

BC CARPENTER APPRENTICESHIP PROGRAM

LEVEL 1

2017 (Harmonized)

Line F: Site Layout

Competency F-1: Lay Out Building Locations

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Symbol Legend



Electric shock: This icon is a reminder for potential electric shock.



Explosive: This icon is a reminder for a possibly explosive situation.



Flammable: This icon is a reminder for a potentially flammable situation.



Important: This icon highlights important information.



Poisonous: This icon is a reminder for a potentially toxic/poisonous situation.



Resources: The resource icon highlights any required or optional resources.



Safety gear: The safety gear icon is an important reminder to use protective equipment.



Self Test: This icon reminds you to complete a self test.

We want your feedback! Please go to the BC Trades Modules website (www.bctradesmodules.gov.bc.ca) to enter comments about specific sections that require correction or modification. All submissions will be reviewed and considered for inclusion in the next revision.

Program Outline

Line A – Safe Work Practices

A-1 Apply Shop and Site Safety Practices

A-2 Apply Personal Safety Practices

Line B – Documentation and Organizational Skills

B-1 Use Construction Drawings and Specifications

B-2 Interpret Building Codes and Bylaws

B-3 Plan and Organize Work

B-4 Perform Trade Math

Line C – Tools and Equipment

C-1 Use Hand Tools

C-2 Use Portable Power Tools

C-3 Use Stationary Power Tools

Line D – Survey Instruments and Equipment

D-1 Use Levelling Instruments and Equipment

Line E – Access, Rigging, and Hoisting Equipment

E-1 Use Ladders, Scaffolds and Access Equipment

E-2 Use Rigging and Hoisting Equipment

Line F – Site Layout

F-1 Lay Out Building Locations

Line G – Concrete Formwork

G-1 Use Concrete Types, Materials, Additives and Treatments

G-2 Select Concrete Forming Systems

G-3 Build Footing and Vertical Formwork

G-4 Build Slab-On-Grade Forms and Suspended Slab Forms

G-5 Install Reinforcement and Embedded Items

G-7 Place and Finish Concrete

Line H – Wood Frame Construction

H-1 Describe Wood Frame Construction

H-2 Select Framing Materials

H-3 Build Floor Systems

H-5 Build Stair Systems

H-10 Build Decks and Exterior Structures

Line J – Building Science

J-1 Control the Forces Acting on a Building

Competency F-1: Lay Out Building Locations

Laying out building locations involves a logical series of steps that must satisfy both legal and construction requirements. Knowledge of these requirements is important, not only to ease assembly and installation of materials, but also to ensure the best use of the site within geographic and legal limitations.

Learning Objectives

When you have completed the Learning Tasks in this Competency, you will be able to:

- identify and use survey markers
- describe excavation and grading procedures
- select appropriate methods to lay out a building site
- lay out a site and square corners
- describe and use batter boards

Competencies

Written: “Lay Out Building Locations”

You will be tested on your knowledge of the terminology for survey, excavation, and grading, and on your knowledge of procedures and sequence of events related to these competencies.

Practical: You will be required to select the most appropriate method to lay out a building site. You will also be required to lay out a foundation project.

LEARNING TASK 1

Describe Excavation and Grading Procedures

Property parcels are defined by measurements and angles. Boundaries are marked using iron pins and other means. Drawings are created to illustrate the location of the property line measurements and where markers are located. These drawings are usually township maps or district maps, and on a larger scale, subdivision plans. This type of work is performed by licensed land surveyors.

To position a building on a lot, a draftsman or builder creates what is known as a “plot plan” or “site plan.”

Once the building’s foundation is complete, the builder is usually required to hire a licensed land surveyor to verify the setback to property lines. This drawing is referred to as a “survey certificate.”

Legal Descriptions

The legal description of a piece of property is simply a written reference on a registered plan. Typically it will have a lot number, plan number, a district lot number, and district name. Terminology has changed over the years. At one time, instead of district lots, there were ranges, or sections, and blocks instead of plan numbers.

The legal description of a property is also found in mortgage, purchase, tax and insurance documents, and on the Certificate of Title.

Subdivision Plans

A subdivision plan is a small drawing showing a property’s relationship to nearby properties. Such plans are registered and stored at the local Land Titles Office and available to property owners and builders.

These plans show the length of property lines, the azimuth angle of the line (degrees from true north), and the location of markers.

When a piece of property is subdivided, each new lot is given a number, and the subdivision plan is also given a plan number upon registration. Subdivision plan numbers are sequential, and a knowledgeable person can determine how old the subdivision is by looking at the plan number.

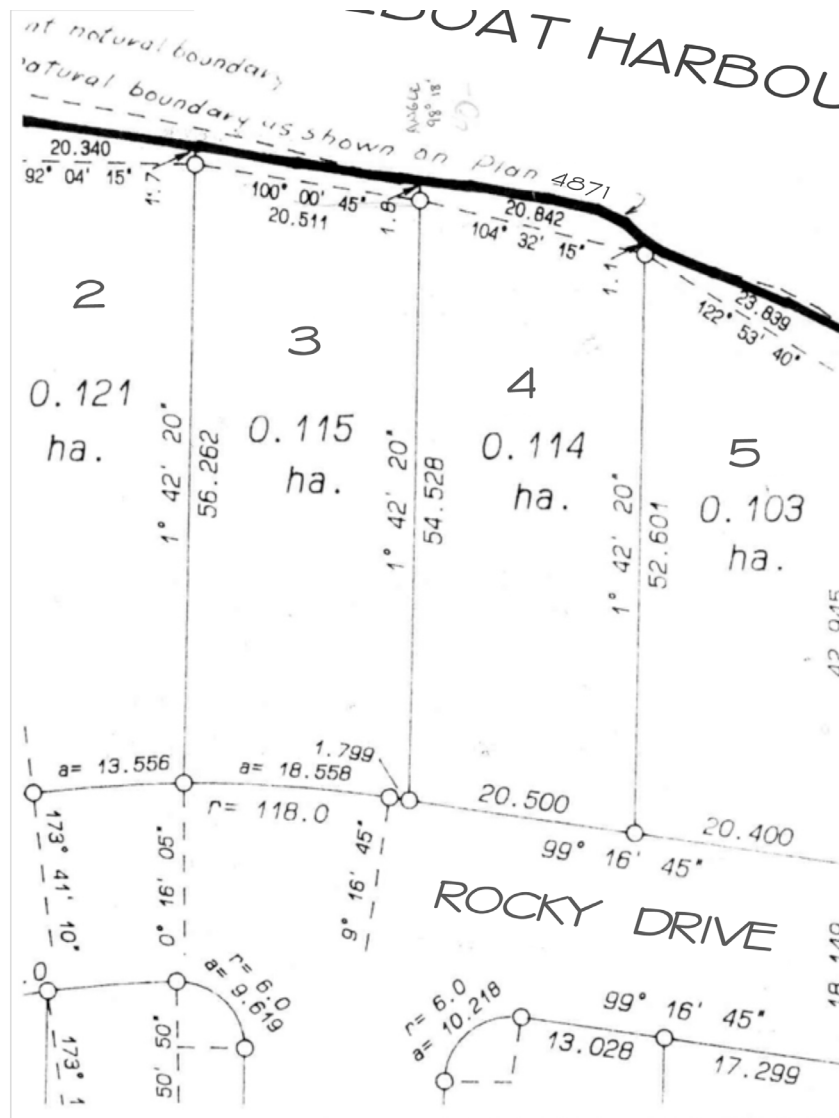


Figure 1 — Portion of a subdivision plan

Survey Certificate

Figure 2 shows a survey plan or survey certificate. This plan is normally required by the building inspector and should be completed shortly after the foundation forms have been stripped.

Mortgage providers will also often require a survey certificate. The purpose of the certificate is to make sure the foundation is not encroaching into the required zoning setbacks, or worse yet, over a property line. It's better to catch problems before concrete is placed. This requires careful attention to site boundaries and setback bylaws. With large houses being built on small lots, most building contractors hire a surveyor prior to the start of construction to make sure the proper setbacks are maintained. Even though not intended for carpenters, the plan can be quite useful for designing and siting additions and additional buildings on a property.

