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Unit Introduction

What you will learn in this unit

By the end of this unit, you will be able to demonstrate knowledge of:

- Engineering terminology
- Common instruments
- Slope and grade
- Common utilities

Why it's important for you to learn this unit

This module focusses on the engineering terminology that you need to be aware of, common instruments used in road building, and common utilities that you may encounter and how to expose them.

It also demonstrates how to identify and control slope creation.

Are you ready to take this unit?

To take this unit, it is recommended for you to have completed the following unit:

- [1002 – Describe Forestry Industry](#)

Does this unit apply to you?

This unit applies to all Road Building Equipment occupations.

Section 1077-01: Terminology

What you need to know about this section

By the end of this section, you will be able to demonstrate knowledge of the following key points:

- 1.1 Terminology related to engineering concepts

Key Point 1.1: Terminology Related to Engineering Concepts

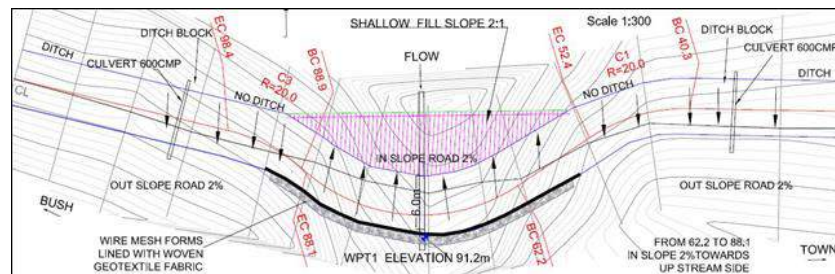
The terms related to engineering discussed in this section include the following:

- road layout
- maps
- profiles and cross sections
- centre line
- offsets
- riparian zones
- grade
- adverse vs. favorable grade
- pits
- rock cuts
- subgrade
- ballasting
- puncheon
- resource prescriptions
- spoil sites

Road Layout

Road access is an important factor in planning forest development. The principles for choosing road locations apply to main and secondary Forest Service Roads (FSRs), but secondary roads are more site-specific for the harvesting system and equipment.

Road layout is a process of route selection and field marking based on pre-field investigation and field scouting to choose a site-specific road location. The detail and information needed for road layout depends on the road design standards, the terrain, the size and complexity of stream crossings, and other resource values.



Sample road design through gully near Lumby, BC - plan view. Image from Chris Cole, RPF, P. Eng.

Maps

Maps, air photos, and LIDAR (Light Detection and Ranging) scans are a common source of information for terrain features and collecting information. Some key kinds of maps used for pre-field preparation are:

- contour maps
- Terrain Resource Information Management (TRIM) maps
- forest cover maps
- soil and land form maps, terrain and stability maps, and ortho imagery

Maps and air photos can be used to identify features and control points along route locations, including:

- stream crossings where location is critical
- rock bluffs, benches, passes, saddles, and other dominant terrain features
- potential switchback locations
- harvesting systems and potential location of landings
- potential disposal sites for excavation spoil or debris
- alienated lands, including power line, gas pipeline, or railway crossings
- current access to and junction with existing roads
- log dumps, mill yards, or other destinations
- avalanche chutes
- talus slides
- swamps and wet areas
- forest cover and stand condition
- potential environmentally sensitive areas



Learning Point

The working map provides a visual summary of all information gathered during the pre-field investigation.

Once the final road location has been marked in the field and approved, field maps, profiles, and cross sections will be created to guide road construction operators in building the road. The field map created will show the start and end of the road section and other important features such as locations of stream crossings.



Reference

BC Forest Safety Council

Guide for Road Construction Design Maps - Key elements to maps, profiles and cross sections

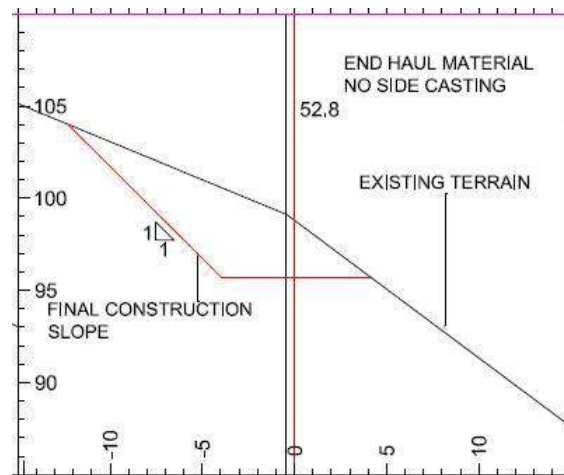
<https://www.bcforestsafecouncil.org/wp-content/uploads/2021/02/Training-Guide-Road-Design-Elements.pdf>

When you are finished, continue in this section.

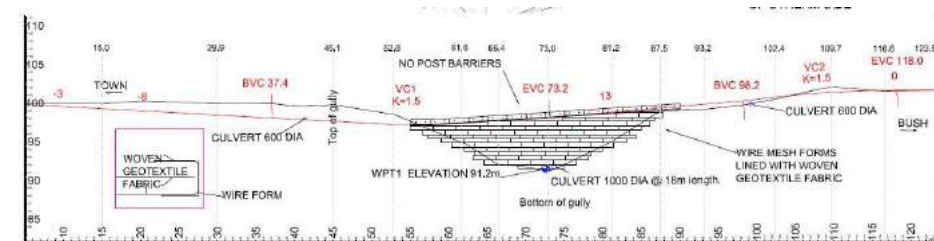
Profiles and Cross Sections

Cross-sections are the natural ground profile perpendicular to the road; they show the slope and angle of topography at any given point. A road template shows the shape of a road set on the cross-section— that is, set on the slope of the natural ground.

