sense to do it as early in the design process as possible to avoid massive redesign.

Current construction practices are tending toward getting the construction manager onboard early in the design process, sometimes as early as during the conceptual design phase. This allows the constructibility review to be a design input that may pay for itself many times over in smooth project execution.

e. ***Manage contingency funding.***

Successful management of contingency funding is based upon a comprehensive project control system, which should include:

- Updated and current CPM network;
- Design and procurement schedule showing actual progress compared to that scheduled;
- CPM summary schedule showing actual contract progress compared to scheduled progress for each contract;
- Cost report comparing forecast-at-completion costs, including committed and estimated contract costs to complete, compared to budget estimates;
- Weekly and monthly progress reports; and,
- Continuous estimation of the project costs, complied in a estimated to complete chart, plotted against contingency funding cash flow over time.

With this type of control system in place, sufficient information is available to make factually based decisions concerning the use of contingency funding.

Early in the project design process, when the uncertainties are greatest, a significant contingency fund should be retained, say 10-20% of the total project cost. As the design matures, this contingency should be tightened, so that at start of construction, it is no more than about 5%.

The contingency must be reserved for the unforeseen, but almost guaranteed difficulties which will arise during actual construction. Care must be exercised to avoid using this contingency at a faster rate that the project's actual progress. Additionally, contingency must not be used for add-ons (extras) or significant changes to the detailed design (Title III) package. If significant changes must be made, they should be treated as new work which needs to be subjected to the same rigors and contracting process as the original project package. Added work should come with its own share of contingency funding.

f. Prepare a Project Status Report and determine deviations from the estimates.

Management-level reporting must provide a straightforward statement of work accomplished, predict future accomplishment in terms of the project cost and schedule, and measure actual accomplishments against goals set forth in the plan. It should also review current and potential problems and indicate management action underway to overcome the effects of the problems.

Project status reports should be prepared at least monthly, with weekly, less formal updates. For the report to be of value, it must be submitted (and reviewed by the owner) in a timely manner, not more than a few days into the new reporting period. The Project Status Report should include the following:

- **Summary of Project Status** – Represents a short overall summary of project status. It may contain a brief narrative description of each major phase, provide quantitative information such as the physical percentage complete compared with the scheduled completion, and forecast at-completion costs against budget.

- **Procurement Status** – Reviews contracts awarded during the report period, contracts currently out for bid, and other significant information. A simple bar chart showing actual procurement status and contract awards compared to the original plan is often helpful.

- **Construction Status** – Provide a description of work accomplished during the period, significant work to be accomplished during the next period, and a discussion of major problems with solutions or proposed solutions. Quantitative information more significant than general discussion.

- **Schedule Status** – Contain the summary control schedules by contract and by facility, showing actual progress compared to early- and late-start schedules. Where contracts or facilities are behind schedule or are slipping, an explanation of the problems and the indicated solution or measures being adopted to solve the problems should be included.

- **Cost Report Summary** – Show actual recorded costs, committed costs, and estimated costs-to-complete. It should compare "at-completion" costs with project budgets and identify and explain changes from the previous report. An evaluated contingency should be included so that the overall estimate of actual costs at completion is provided. Professional construction management costs should appear in a similar manner. A summary of value engineering savings to date and new items added during the period can be included.

All project reporting must be factual and auditable. These reports become part the record file of the actual construction and may be subject to legal (or governmental) review.

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[1] Barrie and Paulson, *Professional Construction Management*, 3rd edition, published by McGraw-Hill, 1992.
[2] Adrian, *Construction Estimating* 1st edition, published by Reston Publishing Company, Inc., 1982.

4.8 Construction management and engineering personnel shall demonstrate the ability to interact with Federal, state, local, and public stakeholder representatives.

Supporting Knowledge and/or Skills

a. Discuss the roles and responsibilities of site and/or community advisory boards on construction management and engineering issues.