The survey plan provides:

- the legal description of the property
- the name of the owner
- the name of the person responsible for surveying the property
- the location of the property relative to streets and adjacent properties
- the type and setbacks of buildings on the property
- the orientation of the property relative to the north point on the compass
- information regarding encroachments on other properties (e.g., a house's eaves projecting over a neighbouring property line)

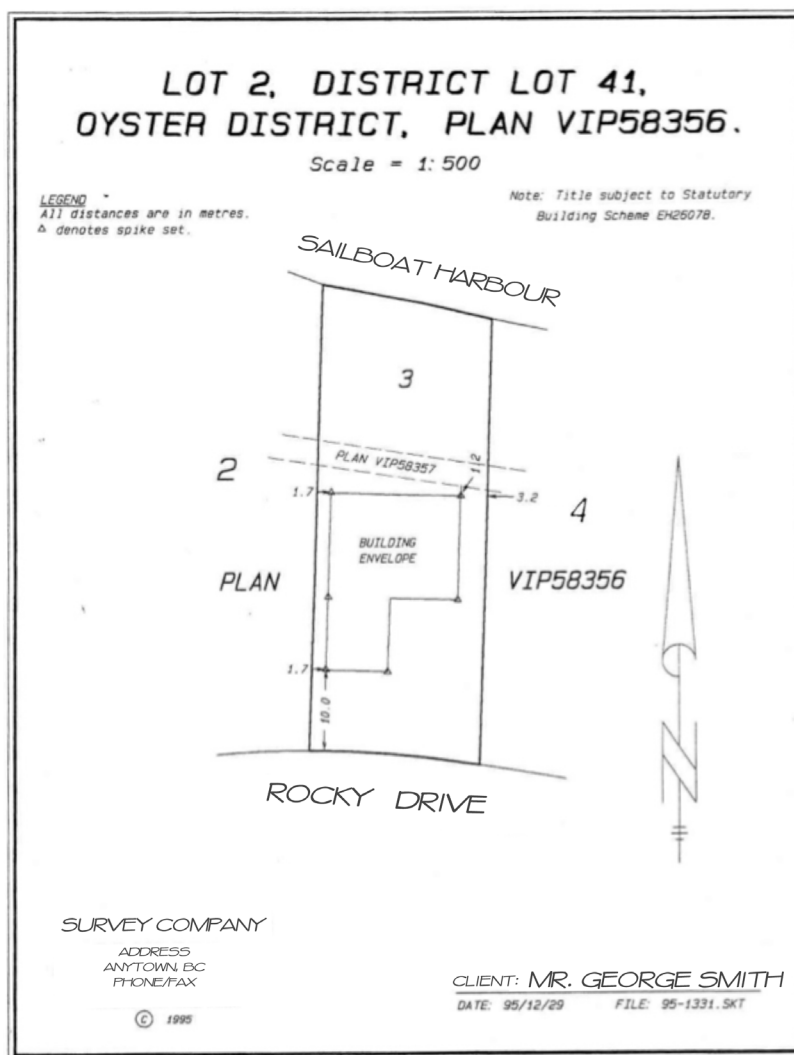


Figure 2 — Survey certificate

Plot Plans

A plot plan (also called a “site plan”) is designed for use by those working on the site, such as carpenters. It’s also required in order to obtain a building permit. A plot plan gives most of the information in the survey plan, but also gives details regarding the future location and foundation height of buildings, sidewalks, and driveways (Figure 3). You’ll use this type of plan for laying out the building’s foundation and setting grades. A licensed land surveyor may be needed to pin the location of the building corners.

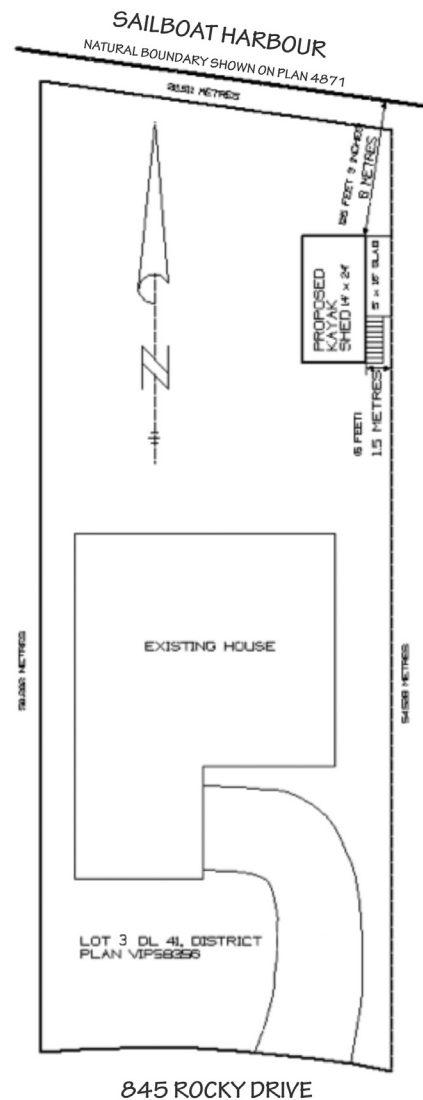


Figure 3 — Plot plan

Another example of a site plan can be found on page 2 of the Ladysmith Vacation Cabin plans. That plot plan includes elevations for the top of the foundation wall (TOW) and for one iron pin.

Zoning Considerations

It's particularly important, before planning lot layout or designing the structure, to check the zoning of the area in which you intend to build. Municipalities have varying rules regarding building size, height of building, permitted side, front and back yard setbacks, and the percentage of the lot allowed to be covered by the building.

Front, rear, and side zoning setbacks are measured differently in different jurisdictions. In some cases, the measurements are to the foundation, and in other areas measurements are to the farthest projection (outside of gutter). Do not waste time and money—know the zoning requirements first.

Describe Excavation and Grading Procedures

Carpenters often have to oversee every phase of construction, including site preparation and excavation. All underground services must be located before any work can be started. Excavations greater than 3.7 metres wide are considered bulk excavations. Although the safety requirements are similar to those for trench excavations, there are some differences.

Site work may involve removal or placement of fill dirt to achieve the desired contour or drainage. In most cases, some excavation is also required. It's important that you're able to determine which excavation or grading procedures are required.

Clearing the Site

On some sites, it's necessary to remove garbage, trees, brush, debris, or old frames and foundations before anything else can be done. This time-consuming process is called "grubbing."

Site Survey

Most sites are not perfectly level before the excavation. Elevations over the entire site are shot and a plan prepared for cut and fill along with an estimate of soil that must be brought in or removed.

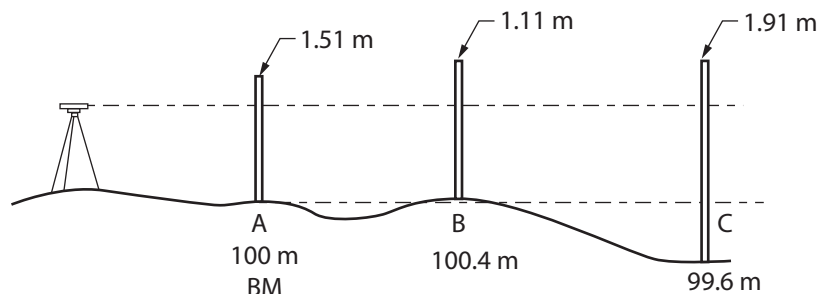


Figure 4 — Benchmark and grade elevations

As part of the site survey, test pits will be dug to the full depth of the excavation to determine water table heights and what type of soil will be encountered during the excavation. Test pits will also determine if bedrock is present, requiring drilling and blasting. The locations of the test pits are determined from the site plan.

To determine whether there are any ground water problems, the test pits should not be filled in immediately after being dug—leave the test pits open for several hours to see if water seeps into the pit. If there is water collecting in the pit, then it will collect in the excavation and will have to be removed. Test pits can be dangerous when left open and should not be left unguarded or unattended.

Grading

The term “grade” refers to the surface of the ground on the job site. Natural grade is indicated by the abbreviation “NG.” Natural grade may not be what nature provided—it’s the grade at the time the subdivision was registered as complete. Natural grade is used to determine building height in regards to zoning requirements.

The architect’s plan may require the ground’s surface to be raised or lowered. The finished grade is indicated by the abbreviation “FG.”

“Grade” also means “slope.” For example, a 2% grade means that the earth drops or rises 2 m vertically for every 100 m travelled horizontally. Alternatively, this is sometimes called a 2% fall or rise.

Grade elevations are often established by referencing them to a benchmark on or near the building site. This benchmark is often arbitrarily assigned an elevation of +100.000 m. Points on the job site that are higher than this benchmark have values greater than 100 m. Points that are lower have values less than 100 m.

Gridlines and Grade Stakes

On a large site where grading is required, a series of gridlines is set up to determine where soil must be removed or added. Gridlines are lettered in one direction and numbered in the other direction.

A grade stake is driven into the ground at the intersection of the gridlines and the amount of cut or fill is marked on each stake. The stakes are usually spaced far enough apart to allow movement of earth-hauling equipment between the lines.

By using gridlines, the stake locations are easily identified on site and on the layout plan. Grade stakes located at the corners of excavations indicate the depths of cut. Figure 5 shows a sample layout for grade stakes is shown in Figure 5, and includes an enlarged picture of a grade stake with its markings.

