Forest Road Construction

Introduction 4-1
Goals of Road Construction 4-2
Objectives of Road Construction 4-2
Road Construction Strategies 4-2
- Timing 4-2
- Clearing and Grubbing 4-3
- Options for Disposal of Clearing and Grubbing Debris 4-4
  - Sidecast 4-4
  - Scattering 4-4
  - Pile and Burn 4-5
  - End-Haul 4-5
  - Chipping and Scattering 4-5
- Balanced Cut and Fill (BCF) Construction 4-6
- Full Bench Construction 4-7
- Construction on Marginally Stable Slopes 4-8
- Grading and Compaction 4-9
- Subgrade and Surfacing 4-10
- Erosion Control 4-10

Introduction

During the construction phase of a road project, the planning and design decisions that were made earlier are carried out on the ground to achieve the desired road standard in a way that is efficient and effective and results in minimal impact to the environment. Each phase of road construction will be conducted according to the formulated plans, unless exceptions are approved by the appropriate supervisor. Poor execution of plans, no matter how well designed, can result in a poorly constructed road that may have a serious impact on the environment. Untrained project administrators or unskilled operators most often are the cause for poor execution of plans. Thus, the skill and experience of administrators and equipment operators selected to complete the road project will play a key part in determining its success.

Plans and designs may need to be modified during construction as changing conditions are encountered in the field. Experienced administrators and equipment operators can accomplish minor changes in the proposed work in the field. However, substantial changes in road design will be made only by qualified personnel and through the proper procedures and approval processes for contract modifications.

Goals of Road Construction

1. Construct roads that will become an efficient and effective part of the overall transportation system by constructing them according to the plans and design specifications and using the best management practices for road construction.
2. Protect water quality, aquatic habitat and other natural resources.

Objectives of Road Construction

1. Construct roads according to design.
2. Minimize soil disturbance during road construction.
3. Minimize impacts to water quality during construction.
4. Minimize impacts to aquatic and terrestrial wildlife habitats.
5. Make on-the-ground decisions and/or changes to the road design specifications that react to unforeseen conditions during road construction in a manner that will achieve the goals of the project. Professional level expertise and input will be utilized in the formation of the decisions and/or changes.

Road Construction Strategies

Road construction strategies are the specific actions and standards that will lead to achieving the goals and objectives of this section of the manual.

Timing

While planning, design and field reconnaissance work can be conducted at any time of year, the timing of each phase of road construction is critical to completing a successful project. Roads must be constructed during the time of year when the best results can be achieved with the least damage to the environment. For example, scheduling road construction on steep slopes during the drier months can be an effective erosion control measure.

The best time for conducting each of the road-building activities (clearing, grubbing, excavation and grading, compaction, stream crossing installation and surfacing) varies.

Some clearing (cutting and removal of trees and brush from the right-of-way) can be performed during wetter weather. However, it must be conducted in a manner that does not result in large amounts of bare soil being exposed to surface erosion and/or the soil is not subjected to rutting, puddling or other damage. The clearing of shrubs, low vegetation and organic material from the soil surface should be delayed until the threat of erosion from the disturbed areas is minimal.

Grubbing (the removal stumps and protruding objects) will result in significant exposure of the soil surface and should be performed only when the threat of erosion from the disturbed areas is minimal.

Grading (the excavation and creation of the road bench) creates large expanses of bare soil, and should therefore be performed only during dry spring, summer or early fall conditions.

Soils require an optimum moisture content to achieve the proper compaction of fill materials used in stream crossings, landings, and along cut-and-fill road benches. Rocky, coarse-textured soils may be compacted under a relatively wide range of moisture content. On the other hand, fine textured soils that are overly dry or very wet often cannot be compacted enough to produce the soil strength needed to support loaded trucks or to remain stable on steep slopes. If the soils are too wet, they should be allowed to dry, and if they are too dry, they should be watered to achieve adequate compaction. An experienced engineer or geotechnical specialist can recognize improper soil moisture conditions by using simple field tests. They should be consulted whenever soil moisture conditions are in question.

The timing of a stream crossing installation is critical to maintaining and protecting water quality. Timing is also important to fisheries in many watersheds. Work should be performed as quickly as possible during the dry period of summer, when streamflows are at a minimum (or the channel has dried up) and there will be minimal soil disturbance and risk of sedimentation. An ODFW Fish Biologist will be consulted for the proper time to construct stream crossings across fish bearing streams.