The primary charter of the Citizen Advisory Board (CAB) is to provide informed recommendations, ideas, and advice to DOE, EPA and local health departments on policy and technical issues and decisions related to cleanup, waste management and associated activities. The CAB is an advisory function, only. Information on projects should be sent to the CAB early in the decision making process, and the CAB given the opportunity to be provide recommendations prior to final decisions being made. Concerns and comments of the CAB and stakeholder should be reflected in the overall decision making process at Federal facilities.

b. Discuss the Department of Energy's position on construction management and engineering issues that impact Federal, state, local, and public stakeholder segments.

The Department of Energy recognizes the value of stakeholder involvement in making decisions regarding DOE facility activities and operations. Therefore, it is the position of DOE to share pertinent and requested information, and consider and respond to stakeholder positions and comments before final decisions are made.

Communication is particularly critical to project planning at the definition of project scope, budget, and schedule baselines. Failure to adequately plan and anticipate public and stakeholder issues, concerns, and reactions may cause delays and loss of resources, and can create significant difficulty in maintaining established project baselines. Many environmental regulations require consultation with other agencies and stakeholders.

c. Discuss the Freedom of Information Act (FOIA) and its impact on Department of Energy construction management and engineering programs. Discuss security precautions to be taken in relevant programs in terms of the Freedom of Information Act.

It is the policy of the DOE is to make information publicly available to the fullest extent possible, except where this information is exempt from disclosure under the FOIA, 5 U.S.C. 552 (Public Law 90-23, as amended) or under other applicable statutes (the Privacy Act of 1974, 5 U.S.C. [a]). Officers and employees of the Department may furnish to the public informally and without compliance with the procedures of this Order, information and records of types which are customarily furnished to the public in the regular performance of their duties. There is no obligation on the part of the Department to compile or create a record solely for the purpose of satisfying a request for records.

Where a contract with the DOE stipulates that any documents relating to work under the contract shall be the property of the Government, such records shall be considered to be agency records and subject to disclosure under the FOIA. However, if a contract does not make such specific provisions, no DOE contractor records shall be considered to be agency records unless and until such time that the DOE acquires possession of the particular contractor documents.

For specific roles and responsibilities, see DOE Order 1700.1. Roles and responsibilities described with regard to the FOIA include those for the Direction of Administrative and Human Resources Management, Director of Administrative Services, the General Counsel, Heads of Field Elements, Freedom of Information Officers, and Authorizing Officials. Personnel not fulfilling any of these roles should forward any requests to the appropriate DOE official. For a FOIA request, records are to be promptly identified and reviewed by an Authorizing Official. The Authorizing Official will consult and obtain concurrence of the General Counsel prior to any determination to deny access to records.

Protection of classified or UNCI information and restricted access to classified materials and many facilities is required. If there is any potential that information in the project documentation is classified, then classification guidance should be requested or documents reviewed by an authorized classifier. DOE Order 5632.1C, Protection and Control of Safeguards and Security Interests, ands DOE M 5632.1C-1, Manual for Protection and Control of Safeguards and Security Interests require a security plan for projects considered to be a concern.

d. Communicate effectively with the public and other stakeholders.

This is a demonstration requirement.

Public participation is the ongoing, two-way communication, both formal and informal, between the DOE and its stakeholders (anyone interested in or affected by its actions, including employees). This interaction enables all parties to learn about and better understand the views and positions of others, thus leading to better and more timely decisions. Suggestions for effective stakeholder involvement:

- Seek early and continuous public involvement;
- Inform the public in a timely manner about activities and empower them to participate in the DOE's decision-making process;
- Actively seek and consider public comment and incorporate the views of stakeholders in the decision-making process;
- Work with the Communication Department staff to determine which projects require stakeholder involvement;