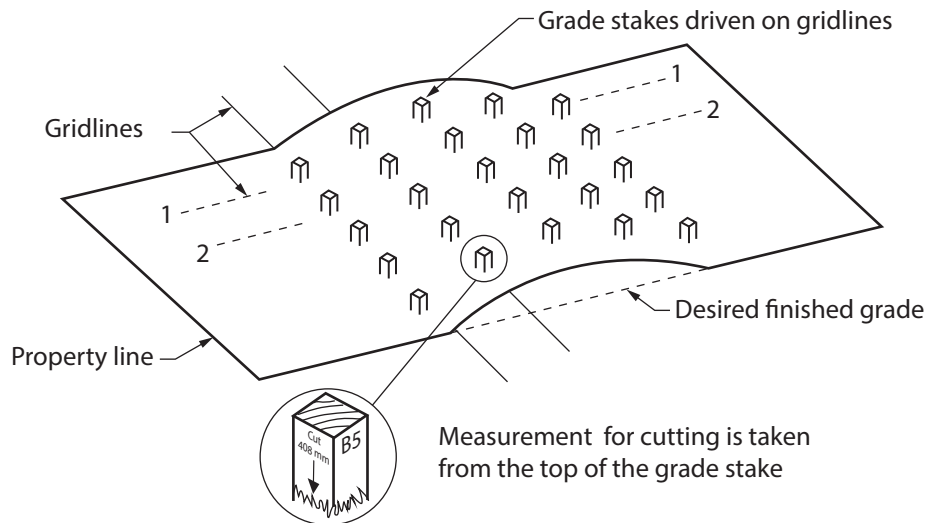


Figure 5 — Sample layout of grade stakes

The stakes are sometimes very tall if fill is to be piled around them. If considerable earth cutting and removal is required, the earth around the grade stakes may be left undisturbed and removed after the spaces between the stakes have been cut to grade (Figure 6).

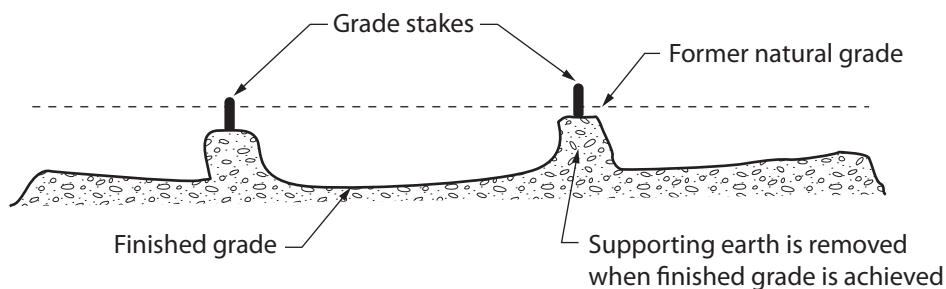


Figure 6 — Grade stakes with supporting earth during excavation

Cut and Fill

Costs of construction are directly related to the amount of work that must be done. It is wise, therefore, to determine how much brush and debris must be removed and how much cutting (excavating) of high areas and filling of low areas must take place. Experienced planners attempt to balance the amount of earth to be cut with the amount of fill required. Significant savings can be realized if the amount of fill removed is equal to the amount of fill required (Figure 7).

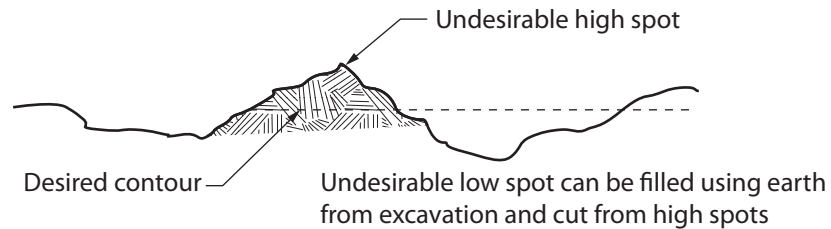


Figure 7 — Excavation site showing earth movement

Excavation Planning

Excavations need to be carefully planned. The bottom of the excavation must be kept free of standing water and not allowed to freeze. Sides of excavations need to be sloped, benched, or shored. Provisions to get the excavation equipment out of the excavation are required. Trucking away excavation material is often required.

In some cases, there may be a requirement that a laboratory test the soil for density, porosity, and cohesion. These factors, along with moisture content, have a strong bearing on the safety of the excavation and on foundation types and equipment used.

If the bottom of an excavation cannot be drained by gravity and grading, a sump pit must be created and a pumping station set up. The bottom of the excavation will be graded to drain into the sump. In some cases, a dewatering system is installed by sinking a series of small-diameter well-points over the excavation area and then pumping to maintain the desired water table height.

The excavation is usually larger than the building on each side by 0.6 to 1.0 m. This is to provide working room and for the projection of the footing and drain tile beyond the foundation wall. If the excavation is deep, the working room is usually greater to allow for larger forms and to allow for rubble sliding into the excavation. If there is to be a granular base or a void under the building, the excavation is made deep enough to accommodate this additional base.

Topsoil is usually stripped away and stored on site—it's replaced when the project is complete. The location and depth of underground services must be known so that they're not damaged during excavation.



Call 1-800-474-6886 before you dig. BC One Call provides a free service to locate underground services. You can also get this information online by filling out an E-ticket at <http://www.bconecall.bc.ca/>. This service may take up to three days, so call ahead of time.



Figure 8 — A good reason why services must be located before excavation begins

Excavation Safety

Excavating for a building's foundation must be done in a safe manner. The finished excavation must provide a solid bearing surface for the building's foundation.

Truck excavated materials away from the site, or pile the material away from the edge of the excavation. For bulk excavations, the pile must be at least 4 feet from the edge of the excavation. If digging a trench, keep the pile back at least 2 feet.

Do not pile excavated materials in steep-sided piles that can slough and injure workers. Stabilize utility poles, trees, and large boulders. Do not place boulders where they can roll into the excavation.

Sloping, Benching, and Shoring Requirements

An excavation is a hole in the ground. When a hole is dug, it changes the stability of the soil that surrounds the hole. For most soils, if a vertical cut is made, some sloughing (sides caving in) will occur.

If the hole is left for a few months, the sloughing will reside and stabilize at a constant slope. The angle this slope forms is referred to as the “natural angle of repose.” Every type of soil has a different natural angle of repose. If an excavation is dug and the sides of the excavation are not sloped, it will cave in until the natural angle of repose is formed.

As sloughing can be dangerous to workers, measures must be taken to prevent this from occurring. These measures consist of sloping the sides of the excavation, benching the sides, or providing shoring.

Sloping

Sloping requirements for bulk excavations are the same as for trenches. The maximum allowable slope is 0.75:1 (3 horizontal to 4 vertical). WorkSafeBC's *OHS Regulation* also allow for a vertical cut up to 1.2 metres and then sloping to finish the excavation. The angle of the slope is dependent on the depth of cut (Figure 9).

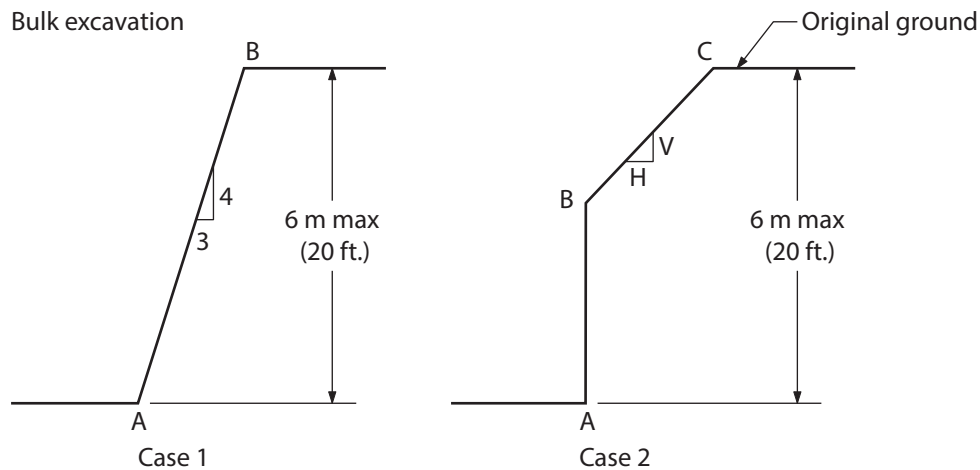


Figure 9 — Sloping in lieu of shoring

Case 1: maximum slope of excavated face, shown as line AB, in hard and solid soil is 3 horizontal to 4 vertical.

Case 2: maximum height of vertical portion, shown as line AB is 1.2 metres (4 ft.).

For case 2, the maximum permissible slope of the excavated face BC for the corresponding height of the lower vertical cut AB is as follows:

Height of line AB		Maximum slope of line BC (in hard and sold soil)
cm	feet	
up to 30	up to 1	1 horizontal (H) to 1 vertical (V)
30–60	1–2	3H to 2V
60–90	2–3	2H to 1V
90–120	3–4	3H to 1V

Benching

Benching is often more desirable than sloping. It can provide a better area to anchor wall form braces to, and it provides better access to catwalks along wall forms. WorkSafeBC's *OHS Regulation* allows three different benching cases (Figure 10). It should be noted that Case 3 does not allow workers to be on any of the benches.