Common to most cross-sections are the cut and fill sections of the road, where the “cut” is the portion of the uphill bank that is removed, and the “fill” is where material has been added to and compacted on the downhill side of the road.



Cross section sample image



Road Profile sample image associated with plan view of gully crossing above



Learning Point

Road sections are considered “balanced” when the volume of earth cut equals the volume of compacted fill along a specified road section. An “unbalanced” road design would imply hauling or importing soil material via truck to or from a borrow or spoil site location.

Often when building secondary, temporary or in-block roads cross sections and profiles will not be available.

Centre Line

Road builders are usually presented with a felled and bucked right-of-way that's 20 to 30 meters wide, with the road centerline marked with

flagging tape at the middle. The road grade and alignment will be dictated by those boundaries.

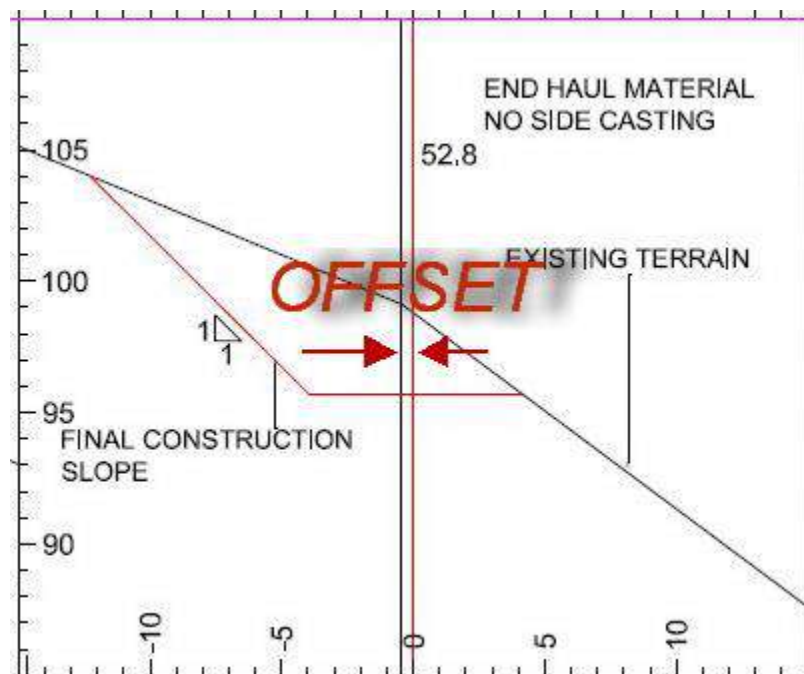
Cuts and fills will be balanced as best as possible. Road widths will be stated in the road construction plan. Resource roads are often single lane roads with wide pullout locations used when vehicles pass.

Offsets

The two terms most commonly associated with survey and design are the P-line (Preliminary Line) and L-line (Location Line).

The P-line is determined in the field. It is a plotted line on a drawing to give the horizontal and vertical control for the roadway centre line. The L line is the designed roadway centre line shown on a drawing.

The L-line is often established in the field as offsets to the P-line based on the road centre line design. Where close control of cut and fill slopes are needed, the L-line is established with grade stakes.



Horizontal offset shown to be about 1 metre

Riparian Zones

Riparian area is a term that describes the areas next to streams, lakes and wetlands. The blend of streambed, water, trees, shrubs and grasses in a riparian area provides important fish and wildlife habitat.

When constructing resource roads, operations may take place close to or within riparian zones. Construction of stream crossings is a good example. When operating within these zones, it is important to protect the vegetation and streambed and minimize silt or other materials entering the waterway.

For urban development sites these zones are covered by the Riparian Areas Regulation (RAR) to protect the varied features, functions, and conditions that are vital for maintaining stream health and productivity.

Grade

Road grade is the difference in elevation between two points along a road surface. Grade is positive (+) uphill and negative (-) downhill. Grade is expressed in percent (%) with the vertical change of a road elevation over a horizontal distance. For example, the change of grade uphill (+) 10% would be a change in elevation of 10.

The physical grade affects the construction, maintenance, and safety standards on forestry roads. A complex road section may be on steep or unstable terrain and needs to have specific grade or crossing control points carefully marked or staked on the ground.

These design conditions are considered in maximum road grades:

- Road surface
- Anticipated vehicle types
- Vehicle speed
- Length of pitch
- Curve radius
- Terrain hazards



CAUTION!

Complex road sections may need more detailed field markings for greater control of location and grade.

Adverse vs. Favorable Grade

A positive grade in the direction a loaded log truck is travelling is called an *adverse* grade. A negative road grade in the direction of a loaded log truck is called a *favorable* grade.

The grades constructed for a forest road will be outlined in the plans and profiles for the job. Under normal road surface conditions, the maximum adverse grade that a loaded log truck can successfully drive up is dependent on the truck, trailer and load configuration, and many other factors. Generally for efficient log hauling, resource roads should be constructed with adverse grades of 8% or less. Short sections of road with pitches up to 10% adverse may be acceptable.

A common design criteria for a maximum favorable grade is 12%, however short pitches of 15% to 18% may be acceptable. Sustained steep grades should be broken up with less aggressive grades, and switchbacks or sharp curves require slower speeds to navigate safely so more gentle pitches are required.

Pits

Gravel or borrow pits are excavated areas where gravel or other material is removed for use in road construction. Gravel pits and

borrow pits are important to remember when clearing for road construction. The minimum clearing width needs to factor in major sites such as pits and quarries.

Once rock or surfacing material is removed from a borrow pit, the void may be used for holding or “spoiling” organic or excess material from other road sections.