- If activities are a part of an NEPA environmental impact statement, formal public involvement is necessary, including public comment periods;
- Use a variety of public involvement methods;
- Consider including regulatory agencies and stakeholders on project teams at the beginning of a project;
- Involve stakeholders and allow for meaningful opportunities to affect the outcome, don't just give information;
- Tailor public involvement plans to the proposed action and to the various affected segments of the population, especially taking into consideration historically disadvantaged groups. Seek the participation of low-income and minority groups that may be disproportionately or adversely affected by the proposed action; and
- Present alternatives fairly and objectively. Do not use the public participation process to defend a proposal. Do not exaggerate the benefits or minimize the costs of a proposal under consideration.

e. ***Given construction management and engineering related program data, identify those portions of the data required to be communicated to organizations external to the Department of Energy construction management and engineering personnel. Discuss any potential impacts on Department of Energy programs.***

This is a demonstration requirement.

The following activities require stakeholder involvement:

- Activities and project with potential risk or impact to the human health or the environment;
- Any activity requiring regulatory oversight by another local, state, or Federal agency; and
- Any activities where stakeholder buy-in would benefit the project moving forward and the overall credibility of the agency (resolve conflict or controversy, support funding, etc.).

The following environmental regulations require communication with external agencies, and are commonly related to agency projects:

Laws and Orders Commonly Related to Agency Projects		
Environmental Laws and Executive Orders	**Oversight Agency**	**Concern/Action**
Endangered Species Act	U.S. Fish and Wildlife National Marine Fisheries Service	Protection of threatened and endangered species/biological assessments and opinions
Fish and Wildlife Coordination Act	U.S. Fish and Wildlife	impacts to fish and wildlife/consult, mitigation
Coastal Zone Management Act	National Oceanic and Atmospheric Agency	impacts on coastal zone/findings of consistency with State Management Plans
National Historic Preservation Act	State Historic Preservation Office	preservation of prehistoric and historic sites/consultation
Native American Graves Protection and Repatriation Act	State Historic Preservation Officer Affected Native American Tribes	protection to gravesites, human remains, and funerary objects/consultation with Native American Groups and SHPO
Clean Air Act (Conformity Rule)	Environmental Protection Agency (State Primacy)	Air pollution/permits, inspection, reports
Federal Water Pollution Control Act (Clean Water Act)	Environmental Protection Agency (State Primacy)	water pollution/ National Pollution Discharge Elimination System (NPDES) permit (EPA) and Section 404 permit-Dredge/fill (Corp of Engineers) inspections, reports

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	Environmental Protection Agency (State Primacy)	past disposal of waste/taxing, reporting, liabilities
Resource Conservation and Recovery Act (RCRA)	Environmental Protection Agency (State Primacy)	Hazardous and Nonhazardous waste management/permits, manifests, inspections, reports

Additional regulations and executive orders that involve consultation and/or stakeholder involvement include:

- Executive Order for Environmental Justice-affected minority and low income groups;
- American Indian Religious Freedom Act-affected Native American groups;
- Prime and Unique Agricultural Lands-Department of Agriculture; and
- Local regional, state land use and zoning commissions.

Proper and adequate environmental planning is critical to the project management process. For any given project, a large number of environmental requirements may be applicable. Compliance planning is an integral part of any project. Failure to adequately plan for environmental compliance may cause delays and loss of resources. Environmental issues, if not given adequate consideration, can create significant difficulty in maintaining established project baselines.

f. Communicate with Headquarters Program Office representatives, Department of Energy Legal representatives, contractors, state, and local officials.

This is a demonstration requirement.

The following types of information should be communicated to Headquarters Program Office representatives, Department of Energy Legal representatives, contractors, state, and local officials:

- Information related to the official oversight role (i.e., potential environmental impacts, land use.);
- Potential problems with public stakeholders;
- Potential for demonstrations or news-worthy events;
- Problem or an emergency associated with a project; and
- Stakeholder issues associated with a project, prior to a visit.

Emphasis should be on early meaningful involvement, or as soon as an issue has arisen (no secrets or surprises).