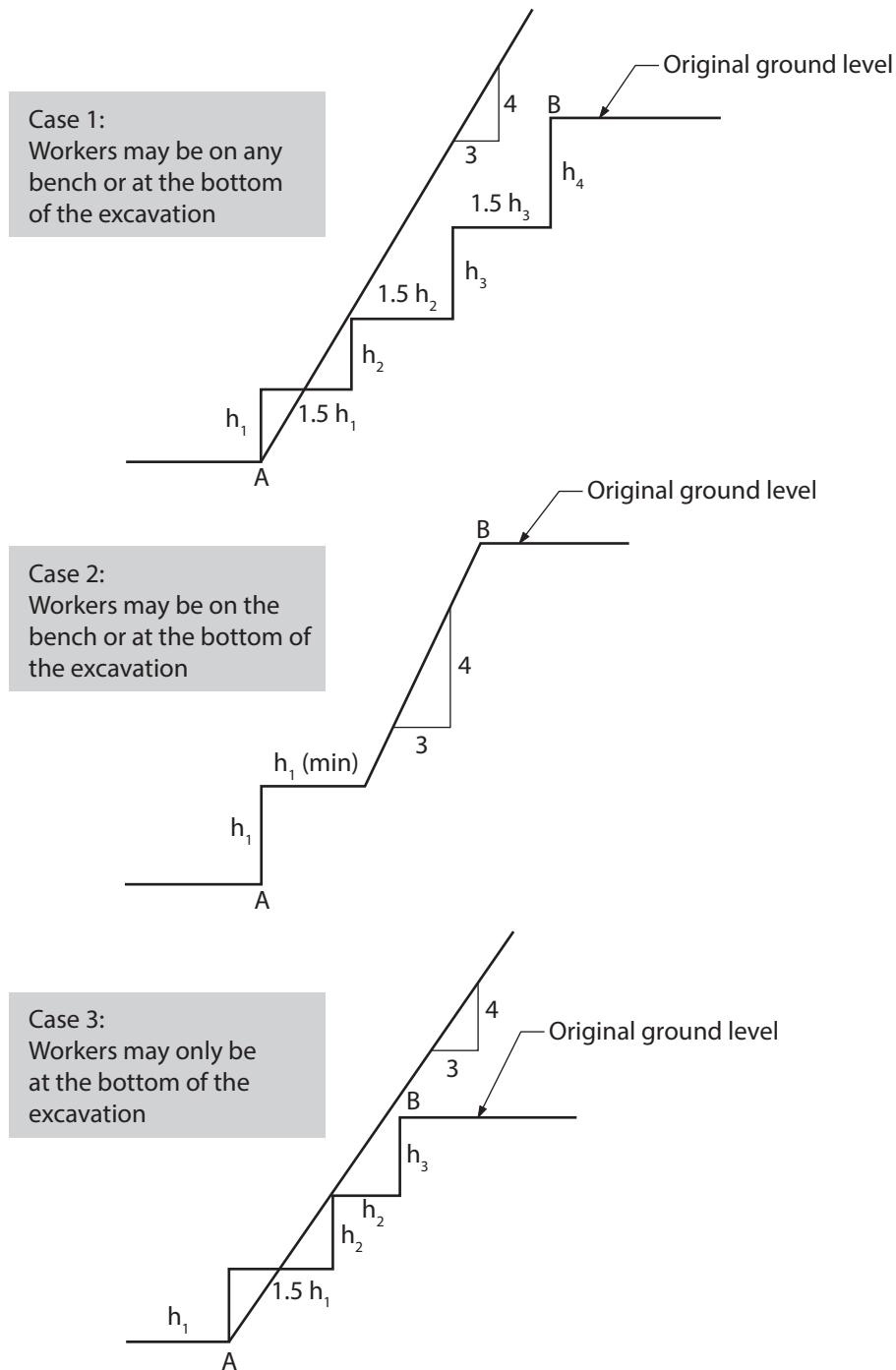


Figure 10 — Benching in lieu of shoring

For each case:

- Point A is the bottom or the deepest part of the excavation.
- Point B is the original or unexcavated ground level.
- Maximum difference in elevation between A and B (Max depth of excavation) is 6 metres (20 feet).
- Maximum height of each bench (h_1, h_2, h_3, h_4) is 1.2 metres (4 feet).

In all cases, if maximum depth of excavation is greater than 6 metres (20 feet), instructions from a professional engineer must be followed.

Shoring

Many job sites do not have room to allow for sloping or benching. In these cases, the sides of the excavation need to be shored when the cut is more than 1.2 m (4') deep. Because bulk excavations cannot be easily cross-braced as with a trench excavation, a professional engineer is required to design and inspect the shoring.

Excavations for tall buildings are sometimes deeper than 30 m (100'). The type of shoring will depend on the depth of cut, type of soil, and the building foundation requirements.

Estimating the Volume of Excavated Material

It is important to be able to estimate the volume of material excavated from the site of a foundation. The estimate of excavated material is used to determine the cost of the excavation and what type of equipment is required.

The estimate will also allow the builder to determine if fill material is going to be required or if the excavated material will have to be hauled away from the site.

Soil Types

When material is dug out of the ground there is always a certain amount of bulking of the material. The bulking factors are used to determine how much actual material is going to have to be dealt with, either hauled away or moved to a location on the site that needs to be filled. To allow for the bulking, calculate the amount of material to be excavated and then multiply that amount by the factor for the type of soil.

For example, if 1200 cubic metres of average clay was to be excavated it should be expected to bulk up by 20%. So instead of having 1200 m³, there would be $1200 \times 1.20 = 1440$ m³ of material that will have to be dealt with.

Bulking of Soils During Excavation

Soil Type	Bulking Factor	Bulking Percentage
Sand	1.05 to 1.12	5 to 12%
Gravel	1.10 to 1.15	10 to 15%
Clay	1.15 to 1.30	15 to 30%
Loam	1.15 to 1.25	15 to 25%
Topsoil	1.25 to 1.30	25 to 30%
Well blasted rock	1.20 to 1.25	20 to 25%
Poorly blasted rock	1.35 to 1.50	35 to 50%

Figure 11 — Bulking factors

Calculate the Volume of Excavated Materials

The bottom of an excavation is usually larger than the building's footprint. To be able to work around the outside of the foundation walls, some working room is required. The working room is used to strip the formwork, coat the foundation with dampproofing or waterproofing materials and to lay the perimeter drainage.

Unless shored or benched, the sides of the excavations are sloped at 0.75 horizontal : 1 vertical making the top of the excavation larger than the bottom of the excavation.

Volume for rectangular solids is normally calculated by multiplying length × width × depth. As the top of excavation is larger than the bottom due to sloping, the shape is not a true rectangular solid. Its shape is known as a rectangular frustum.

The formula for volume of a rectangular frustum is:

$$\text{Volume} = \frac{\text{Area of Bottom} + \text{Area of Top}}{2} \times \text{Depth}$$

Example 1

Assumptions:

- the excavation is on perfectly flat land
- the building is 6.500 metres long and 4.200 metres wide
- excavation depth = 2.5 metres
- sides of the excavation will be sloped at 0.75 : 1
- working room = 600 mm on each side
- bulking factor is 10%
- working room allowance is 600 millimetres
- volume will be rounded to the nearest cubic metre

The volume is calculated in four steps:

1. Bottom area of the excavation is building size plus working room
 $(0.6 + 6.5 + 0.6) \times (0.6 + 4.2 + 0.6) = \text{Area of Bottom}$
 $7.7 \times 5.4 = 41.58 \text{ m}^2$
2. Top area of the excavation is the bottom size plus the sloped area
 $((0.6 + 6.5 + 0.6) + (0.75 \times 2.5)) \times ((0.6 + 4.2 + 0.6) + (0.75 \times 2.5)) = \text{Area of Top}$
 $(1.875 + 7.7 + 1.875) \times (1.875 + 5.4 + 1.875) =$
 $11.45 \times 9.15 = 104.77 \text{ m}^2$

Using the formula for a rectangular frustum

$$\text{Volume} = \frac{41.58 + 104.77}{2} \times 2.5 = 183 \text{ m}^3$$

By adding 10% for bulking

$$183 \times 1.10 = 201 \text{ m}^3$$

The total volume for the excavation is 183 cubic metres. The bulking factor of the soil is applied to the total volume to get the actual volume of 201 cubic metres of material to be trucked away or used on site.



Now complete Self Test 1 and check your answers.

Self Test 1

1. What is the “legal description” of a property?
 - a. a drawing showing its relationship to other properties
 - b. a written reference on a plan or mortgage document
 - c. a drawing showing its relationship to the city or municipality
 - d. a written reference describing such things as buildings and sidewalks
2. What information is in a legal description?
 - a. size of structures, location of city services, and streets
 - b. size of lot, structures, surrounding lots
 - c. lot number, plan number, district lot number, district name
 - d. owner, mortgage company, surveyors, lawyers
3. Which of the following is on a surveyor’s certificate or survey plan?
 - a. location of trees and shrubs
 - b. lot elevations
 - c. electrical and water services
 - d. adjacent street names
4. Which of the following is on a site or plot plan?
 - a. lot elevations
 - b. door and window sizes
 - c. water table information
 - d. description of foundation materials
5. What is an encroachment?
 - a. an easement
 - b. any property bordering on water
 - c. a building that extends onto another property
 - d. an oath sworn by a legal land surveyor
6. Why is the site plan more useful than the survey certificate to the carpenter?
 - a. The survey certificate is produced by the architect.
 - b. The survey certificate omits unnecessary details.
 - c. The site plan is a drawing, but the certificate is a description.
 - d. The site plan contains more relevant information.