Rock Cuts

When rock hardness, weathering, and jointing (fractures in the rock) allows for it, a hoe-mounted hydraulic hammer or dozer mounted ripper are used for rock breaking. Where these techniques are not useful, the rock is fractured by drilling and blasting.

Qualified blasters assess rock and site conditions, create blast designs, learn from previous results, and revise field practices to reflect changing conditions. Controlled blasting techniques are used where the cut bank height exceeds 5m. Where site conditions are beyond the blaster’s experience, a specialist professional engineer is consulted.

The rock cut should have a ditch with a width that can capture falling material, and that drilling and blasting techniques minimize:

- Fly rock (airborne rock displaced beyond the blasting) to avoid damage or disturbance to forest resources and existing improvements
- The potential for landslides or slope instability
- The amount of overbreak (material that is excavated, displaced, or loosened beyond the design)

Subgrade

The subgrade is the foundation of the road surface. The stronger the subgrade material, the less surfacing rock is needed. Rock subgrade may not need any surfacing. Soil subgrade needs gravel or crushed rock surfacing for log hauling during periods of wet weather.

Ballasting

Ballasting is using rock to build the road subgrade when other material won’t support the design for the traffic load.

Ballast material needs to:

- Drains well
- Forms a structurally sound fill
- Compacts well
- Resists erosion

Puncheon

Puncheon refers to small logs and limbs that are left in the road subgrade when overlanding. Overlanding is a construction approach used where the underlying soils are too weak to support the road. The road fill is placed on undisturbed organic soil, stumps, and

vegetative material, using geosynthetic fabric, corduroy, or puncheon (small logs and limbs) as the separating material mat.

Puncheon reduces the amount of road fill required. Puncheon should only be used for short term roads as it will rot and settle in time leading to road maintenance problems.

End Haul

End haul happens when material is excavated from a road section, placed in a truck, and hauled to a different location. These materials are one or more of the following:

- unsuitable for road construction and are considered waste material, so are hauled to a spoil site
- suitable for road construction and are hauled to another road section, a storage site, or a spoil site

Resource Prescriptions

A resource prescription is a document written and signed by a forest professional to communicate a plan, provide advice, or explain a course of action required to achieve a desired outcome.

Resource prescriptions often include maps, photos, and data tables to communicate messages and provide supporting documentation.

Examples of a resource prescription may include a land stewardship plan, harvesting plan, watershed protection plan, silviculture or reforestation plan, or a road deactivation plan.

Spoil Sites

Spoil sites are areas where extra excavated material is stored. During road building, material is often excavated and moved to a spoil site by a truck or an excavator.

These sites are in a flat spot where there are no creeks or wetlands or slopes causing the material to slide. If the excess road material consists of overburden and debris, then spoil sites are located as close to the construction area as possible. Abandoned quarries, gravel pits, and roads are some possibilities for spoil sites.



Learning Point

Whenever possible, reduce end hauling by using the cut material. For example, some materials may be used for the road subgrade, base course, turnouts, curve widening, and building up the grade to reduce steep pitches.

Phases of Forest Road Construction

The phases of forest road construction are:

- Planning
- Assessment
- Road layout and survey
- Right-of-way falling
- Sub-grade construction
- Stream crossings
- Surfacing
- Maintenance
- Deactivation

Planning

Forest roads can be very expensive to construct and result in long lasting physical changes through the landscape. Planning is essential to minimize construction and long term maintenance costs and to avoid unnecessary damage to the surrounding environment.

Roads must be built with purpose and intent to provide physical access for specific equipment or trucks, with a specified life cycle. If all the surrounding terrain is to be harvested over time, roads must be planned spatially to access all areas.

Road planning may be determined by total change plans, or plans that account for access to all physical areas over several timber harvests distributed across the landscape. When no historic roads exist in a landscape, planning includes road with different life cycles. For example, a mainline haul road may be built as a permanent road to access an entire valley. Shorter term spur roads may be planned that junction off the mainline roads, and may be permanent, or deactivated after a few years of use if they are not needed for several years.

Within a cut block, seasonal roads may be built with the intended use during the harvest of the cut block, then deactivated once the planting of the cut block has been completed.

Compared to short term roads, permanent mainline roads require greater time to build and will cost more due to the attributes of generally being wider, having more gentle grades, being constructed with better aggregate or rock materials, and having steel or concrete bridges design for flood events with a long return period.

One metric that is often used to access environmental health of a watershed is road density, measured in km/ha. Minimizing road density across a landscape minimizes operating costs and minimizes the environmental footprint of a harvesting operation.

Minimizing road density also minimizes loss of plantable soil area for reforestation. Road planning includes a wide scope of considerations at the landscape level and well as site specific details on the ground.



A typical landscape near Golden, BC requiring a wide variety of road planning considerations



A road location planned near Salmon Arm, BC with very high down slope consequences if a roadway failure were to occur

Assessments

Before road construction can begin, several assessments may be required to ensure the proposed plan minimizes costs and environmental footprint.