All road construction activities, including the installation of stream crossings and erosion control work, will be scheduled for completion before the onset of the rainy period, which is usually around the middle of October. Final grading and proper installation of road drainage structures are critical to keeping erosion from the new road to a minimum during the first winter. Likewise, all temporary stream crossings must be removed, and all erosion control measures installed before the winter begins.

The Oregon Forest Practices Act's rules and guidance, Department of Forestry biologists and Geotechnical Specialists, Oregon Department of Fish and Wildlife (ODFW) biologists, or other sources will be consulted for timing guidelines related to road construction, particularly as they pertain to streams, threatened and endangered wild life species, or other sensitive resources. These guidelines will be used wherever they are applicable.

Clearing and Grubbing

One of the first steps in forest road construction is clearing and grubbing. The method of disposal of clearing debris is important to the future stability of the road. The clearing debris must be removed from the area of the road prism to eliminate the bridging effect that occurs when dirt is deposited against the debris. This also eliminates a safety hazard to anyone working below the road.

The clearing and grubbing method used will be consistent with good safety and environmental practices while keeping construction costs to a minimum.

Depending upon the design standard that was used, the road centerline and/or the cut and fill staking should be marked on the ground prior to clearing.

The upslope and downslope boundaries of the right-of-way should be marked prior to clearing and grubbing. The boundaries will provide the minimum width needed to construct the desired road. This will help prevent over-clearing or under-clearing. The lower boundary will be located at the base of the fillslope. The upper boundary will be located at the top of the cut slope plus enough distance to assure that the root systems of remaining trees will not be damaged by the excavation of the road prism.

Clearing. Trees and other large vegetation within the right-of-way boundaries should be felled and bucked. In addition hazardous snags and unsafe trees adjacent to the right-of-way should also be felled at this time.

Merchantable logs should be yarded to decking areas that will not interfere with the construction of the road or turnouts. Unmerchantable material should be disposed of according to the design specifications and follow the guidance listed later in this section.

Grubbing. During grubbing of the surface, all stumps and protruding objects should be removed from within the road prism, and anywhere fill or sidecast material will be deposited. Stumps overhanging the top of cut banks should also be removed. Stumps and other large organic debris in the road fill should never be left in the road prism because the voids that form when the wood decomposes will affect the stability of the fill. All chunks, logs and slash over approximately 3 inches in diameter and 3 feet in length should be removed and disposed of outside of the road prism. Small amounts of miscellaneous fine slash and small limbs are usually not a problem if they are scattered throughout the road prism and not left in concentrations.

On slopes over 35 percent in gradient, the organic layer (duff) on the soil surface should be substantially disturbed or removed prior to fill placement or sidecasting. If substantial amounts of this material are left in place, the material can create a slip plane for fill or sidecast failure when it decomposes.

Options for Disposal of Clearing and Grubbing Debris

There are several options for disposing of clearing and grubbing debris. Oftentimes contract specifications or the road design will indicate the option that will be used. If an option is not specified, the one that is chosen should match the road design and the on-site conditions.

1. **Sidecast.** This is very common and usually the most economical technique used for forest road construction. Clearing debris is pushed outside of the road prism a minimum of 5 feet from the top and bottom of cut and fill slopes. It is very important that clearing debris not be incorporated into any sidecast or fill material supporting the road. Clearing debris that is sidecast on steep ground is difficult to control and can create a safety hazard for logging crews that may be working below the road at a later time. Stumps and logs could become dislodged and roll down the hill during the logging operation. Sidecasting will be limited to slopes less than 55%. Clearing debris should not be left lodged against standing trees.

2. **Scattering.** Debris is pushed or placed outside the right-of-way where natural openings in the stand exist, provided that:

    a. Debris is not pushed against trees.

    b. Tops and limbs are lopped to lie flat on the ground.

    c. Excessive accumulations do not result.

    Scattering should be limited to slopes less than 55% for safety and economic reasons. Scattering should also be limited to stands that are open enough to facilitate this technique (e.g., dense reproduction and very thick hemlock stands are not conducive to scattering.)