7. Referring to the Ladysmith Vacation Cabin plans, how high is the top of the foundation wall above the elevation of the northeast iron pin?

8. Referring to the Ladysmith Vacation Cabin plans, how far does the top of the foundation wall project above the contour line elevations shown?

9. Why does the foundation wall project this much?

10. How can the builder take advantage of cut and fill practices to reduce the cost of transporting fill dirt?

- a. by advertising and selling the excess excavated material
- b. design the building so that the excavation is shallow
- c. by using as much excavated dirt as possible to fill low areas
- d. sell the topsoil and use ground covers such as crushed rock

11. What does the term “grade” describe?

- a. the surface of the ground, or sloping ground
- b. the height of the building above ground
- c. the finish floor of the basement below ground
- d. the type of soil as sampled below ground

12. What is the arbitrary height usually assigned to a benchmark?

- a. 0.000 m
- b. 10.000 m
- c. 100.000 m
- d. 1000.000 m

13. Grade stakes are usually placed on:
- gridlines
 - grade lines
 - high spots
 - low spots
14. If grade stakes are placed very close to each other, they can:
- cause confusion for the surveyor or carpenter
 - be destroyed by the earth-moving equipment
 - be difficult to interpret
 - cause a tripping hazard for workers
15. Gridlines are usually indicated by:
- flagged surveyors' lath
 - batter boards and lines
 - information on the plot plan
 - a letter and a number
16. Where is the depth of a cut taken from?
- surveyors' certificate
 - the soil beside the grade stake
 - the top of the grade stake
 - plot or site plans
17. The removal of garbage, brush, debris, old frames, and foundations during the clearing of a site is called:
- backfilling
 - grubbing
 - shrubbing
 - grading

18. Find the volume of excavated material for the following specifications:
- a. Building 4.500 metres long and 3.200 metres wide.
 - b. Excavation depth = 1.5 metres.
 - c. Working room = 600 mm on each side.
 - d. Slope the sides of the excavation to the WorkSafeBC required slope of 0.75 horizontal to 1 vertical.
 - e. The soil is consistent over the whole site and is clay.

LEARNING TASK 2

Build Batter Boards

In order to construct a square and accurate foundation, the layout must also be square and accurate. Building lines are transferred to the bottom of excavations from string lines attached to batter boards. The best way to ensure square during layout is to check the measurements of the sides and then compare the measurements of the diagonals.

Diagonals Method

The Pythagorean Theorem states that for a right angle triangle, the square of each side added together equals the square of the hypotenuse ($a^2 + b^2 = c^2$).

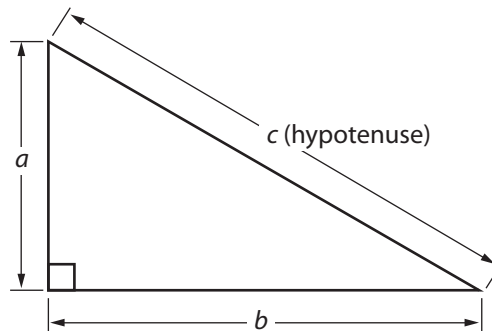


Figure 1 — Right angle triangle

The diagonal length of a building is found by squaring the building's front length and side length, adding them together, and taking the square root of the sum. If a four-sided object is a true rectangle with equal opposite sides and 90° corners, both diagonals will be the same length. If the opposite sides are equal and the diagonals are not the same, the layout is not square.

Measuring the sides and diagonals in a layout requires at least two people. Normally two 30 m (100') measuring tapes are required. It's important to ensure that the tapes are very tight, because sagging gives a false reading. All measurements must be done on the horizontal plane.

The following method is used:

1. Using the setbacks found on the site plan, set the two front corners in the correct locations.
2. From one front corner, run a tape measure the side length of the building. From the other front corner, run another tape measure the length of the diagonal (Figure 2).
3. Where the two tape measurements intersect, mark the third corner.

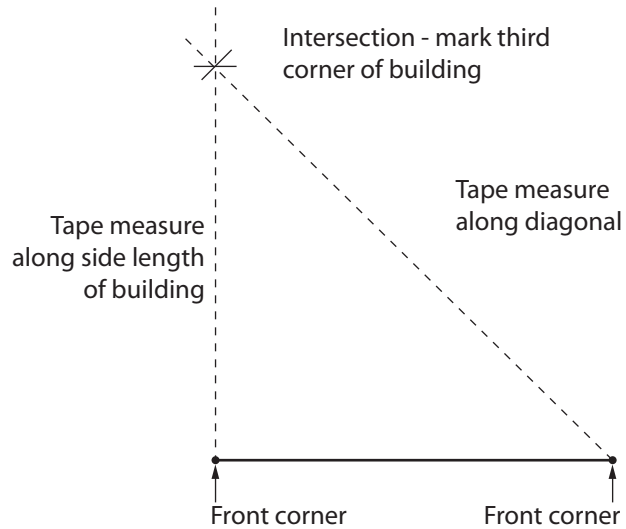


Figure 2 — Locating the third corner

4. Measure both missing sides to find the location of the fourth corner. To do this, use two measuring tapes, one running from the third corner across the back building line and the other from the front corner along the missing side building line. Mark the fourth corner where the two measurements intersect (Figure 3).

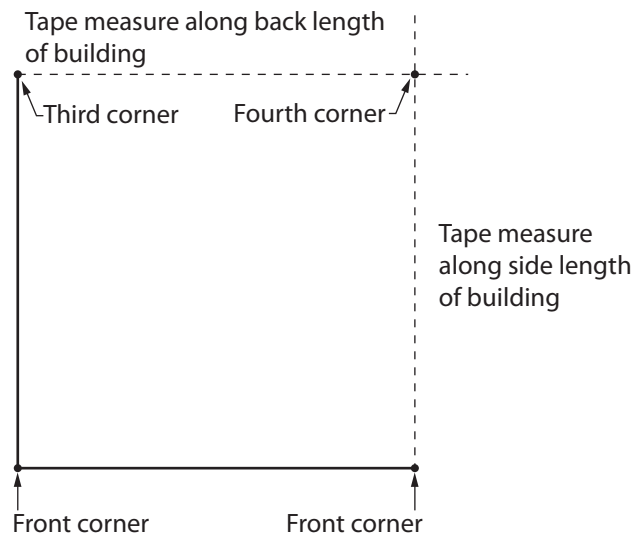


Figure 3 — Locating the fourth corner

5. Measure the other diagonal. If the layout is square, the diagonals will be within 1 to 2 mm of each other (Figure 4).

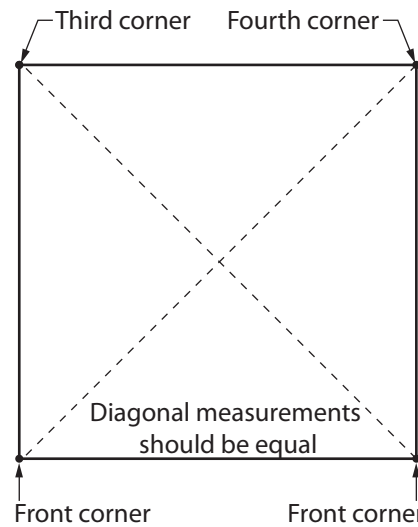


Figure 4 — Measuring diagonals to confirm locations of third and fourth corners

Accurate layout is extremely important. Once the foundation is poured, there are no second chances. All four sides and both diagonals should always be checked a second time and by a second person. On larger projects, gridlines are then placed parallel to front and side lines at predetermined intervals.

3-4-5 Method

A 3-4-5 triangle is a right-angled triangle because it satisfies the Pythagorean Theorem. In other words, $3^2 + 4^2 = 5^2$. The benefit of this method is convenience since it doesn't require a calculator. Multiples of 3-4-5 (such as 12-16-20) may also be used.

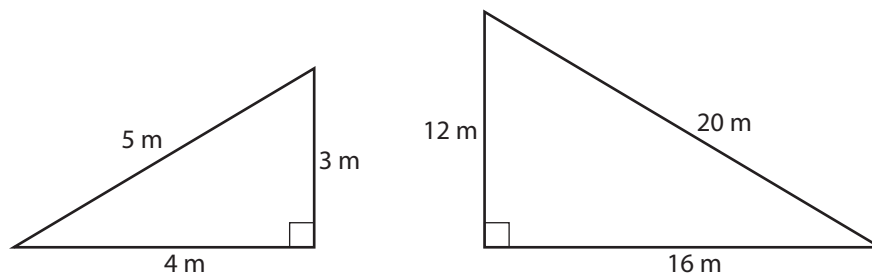


Figure 5 — Right-angled triangles with sides proportional to 3-4-5

Normally the measurements used with this method will be shorter than the actual layout size because not all right-angled triangles have sides in exact multiples of 3, 4, and 5. The larger the triangle used in this method, the more precise your layout will be. You should calculate the largest possible multiples of 3, 4, and 5 that will work in any given layout. Any measurement error that occurs will have a proportionately smaller effect. In Figure 6, the small measurement error shown in Example A has a more serious effect on layout than the same measurement error in Example B.