Examples of typical assessments are:

- Terrain Stability Assessment: Completed by a P. Geo /P. Eng. terrain specialist, a TSA consists of a field review of the area for the proposed road. Terrain and slope stability reports often recommend road location adjustments and identify natural hazards associated with building roads and harvesting trees
- Stream and River Crossings: These include culvert sizing and bridge designs
- Watershed Assessment: Completed by a specialist, identify drainage and hydrology related attributes and hazards. Often thresholds for ECA (Equivalent Clearcut Area), roads density, soil types, and other attributes influencing road construction are identified
- Fish, Wildlife, and Species at Risk Assessments, influencing road planning and construction location constraints



A Geoscientist collects soil samples from an old road cut slope near Quesnel Lake, BC



Biology specialists assess a creek and identify a species at risk near the Cowichan River on Vancouver Island



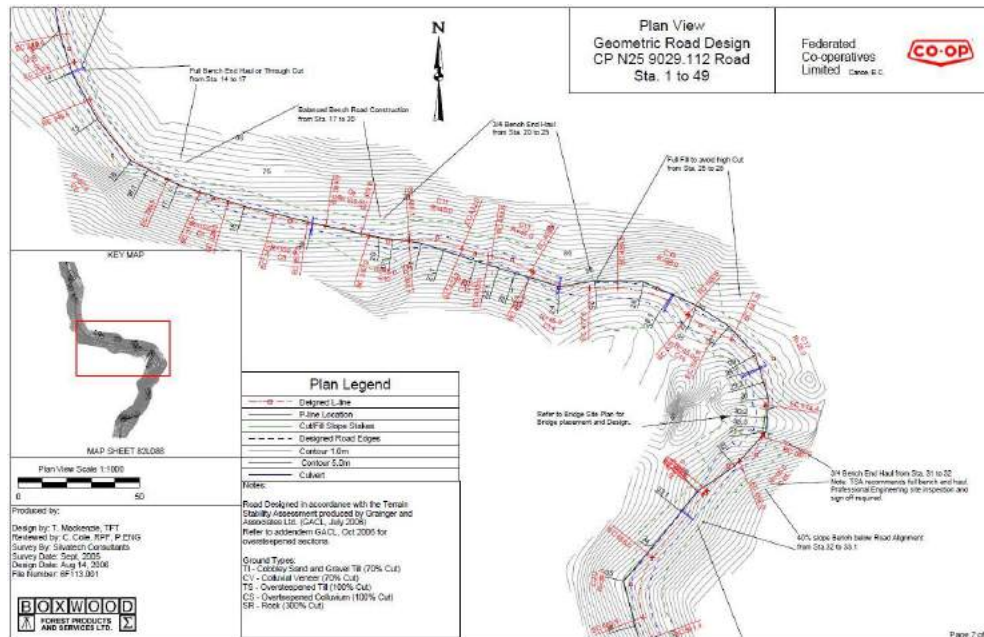
A Professional Engineer assesses a karst cave found on Vancouver Island where field crews had proposed to build a road

Road Layout and Survey

Once an overall plan has been approved, field layout of the road locations can begin. Crews “hang ribbon” to mark road centerline. The ribbons marking the road centerline create the “p-line” or preliminary road centerline. Generally, if the terrain is flat, the p-line is recorded with a GPS and brought back to the office for mapping. If the terrain is steeper or the assessments identified any challenging road construction conditions, the p-line may be surveyed and additional attributes including ground types may be collected for the purpose of designing the road using office software, and refining the cost to build the road.

Once a road design is completed, additional field layout may be required to hang ribbons along the “I-line” or “location-line” which is the adjusted road centerline from the design.

Cut and fill slope stakes may also be ribboned in the field, as well as the right-of-way boundaries in preparation for tree removal.



The plan view of a typical road design completed for a steep section near Shuswap Lake, BC

Right-of-way Falling

Right-of-way falling includes harvesting trees by hand falling or feller buncher, and generally placing the trees off to the side to make way for road building. The trees can be bucked and processed after the road is built, or during the falling process. All trees within the right-of-way ribbons are removed.

The next step is “stripping” or “grubbing” and includes pull all stumps and stripping all organic forest floor materials out of the way. Generally, organic materials are not allowed to be used in the roadway fill prism.

In very wet, flat terrain conditions, over-turned stumps and non-merchantable logs are laid over the ground, making up “puncheon” to “float” the road over the wet soft soils. Blasted rock and suitable road building material is imported to the site and used to build up the roadway.

Sub-grade Construction

Usually completed by an excavator, the operator will cut into the soil of the higher side of the roadway and fill or move the soil to the lower side of the roadway to make a rough level roadway. This is called “cut and fill” construction.

Ditches are excavated at the same time. Occasionally, the terrain side slopes are too steep for filling on, so all material must be excavated and trucked to a “spoil site” or location on more gentle terrain. This is called “full bench end haul” construction.

In the case that puncheon is used, the sub-grade material must be excavated from a borrow pit and trucked to the site. This is called over-land construction. The sub-grade is often compacted as the machine works on the site, but occasionally the sub-grade is further compacted with a roller compactor.



Road sub-grade is being prepared in steep terrain near Sicamous, BC



Puncheon used in the road subgrade on Haida Gwaii, BC coast

Stream Crossings

Stream crossings may vary from large steel and concrete bridges design and installed by specialists, to smaller culverts. Generally in BC, a Professional Engineer is required to design and sign off on the installation of any bridge, a culvert that is 2 metres in diameter or larger, or a stream crossing where the maximum flow is determined to be 6m³ per second or greater.

Logs and compacted soil structures are also commonly used for smaller short term stream crossings. Any stream with fish presence, or that is located in a community watershed must be “spanned” or crossed with an open bottom structure, rather than a culvert. Soil compaction techniques and specialized construction knowledge are required for bridge building and culvert installation.



A permanent bridge installation project in avalanche prone terrain near Revelstoke, BC



An old culvert is replaced with an open bottom concrete slab bridge a fish bearing creek near Kelowna, BC.

Surfacing

Road surfacing is the spreading of the top layer of material on the roadway. Generally this material is a well-draining aggregate or shot rock, and will vary depending on location, material availability, and intended use and life cycle.

In wet coastal environments, surfacing materials tend to be very coarse blasted rock. This type of road stands up to heavy traffic better during rainy wet conditions and allows for adequate traction on steep grades. The surfacing is placed on the roadway to form a “crown” or elevated road center to facilitate rain water drainage off the road.

When the surfacing is graded and compacted, the surface on the road will resist rutting and provide a stable running surface for trucks during a variety of weather conditions.



A new road is surfaced with shot rock in Haida Gwaii

Maintenance

Greater effort in planning, design, and construction of roads generally results in lower long term maintenance efforts and costs. Regular grading reduces the opportunity for potholes to form, washboards to develop, and also keeps the fine textured material from washing off the road into the ditches.

Fine textured material is need on the road surface to facilitate compaction and binding of soil particles to create a hard, smooth running surface. Regular road maintenance reduces overall road maintenance effort and costs over the long run. If a road is unmaintained and begins to rut, the loss of material for the grader to work with on the surface can be very costly to replace. Unmaintained roads contribute to unnecessary erosion, clogged ditches and culverts, and sedimentation in downslope creeks.



A plugged culvert prevents rain water to drain from a ditch near Lake Cowichan, BC



Road maintenance requiring the replacement of old culverts on Haida Gwaii

Deactivation

Once a road is no longer needed to access a cut block or resource, it can be deactivated by using an excavator to remove culverts and bridges, and restore natural cross slope drainage patterns. Cross ditches drain road side ditches by an open ditch across the road prism.

Waterbars are shallow excavations across the road surface to collect and drain water from surface of the road. In some cases, the entire road prism is excavated and “re-sloped” to match the surrounding terrain.

Road deactivation may occur on a localized basis within a cutblock when a short-term seasonal road was built for harvesting and is no longer needed. Once excavated and the soil is loosened, the site can be replanted with trees for the next rotation.

Road deactivation may also occur on a larger or entire valley scale when all seasonal, spur roads, and mainlines are deactivated. This is more common when tenure change occurs or there are specific land management plans being implemented that require restricting future access, such as Mountain Caribou habitat protection.

Roads may be permanently deactivated, or temporarily deactivated when an owner wishes to reduce road maintenance obligations and liabilities while trees regrow for a future harvest.

Road deactivation involves careful planning and consideration of local soil types, terrain, terrain stability and landslide history, geology, ground water flows, and surface flows associated with flooding and storm events.

A Professional Engineer or Geoscientist is usually involved and a prescription is prepared before the road deactivation is implemented. There have been many cases in the past where road deactivation was not completed with the appropriate level of diligence, and the actions of road deactivation resulted in the unintended consequence of major landslide events.



A road section is recontoured during deactivation near Quesnel Lake,
BC



One year after recontouring, vegetation grows on a deactivated road near Quesnel Lake, BC



A stream crossing near Williams Lake, BC is deactivated in a community drinking water supply area. Extra measures were taken to minimize erosion, monitor water quality, and facilitate vegetation re-growth

Terminology Related to Engineering Concepts—Self-Quiz

1. What is one benefit of puncheon?
 - ☐ Eliminates road friction on equipment
 - ☐ Allows road construction over soft, wet organic ground types
 - ☐ Acts as a barrier against water
 - ☐ None of these answers
2. Under normal conditions, the maximum adverse grade of a road should be:
 - ☐ 0-8%
 - ☐ 8-10%
 - ☐ 12-14%
 - ☐ 20-25%



Now check your answers on the next page.

Terminology Related to Engineering Concepts—Self-Quiz Answers

1. What is one benefit of puncheon?

Answer: **Allows road construction over soft, wet organic ground types**

2. Under normal conditions, the maximum adverse grade of a road should be:

Answer: **0-8%**

Section 1077-02: Common Instruments

What you need to know about this section

By the end of this section, you will be able to demonstrate knowledge of the following key points:

2.1 Common instruments used in road building

Key Point 2.1: Common Instruments Used in Road Building

In this section, we will review the common instruments used in road building. These instruments include levels, tripods, clinometers, and more.

Levels

A level is an instrument used to establish or verify points in the same horizontal plane. The level is used with a staff to establish the relative heights levels of objects. It is used in surveying and construction to measure height differences and to transfer, measure, and set heights of known objects.

The level establishes a visual relationship between two or more points. This is done by an inbuilt telescope and a highly accurate bubble level. Traditionally, the level was adjusted manually to get a level line of sight. Modern automatic versions balance out any errors and are easier to use.



Learning Point

There are several names for a level:

- Surveyors level
 - Builders level
 - Dumpy level
 - "Y" level
-

Rotary Laser

Rotary level lasers can cast a laser beam in a 360-degree circle. Rotary lasers are a bit larger and are typically mounted on surveying equipment such as tripods.

The laser beam projector uses a rotating head with a mirror for sweeping the laser beam about a vertical axis. If the mirror is not self-leveling, it has readable level vials and manually adjustable screws.

A staff with a movable sensor is used with the rotary laser. The sensor detects the laser beam and gives a signal (like a beep) when the sensor is in line with the beam. The position of the sensor on the staff (also known as a grade rod or story pole) lets you compare elevations between points on the terrain.



Automatic leveling rotary laser. Image Credit: Chris Cole, RPF, P. Eng.



Rotary laser, close up

Pipe Laser

Pipe lasers are used to align pipe and assist in setting grade. They produce a single dot towards the front of the laser and usually include brackets and hardware to clamp onto pipe or manholes for alignment purposes.

Tripods

A surveyor's tripod is used to hold surveying equipment, such as levels. The tripod is placed where it is needed. The surveyor presses down on the legs' platforms to anchor the tripod in soil or to force the feet to a low position on uneven ground. Leg lengths are adjusted to bring the tripod head to a convenient height.