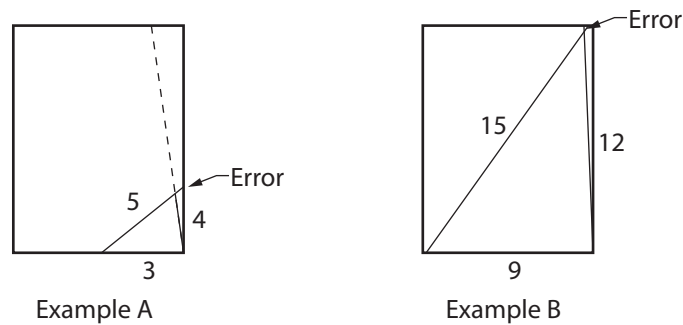


Figure 6—Measurement errors

In most building layout work, the corners have been located using an instrument—it's good practice to check both diagonals in such cases.

Install and Use Batter Boards

Excavation usually extends beyond the building lines from 600 mm (24") to more than a metre in order to allow for footing projection, perimeter drain pipe, and working room. Because of this, corner stake locations are destroyed during the excavation process. To re-establish the corner stakes at the bottom of the excavation, it's necessary to have batter boards in place. Batter boards need to be strong, stable, and easy to use.

Location

Batter boards are erected at approximately the same elevation at each corner of the building site. To give ample working room and to provide a safety factor, the batter boards are typically set back the desired working room from the building, plus $\frac{3}{4}$ the depth of the excavation, plus at least 600 mm from the top of the excavation (Figure 7). Batter boards should be set back farther than 600 mm for unstable soils.

$$\frac{3}{4} \times 3000 = 2250$$

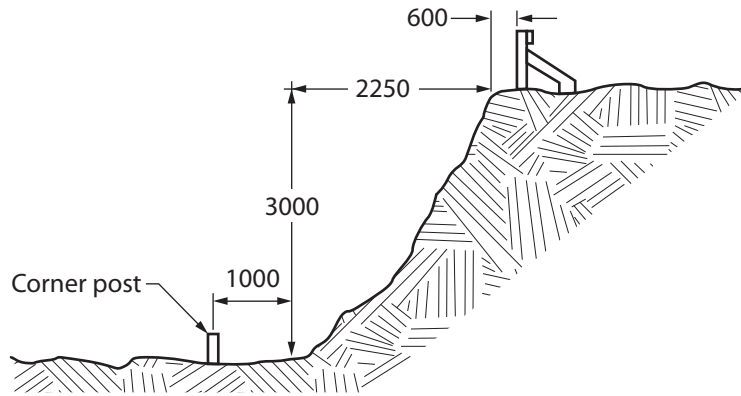


Figure 7 — Setback of batter boards

The batter boards are set so that strings will pass directly over the corner points of the building. For this reason, it's important that the top batter board members be long enough to ensure that the lines can be adjusted when setting them in place.

Construction

Batter boards are usually constructed in place. They consist of horizontal members supported by verticals that are driven into the ground. Always brace the batter boards well, since even a small movement can significantly affect the layout. Never use batter boards as saw horses or nailing benches.

- cut the verticals and horizontals from sound, straight material
- cut the verticals to a sharp point and drive them into the ground no more than 2000 mm apart
- drive the verticals solidly, and brace them securely
- screw or nail the horizontals securely against the outside of the verticals so that the pull of the lines will tend to hold them tightly in place
- make sure the horizontals are at the same height so that the string lines touch where they cross
- check the layout on a daily basis

Figure 8 contains examples of single and double batter boards. Diagonal bracing is often made from 19 mm × 140 mm (1×6) material. Horizontals are 19 mm × 140 mm or 19 mm × 184 mm (1×8). Verticals are at least 38 mm × 89 mm (2×4).

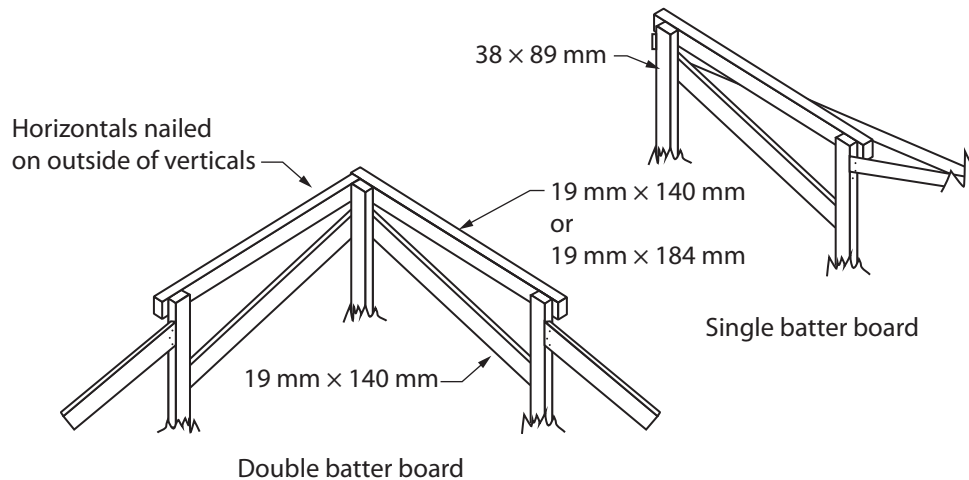


Figure 8 — Single and double batter boards

Batter boards must be high enough to clear the footings in order to be able to locate and mark the position for the foundation walls. Where practical, batter boards should be at a height that permits string lines to be above the top of the foundation wall formwork. On sloped sites, it may be necessary to use much higher batter boards on one end and very low batter boards on the other. In this case, a plumb bob may be required when setting the lines.

Line Setting on Batter Boards

Nylon string line or number 16 wire must be precisely placed on the batter boards in order to maintain the accuracy of the building dimensions. Wire is normally used for larger projects.

Opposite sides must be equal and so must the diagonals in order for the layout to be square. It's much easier to plumb down if the lines touch where they cross.

Locating Lines

Refer to Figure 9 and follow this procedure:

1. Set up the front line (line closest to the road) over the two front corner stakes.
2. Set up the rear line and adjust so that it's parallel to the front line and the exact distance back from the front line.
3. Set up the two side lines over the corner stakes and make sure they're the exact distance apart as per the plan.
4. Check the lengths of the diagonals. If the transfer of position from the corner stakes has been successful, the diagonal measurements should be equal. If they're not equal, adjust only the rear location of the two side lines until the diagonals are equal.
5. Now check all four side measurements and the diagonals. A double check can be performed using the 3-4-5 method.

6. After all adjustments have been made, mark the batter board horizontals where the strings rest on them. Mark and label the locations. Loosen the strings, and move them aside so that shallow saw kerfs can be cut as permanent markers. The saw kerfs work to hold the string in the exact required position, even if bumped. Label the string locations (saw kerfs), such as “building line” or “centre line.”
7. Place the strings back on the nails and in the saw kerfs, and tighten them.

If all four lines are in place for any length of time, check them daily.

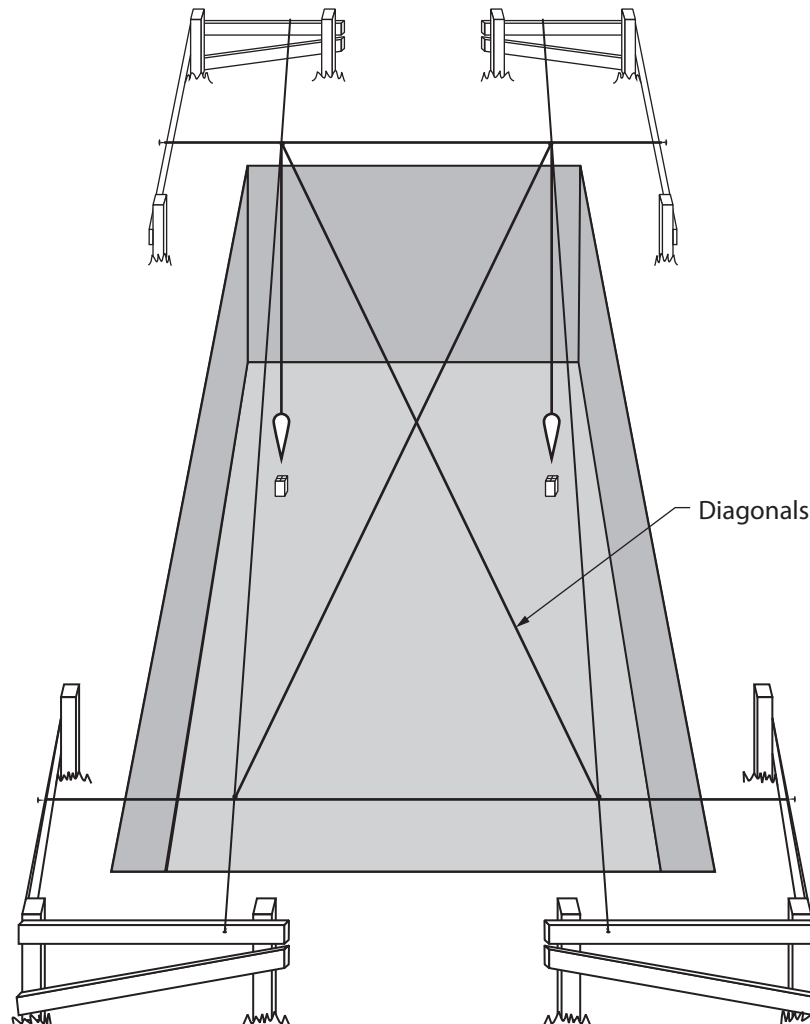


Figure 9 — Batter boards and lines

Layout on larger projects is usually done with a theodolite. The instrument is set up over a corner and is used to precisely measure angles for layout.