Once the tripod is positioned and secure, the instrument is placed on the head. The mounting screw is pushed up under the instrument to engage the instrument's base and screwed tight when the instrument is in the correct position. The flat surface of the tripod head is called the foot plate and is used to support the adjustable feet.

Electronic Measurement Systems

Electronic measurement systems (EMS) are the systems in large machinery that tell the operator where to adjust the machinery settings to do an accurate job. This saves the operator from measuring or adjusting the machine manually and improves accuracy.

For example, the EMS in a grader shows the operator where the blade is. The system allows the operator to adjust the height and level of the blade from inside the machine.

Chain

A chain is a light nylon cord with a metal crimp and is used to measure distance. Chains are used to survey roads and are a two-person measurement tool. GPS is now readily available and has replaced the use of chains.



Measuring Tapes

The two most popular types of tape material are metal or fiberglass. Metal tapes are more durable and have a longer life expectancy than fiberglass.

Measuring tapes have different end options:

- A hook can attach to corners and edges. Most hooks feature a small notch so it can hook onto a nail
- A ring end can be placed onto poles, stakes and nails. It is also less likely to get caught in debris

Clinometers

A clinometer is an instrument used for measuring angles of slope, elevation, or depression. Clinometers measure both inclines (positive slopes, as seen by an observer looking upwards) and declines (negative slopes, as seen by an observer looking downward) using three different units of measure: degrees, percent, and topography.



Clinometer and compass. Photo Credit: Chris Cole, RPF, P. Eng.

Compass

A compass is an instrument used for navigation and orientation that shows direction relative to the geographic cardinal directions (North, East, South, and West).

In a compass, a small, elongated, permanently magnetized needle is placed on a pivot so that it may rotate freely in the horizontal plane. The Earth's magnetic field exerts a force on the compass needle, causing it to rotate until it comes to rest in the same horizontal

direction as the magnetic field. Over much of the Earth, this direction is roughly true north, which accounts for the compass's importance for navigation.

Navigating by compass requires determining bearings with respect to true or grid north from a map sheet and converting them to magnetic bearings for use with a compass.

Global Positioning System (GPS)

GPS is a global navigation satellite system that uses satellites, a receiver, and algorithms to provide location information.

A series of satellites orbiting the earth send a unique signal that is then read and interpreted by a GPS device. To calculate location, a GPS device must be able to read the signal from at least four satellites.

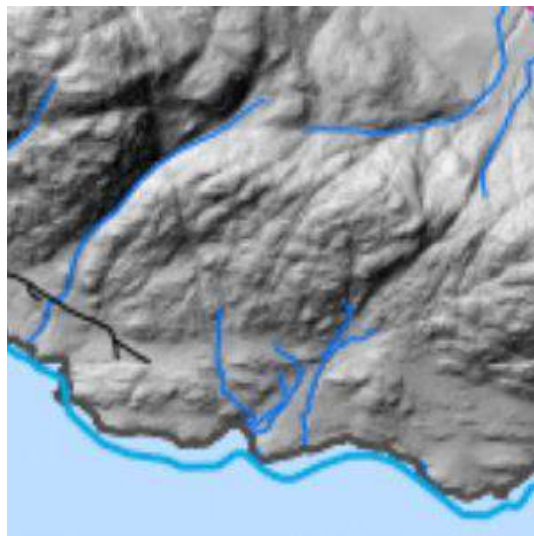
GPS is used in numerous industries for preparing accurate surveys and maps, taking precise time measurements, tracking position or location, and navigating.

Light Detection and Ranging (LIDAR)

LIDAR is a surveying method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor.

The name LIDAR, now used as an acronym of light detection and ranging, was originally an acronym for light and radar. LIDAR is sometimes called 3D laser scanning, a special combination of a 3D scanning and laser scanning.

Differences in laser return times and wavelengths can then be used to make digital 3-D representations of the target.



LIDAR hillside sample shown with vegetation layer removed. Image supplied by Chris Cole RPF, P. Eng.

Common Instruments Used in Road Building—Self-Quiz

1. The name lidar was originally an acronym for:

- ☐ Light and radar
- ☐ Light detection ability
- ☐ Light directional ability
- ☐ None of these answers

2. A clinometer is an instrument used for measuring angles of:

- ☐ Slope
- ☐ Oscillation
- ☐ Depression
- ☐ All of these answers



Now check your answers on the next page.

Common Instruments Used in Road Building—Self-Quiz Answers

1. The name lidar was originally an acronym for:

Answer: **Light and radar**

2. A clinometer is an instrument used for measuring angles of:

Answer: **Slope**

Section 1077-03: Slope and Grade

What you need to know about this section

By the end of this section, you will be able to demonstrate knowledge of the following key points:

- 3.1 How to identify slope
- 3.2 Expression of slope
- 3.3 How to control the creation of slope
- 3.4 Construction initiated slide and prevention measures

Key Point 3.1: How to Identify Slope

Understanding Slope

When identifying slope, you need to determine the distance and elevations with instruments. After distance and elevation have been measured, you can calculate the expression of slope.

When understanding slope:

- 1 or 100% slope. Slope is often referenced in a ratio. In this case, the 1m /1m slope would be 1:1 or 100%. This is a 1 meter elevation change over a distance of 1 meter. A 1:2 slope would be a 50% slope.
- A 100% slope (or 1:1) is also a 45-degree slope when referencing slope in degrees

Identifying Slope

To identify slope when on the terrain:

- Use a clinometer to check the line to see the slope or grade of a site

To identify slope with calculations:

- Slope is defined as rise over run
- Slope is often referenced in a ratio

How to Identify Slope—Self-Quiz

1. To calculate the expression of slope, you need to measure:

- ☐ Elevation
- ☐ Distance
- ☐ Elevation and distance
- ☐ None of these answers

2. Which is a steeper slope: 45% or 45 degrees?

- ☐ 45%
- ☐ 45 degrees
- ☐ They are the same slope



Now check your answers on the next page.