Tying Lines

A properly anchored line can be drawn very tight. If the line is drawn too tight, the anchor nail on the far end may pull out and fly at high speed. Since the line is thin, it's easy to store and clean, but it's also difficult to see and can be hazardous. Surveyor's flagging can be tied on the lines to make them more visible.

Follow this procedure to tighten the string:

1. Tie a permanent loop in the free end.
2. Secure this to a nail driven into the backside of the horizontal batter board.
3. Reel out as much line as needed and drive a second nail securely at the desired location.
4. Make a loop, twist it about four times, and place the loop over the second nail.
5. Using one hand on the part between the nails and the other on the free part, tightly pull all the slack out of the line.
6. Pull the free part toward the nail and push the twists up against the nail (Figure 10).

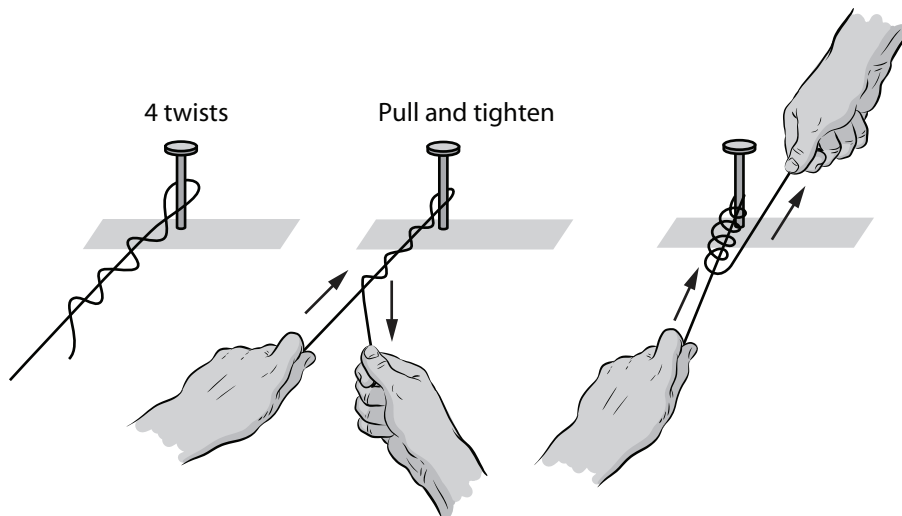


Figure 10—Tying string lines

This method can be done in a matter of seconds and is very easy to release—just pull the free part in the direction of the first nail.

Regardless of how tight the string line is pulled, it will sag a little, usually about 3 mm for every 10 m of length. For this reason, it's not good practice to make accurate vertical measurements from lines.

Plumbing Down from Lines

In locations where the line is close to the ground, it's easy to use a hand level to position new corner stakes. Plumb down from one string and mark the top of the post after it's been driven in solidly. Then plumb from the other string and mark the post in the other direction. The lines will form a cross. Drive a nail at the intersection of the lines (Figure 11). A plumb bob can be used in situations where a carpenter's level is not long enough to span the distance between the corner stakes and the lines. The intersection of the lines is marked directly on the lowest string line, and the plumb bob is tied to the line at that mark.

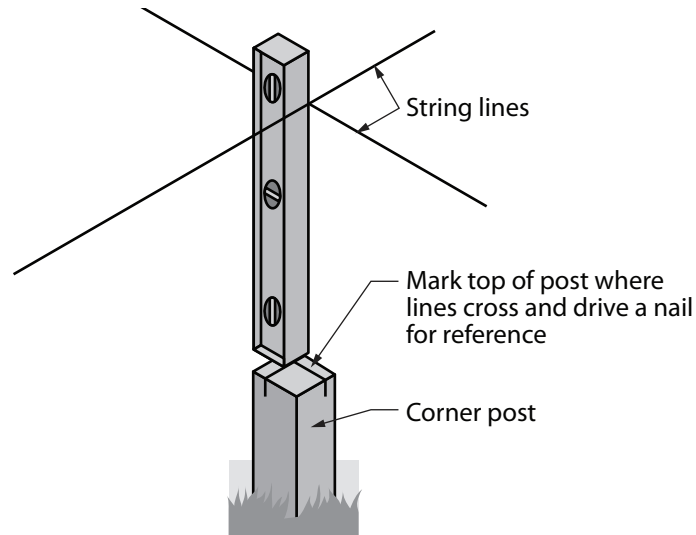


Figure 11 — Marking reference points on corner stakes

In windy weather, it's not possible to use most light plumb bobs. Use of a straightedge and hand level is recommended for these conditions.

Plumb bobs have the advantage of staying in place once they're set up. If they're properly adjusted, they can be checked at a glance. Plumb bobs also centre directly over the point to be established and do not need to be checked in two directions.

A special knot is used to secure the plumb bob that is easy to adjust and untie (Figure 12). It's usually tied about 600 mm (24") from the plumb bob for convenience.

Hang the plumb bob from the lowest string so that the string will not touch anything when it sags. If it's hung from the higher string, it will pull that string down onto the lower string and may roll or slide along it, putting the plumb bob out of adjustment.

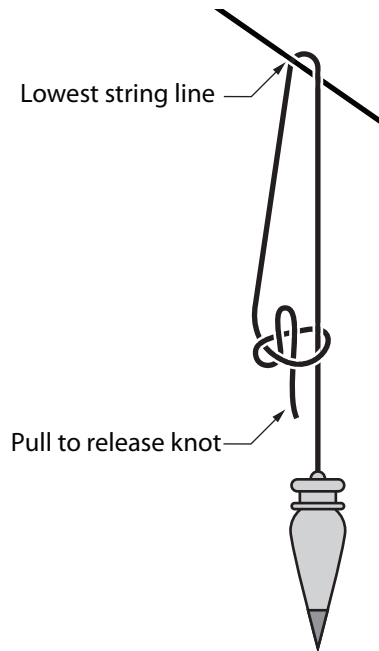


Figure 12 — Plumbing down from lines



Now complete Self Test 2 and check your answers.

Self Test 2

1. A rectangular layout is 21 m $\times$ 29 m. What is the length of the diagonal you use to check for square?

2. What is the length in millimetres of the diagonal you use to lay out a concrete pump base measuring 3550 mm $\times$ 3906 mm?

3. What is the length in millimetres of the diagonal you use to check a layout measuring 6250 mm $\times$ 9150 mm?

4. Your steel tape is 12 m long. What are the most accurate 3-4-5 figures you can use to check a rectangle that is 12 m $\times$ 18 m?

5. Your steel tape is 15 m long. What are the most accurate 3-4-5 figures you can use to check a rectangle that is 12 m $\times$ 18 m?

6. If an excavation is 3.5 m deep with 1.0 m working room, what is the minimum setback distance to the batter boards?
 - a. 1.75 m
 - b. 4.23 m
 - c. 7.00 m
 - d. 8.00 m
7. The depth of an excavation is 3.8 m. The wall forms require 600 mm of working room behind them. How far from the building corner stakes should the batter boards be erected?
 - a. 2.45 m
 - b. 3.45 m
 - c. 4.05 m
 - d. 4.65 m
8. If the soil is very soft and crumbling, what effect does this have on the placement of the batter boards?
 - a. Batter boards are not used in this case.
 - b. Batter boards are braced more securely than usual.
 - c. They're placed at the bottom of the excavation.
 - d. They're moved farther from the excavation.
9. Why is it important to keep all horizontals very close to the same elevation?
 - a. This gives a more professional appearance.
 - b. It's difficult to measure overhead if some elevations are too high.
 - c. It's easier to plumb to the ground from string lines.
 - d. So that the strings touch where they cross.
10. Why are horizontals nailed onto the outside of the verticals, away from the excavation?
 - a. They're easier to repair if you stand away from the excavation.
 - b. They're easier to dismantle if nail heads are away from the excavation.
 - c. The pull of the lines holds the horizontals firmly against the verticals.
 - d. Appearance is neater when viewed by passers-by.

11. How far from the ground should the batter board horizontals be placed?
- waist height
 - no more than a metre
 - no more than the length of your level
 - above the top of the formwork
12. The purpose of the saw kerf is to keep the string from loosening.
- true
 - false
13. If string lines are to be in place for extended periods, they should be checked:
- twice a day
 - once a day
 - twice a week
 - once a week
14. List two advantages that plumb bobs have over levels and straightedges.
-
-
15. Why should you avoid hanging the plumb bob on the higher of two crossing strings?
16. String lines are usually set to cross directly over:
- inside footing corners
 - outside footing corners
 - inside building corners
 - outside building corners or gridlines
17. It's possible to make rough vertical measurements from tight string lines.
- true
 - false
18. Which of the following is the most accurate way to check building lines for square?
- check all four sides and both diagonals
 - check the diagonals
 - check two adjacent sides and the hypotenuse
 - check adjacent sides with the 3-4-5 method

LEARNING TASK 3

Describe Survey Markers

The correct subdivision plan can be obtained for most parcels of land using the legal description for the property. This type of plan shows the location of the survey markers, along with dimensions and angles that define the property boundaries and any easements.

Such plans are registered and stored at the local Land Titles Office and are available to property owners and builders. In many cases these plans are also available at municipal planning offices. An example of a subdivision plan is shown in Learning Task 1.

It's important to be familiar with the purposes of various survey markers. You must understand the abbreviations on survey and site plans and be able to locate and identify the markers themselves.

Types of Survey Markers

The following survey markers are used:

- iron pin
- lead plug
- survey point
- hub
- corner stake
- witness stake

Iron Pin

The iron pin (IP) is a bar about 600 mm (24") long, sharpened on one end and 12 mm (½") square in cross section. To prevent accidental movement, the pin is often driven to below grade level to mark the corners of residential properties. "IP" on a plan indicates "iron pin (or post) set in place." "OIP" indicates "iron pin (or post) found."

Although a property may have four or more corners, it may not have as many iron pins. Often, only every other lot corner within a subdivision gets pinned. Lots may also have more iron pins than corners and there may be two or more iron pins quite close to each other when property boundaries are complicated. Do not assume there's one iron pin at each corner. Always check the subdivision and survey plans for iron pin locations. A metal detector is a good aid to use when locating pins. If in doubt, hire a professional land surveyor.

There's often a white triangular wooden marker post near the iron pin. Typically it's about 60 mm × 60 mm × 80 mm and will have "IP" marked on the 80 mm face. The other two sides will sometimes have inscriptions identifying the parcels. In Figure 1, the IP marks the intersection of District Lot 124 with Section 2 and Lot 2.

Do not mistake these white stakes as the exact location of the property corners—they're placed near the IP to make its location easier to find.



Figure 1 — Iron pin and wooden post

Lead Plug

A lead plug is often used where iron pins are inconvenient, such as near bedrock or on concrete. The lead is pounded into a drilled hole and flattened. The survey point or corner is then marked in the lead using a cold chisel or a small brass tack. “LP” indicates “lead plug is in place.” “OLP” indicates “lead plug found.”

Survey Point

A survey point can be any hub or point used by the surveyor to set up the instrument or to traverse the area. A survey point may coincide with a permanently marked location such as a property corner. Traversing the lot may involve setting up the surveying instrument to take a reading from this first point.

Hub

A hub is the physical marker used to identify survey points. It's often a small wooden stake with a nail in the top, but may also be a common spike shoved into the ground, or a nail driven into the root of a tree. Hubs are not usually considered permanent, but occasionally they will be indicated on plans if it was inconvenient for the surveyor to place a permanent marker.

Corner Stake

Corner stakes are used by surveyors when hired to “pin” building corners so that footings and foundation walls can be positioned accurately by carpenters.

A corner stake is a wooden peg, usually 38 mm × 38 mm, and sharpened at one end. It's driven solidly into the ground as a temporary corner marker during construction. For precise building layout, it usually has a nail driven into the top to indicate the precise intersection of the building lines. If the stake only indicates where excavation is to take place, the precise nail marker is not necessary.

Witness Stake

When it's impossible to set a marker at a required location, a witness stake is used. It's wood or metal (depending upon how long it needs to exist) and is set back along one of the survey lines by a measured distance.

For example, if the corner of a lot falls exactly under a large tree, the surveyor may drive a metal witness stake one or two metres back along one of the surveyor's lines. The abbreviation “WS” indicates a witness stake on a site plan.

Benchmark

Some confusion exists concerning benchmarks. A benchmark may be set to an arbitrary elevation at the job site, or may represent true elevation above sea level like a datum point. It's generally agreed that the benchmark is a reference point used to establish on-site elevations during construction.

The reference point for the benchmark must be solid, such as a manhole cover or the foundation of another building. The abbreviation “BM” indicates a benchmark on a site plan.

Datum Point and Monument

The datum point is an authoritative elevation, referenced to mean sea level, usually made of brass and set permanently. The brass marks are known as monuments or survey markers. These are normally registered with the Canadian Geodetic Survey and GeoBC.

Monuments are also used to mark important boundaries, such as the corners of land districts (Figure 2).



Figure 2 — Canadian Geodetic Survey monument
(located on the north wall of the BC Parliament Building)



Now complete Self Test 3 and check your answers.

Self Test 3

1. The abbreviation "OIP" on a survey plan indicates:
 - a. oval iron pin
 - b. no iron pin
 - c. iron post found
 - d. post in place
2. A witness stake is used when:
 - a. There is disagreement over lot lines.
 - b. A hub has been lost or destroyed.
 - c. The owner takes a sworn oath.
 - d. A setback or offset is required.
3. An LP may be marked precisely using:
 - a. spray paint
 - b. a brass tack
 - c. marker pen
 - d. an iron nail
4. Corner stakes are usually wooden, and are used at _____ locations.
 - a. lot
 - b. building
 - c. instrument
 - d. benchmark
5. Why are iron pins driven below the natural grade?
 - a. They will not rust if they are completely buried.
 - b. They're gradually covered due to soil movement.
 - c. To avoid damage by lightning.
 - d. To avoid accidental movement.
6. A white triangular wooden marker post with the letters "IP" marks the:
 - a. exact location of a corner
 - b. location of a property line
 - c. approximate location of an iron pin
 - d. exact location of an iron pin

7. A lead plug has several advantages over iron pins in certain situations. In which of the following situations would a lead plug be used?
 - a. light sandy soil conditions
 - b. mixed soil and small rock
 - c. exposed bedrock
 - d. bulldozed rubble and broken concrete
8. Why do corner stakes for excavations not have a nail driven into the top?
 - a. The layout has been only partially completed.
 - b. Excavations do not require precise measurements.
 - c. The layout is done by someone other than an engineer.
 - d. Excavation stakes will be destroyed.
9. Which of the following is a physical marker used on-site to establish on-site elevations?
 - a. survey point
 - b. building corner
 - c. monument
 - d. benchmark
10. Which of the following is considered to be a non-permanent marker?
 - a. hub
 - b. survey point
 - c. datum point
 - d. brass tack

Answer Key

Self Test 1

1. b. a written reference on a plan or mortgage document
2. c. lot number, plan number, district lot number, district name
3. d. adjacent street names
4. a. lot elevations
5. c. a building that extends onto another property
6. d. the site plan contains more relevant information
7. $143' 6'' - 142' 6'' = 12''$
8. approximately 24 – 48"
9. For backfill grading to allow for surface water drainage, and to allow for landscaping (top of foundation wall could be stepped if desired).
10. c. by using as much excavated dirt as possible to fill low areas
11. a. the surface of the ground, or sloping ground
12. c. 100.000 m
13. a. gridlines
14. b. be destroyed by the earth-moving equipment
15. d. a letter and a number
16. c. the top of the grade stake
17. b. grubbing
18. without bulking factor = 58 m^3 , with the bulking factor = 67 m^3 to 76 m^3

Self Test 2

1. 35.805 m
2. 5278 mm
3. 11081 mm
4. 6-8-10
5. 9-12-15
6. b. 4.23 m

7. c. 4.05 m
8. d. They're moved farther from the excavation.
9. d. so that the strings touch where they cross
10. c. The pull of the lines holds the horizontals firmly against the verticals.
11. d. above the top of the formwork
12. b. false
13. b. once per day
14. i. stay in place once set up
ii. can be checked at a glance
iii. do not need to be checked in two directions
15. so it won't roll or slide on the lower one
16. d. outside building corners or gridlines
17. a. true
18. a. check all four sides and both diagonals

Self Test 3

1. c. iron post found
2. d. A setback or offset is required.
3. b. a brass tack
4. b. building
5. d. To avoid intentional or accidental movement.
6. c. approximate location of an iron pin
7. c. exposed bedrock
8. b. Excavations do not require precise measurements.
9. d. benchmark
10. a. hub