How to Identify Slope—Self-Quiz Answers

1. To calculate the expression of slope, you need to measure:

Answer: **Elevation and distance**

2. Which is a steeper slope: 45% or 45 degrees?

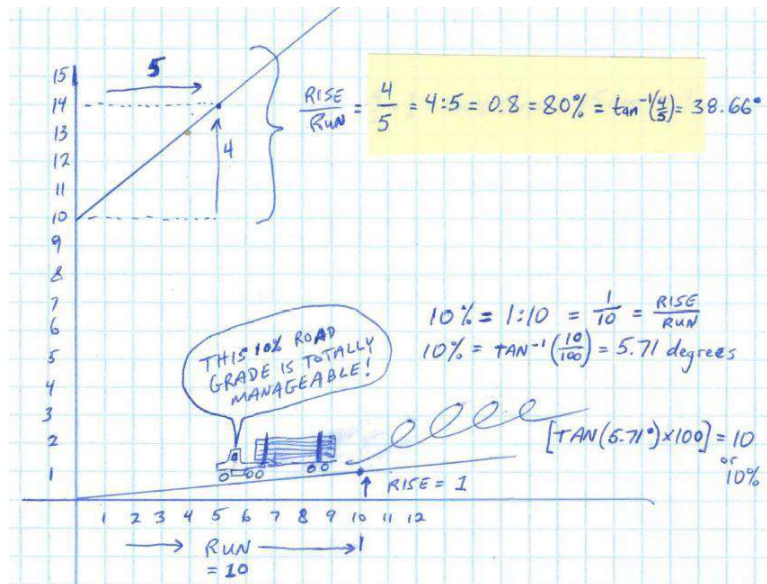
Answer: **45 degrees**

Key Point 3.2: Expression of Slope

In forestry, expressing (describing) the steepness of a slope is most commonly done by percent. For example, percent is often used to express the steepness of a road grade. Percent expression of slope is rise + run x 100.

Examples of expression of slope:

- If a road gains 1m in elevation over 100m in length, the slope would be “rise over run” or $1\text{m}/100\text{m} = 0.01$ or 1%
- If the road gained 5m in elevation over the 100m, the slope would be 0.05 or the road would have a road grade of 5%
- If a steep side hill had a 1m rise in elevation for every 1m horizontal distance into the hill, the “rise over run” would be 1m:1m



Expression of slope. Illustrated by Chris Cole, RPF, P. Eng.



Learning Point

Terrain with a slope over 60% generally is more prone to landslide events.

Expression of Slope—Self-Quiz

1. The expression of slope most commonly used in forestry is:

- ☐ Percentage
- ☐ Degrees
- ☐ Terrain units
- ☐ None of these answers

2. Percentage of slope is calculated by:

- ☐ $\text{Rise} \div \text{run} \div 100$
- ☐ $\text{Rise} + \text{run} \div 100$
- ☐ $\text{Run} \div \text{rise} \times 100$
- ☐ $\text{Rise} \div \text{run} \times 100$



Now check your answers on the next page.

Expression of Slope—Self-Quiz Answers

1. The expression of slope most commonly used in forestry is:

Answer: **Percentage**

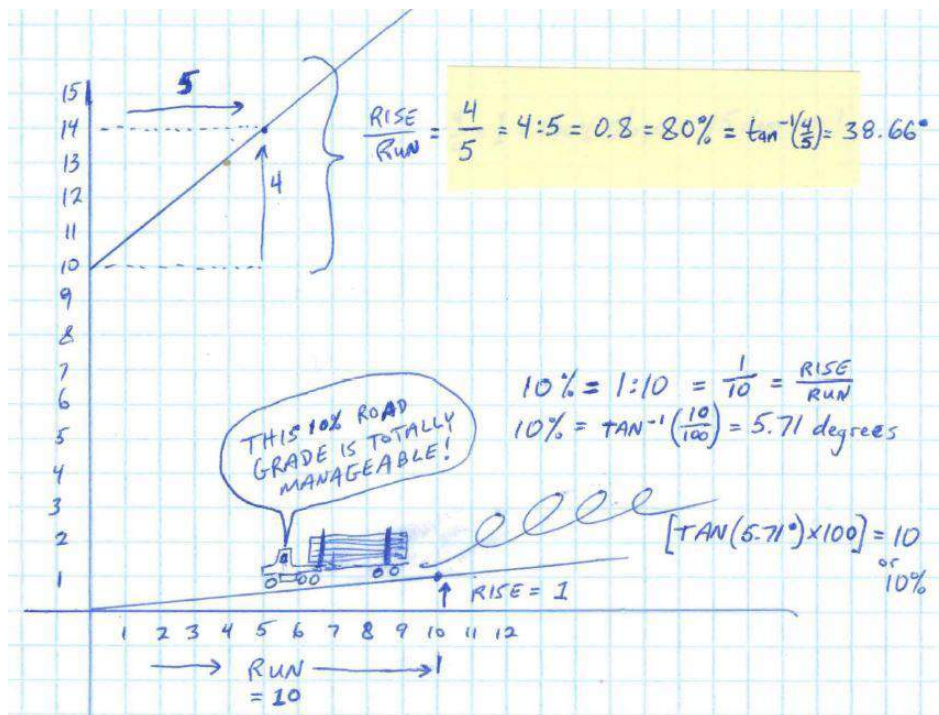
2. Percentage of slope is calculated by:

Answer: **$\text{Rise} \div \text{run} \times 100$**

Key Point 3.3: How to Control the Creation of Slope

The following are the different techniques to control the creation of slope:

- Direct measurement with a clinometer
- Determine distance and elevations with instruments and calculate expression of slope
- Approximate as appropriate for task. For example, eye level and pacing or with a tape measure
- Pipe laser for vertical and horizontal alignment of pipe



Creation of slope

How to Control the Creation of Slope—Self-Quiz

1. What is an easy to use field tool to measure and check the slope of the surrounding terrain?

- ☐ Sight laser
- ☐ Clinometer
- ☐ Lidar
- ☐ Compass



Now check your answers on the next page.

How to Control the Creation of Slope—Self-Quiz Answers

1. What kind of laser can be used to control the creation of slope?

☐ Answer: **Clinometer**

Key Point 3.4: Construction Initiated Slide and Prevention Measures

Understanding Slides

Slides initiated by road construction can be very serious and have significant human, environmental, and operational costs.

Preventing Construction Initiated Slides

Construction on steep slope areas can be complicated. Review and discussion of the plan is critical for all involved in planning, supervision and construction.

These points are critical to prevent slides:

- Watch for key site indicators such as unstable soils, seepage, wet site vegetation, organic soils, and smooth bedrock.
- Ensure water drainage control is appropriate for the circumstances.
- As an equipment operator, know your location and follow the plan.
- Take extra caution through transition zones.
- STOP work if things don't look right, and seek advice.



Video 6:25

YouTube—BC Forest Safety Council

[Road Construction Initiated Slides Awareness Training](#)



Video 50:29

YouTube—BC Forest Safety Council

[Road Construction Initiated Slides - Operator Training](#)

Construction Initiated Slide and Prevention Measures—Self-Quiz

1. Which points are critical to prevent construction initiated landslides:

- ☐ Ensure water drainage control
- ☐ Know your location and follow the plan
- ☐ Watch for key site indicators like organic soils
- ☐ All of these answers

2. What is a key site indicator to watch out for to prevent landslides:

- ☐ Large diameter trees
- ☐ Smooth bedrock
- ☐ Rocky soils
- ☐ All of these answers



Now check your answers on the next page.

Construction Initiated Slide and Prevention Measures— Self-Quiz Answers

1. Which points are critical to prevent construction initiated landslides

Answer: **All of these answers**

2. What is a key site indicator to watch out for to prevent landslides:

Answer: **Smooth bedrock**

Section 1077-04: Common Utilities

What you need to know about this section

By the end of this section, you will be able to demonstrate knowledge of the following key points:

- 4.1 Common utilities and their location
- 4.2 Techniques used to expose existing utilities

Key Point 4.1: Common Utilities and Their Location

A utility company supplies a service such as gas, hydro, electricity, etc. Utilities consist of distribution lines, pipelines, flow lines, sewer and water systems, electrical transmission and distribution lines and more.

All utilities situated on Crown land, whether buried under ground, hung on poles or sunk/buried under water require authorization from the Province of British Columbia, with the exception of provincial pipelines, which are authorized by the Oil and Gas Commission.

Common utilities include:

- Water
- Sanitary
- Storm water
- Hydro (electricity)
- Phone
- Natural gas

Locations

Utility lines are buried (underground utilities) or hung from pole to pole (aerial utilities). These locations should be marked on any operational maps and discussed during pre-work meetings before any work takes place on a work site.

Common Utilities and Their Location—Self-Quiz

1. Which utilities are commonly found in BC?

- ☐ Sewer
 - ☐ Natural gas
 - ☐ Phone
 - ☐ Water
 - ☐ All of these answers
-



Now check your answers on the next page.

Common Utilities and Their Location—Self-Quiz Answers

1. Which utilities are commonly found in BC?

Answer: **All of these answers**

Key Point 4.2: Techniques Used to Expose Existing Utilities

To expose existing utilities, the general practice is:

1. Identify and contract the utility companies to ask for location maps and description of possible utilities buried at the work site. The utility company may come to the site to place markings on the ground to show the locations.
2. Dig by hand using a shovel to expose all buried facilities before using mechanical excavation equipment. Most utility companies state that the hand dig zone extends 1 meter on either side of the line. Yellow warning tape may be buried about 30 cm above the utility. Loose sand may also surround the utility.
3. As an alternative to hand shoveling, a hydro vac truck can be used to spray water and suck the dirt and rocks out from around the buried utility. This is more expensive and can only be done in areas where the truck can drive.



Learning Point

Before excavating ground on or near private land in BC, Call BC One – A utility location service provider that helps people locate utilities free of charge. Find out more at: <https://www.bc1c.ca/>



Video 2:17

YouTube – FortisBC

[Safely excavating around natural gas lines](#)

Techniques Used to Expose Existing Utilities—Self-Quiz

1. What must be done before mechanical excavation is done to expose a utility:
 - ☐ Check for the location of riparian area
 - ☐ Dig by hand to expose the utility
 - ☐ Remove large rocks from the site
 - ☐ Call 911
2. What is an alternative to hand shoveling?
 - ☐ A pick axe
 - ☐ A shot blaster
 - ☐ A hydro vac truck
 - ☐ All of these answers



Now check your answers on the next page.

Techniques Used to Expose Existing Utilities—Self-Quiz Answers

1. What must be done before mechanical excavation is done to expose a utility:

Answer: **Dig by hand to expose the utility**

2. What is an alternative to hand shoveling?

Answer: **A hydro vac truck**