3. **Pile and Burn.** Right-of-way debris is piled in clean, burnable piles within portions of the right-of-way, or at locations approved by the project administrator and burned. The burning may take place prior to, during, or after subgrade construction, depending on the situation. Right-of-way debris should be burned so that there is no residual material greater than 3 inches in diameter and 3 feet in length. Material remaining after burning should be buried or scattered. Burning should be required when other options are not suitable, the clearing debris must be removed from the right-of-way and there are no waste areas for the debris available within a reasonable distance.
4. **End-haul.** Right-of-way debris is pulled, pushed and/or loaded and hauled to a designated waste area. End-hauling of clearing and grubbing debris should be considered where sideslopes are greater than 55%. It may be more economical to dispose of the limbs, tops and other small debris using another option such as chipping and only require the end-haul of the larger debris such as stumps and cull logs.
5. **Chipping and dispersal.** Right-of-way debris is fed through a chipper and chips are dispersed through openings in the trees in layers less than 36 inches thick. This method works well in thick-growing young trees (less than about 14” in diameter) where there is limited room for scattering debris and the average size of the clearing and grubbing debris is small enough to be chipped.

Balanced Cut and Fill (BCF) Construction

In BCF construction, the dozer starts at the top of the proposed cutslope, excavating and sidecasting material until the desired road grade and width is obtained. Material is pushed or "drifted" in front of the blade to areas where fill is needed. Road fill is used to cover culverts and build up flat or low areas along the alignment. Since fill must support traffic, it needs to be spread and compacted as much as is possible to develop sufficient strength. Unfortunately, this common method of BCF road construction does not always lend itself to standard compaction methods, where fill is placed and compacted in thin layers. Therefore, additional compaction should be required in areas where the stability of fills is important such as adjacent to streams and/or where required in the design specifications of the project.

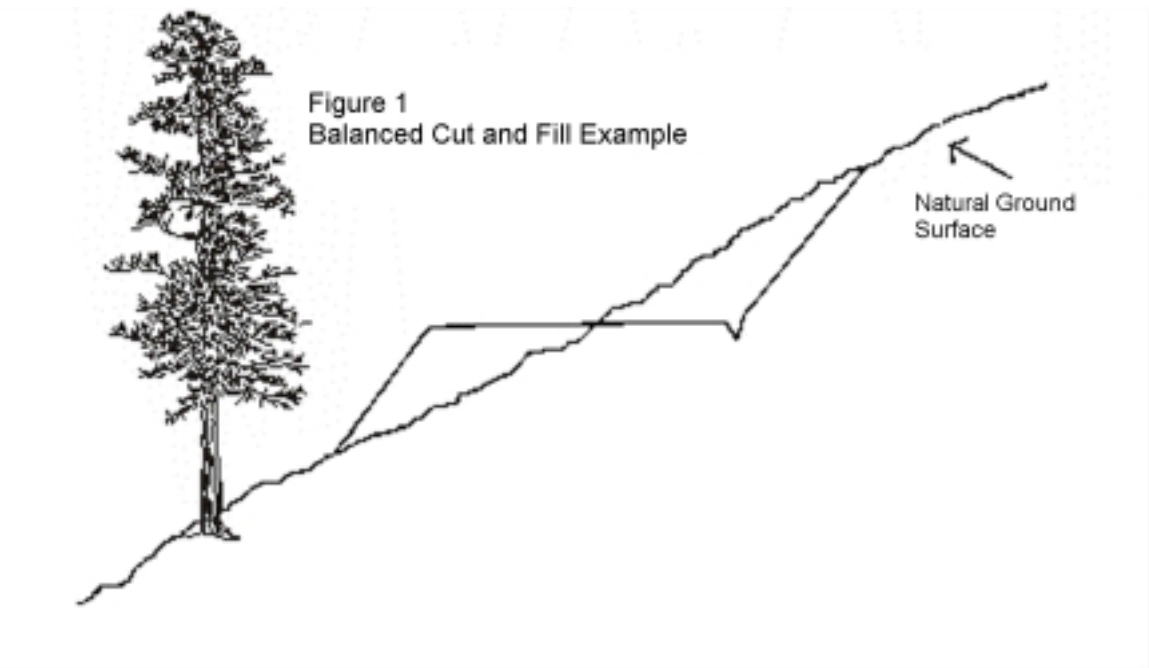


Figure 1
Balanced Cut and Fill Example

In BCF construction, some of the waste material moves down the slope below the final roadbed and cannot be adequately compacted or contained. For this reason, BCF construction methods are <u>not</u> suitable on steep slopes (over 55%) or moderate slopes (40% - 55%) that are near streams where uncompacted material could become saturated during wet weather and move downslope.

During BCF construction, it is critical to avoid letting sidecast or waste material enter streams or placing it where it could erode and be delivered to a watercourse.

A good rule-of-thumb is not to sidecast on slopes of over 55%.

On moderate slopes (<45%) sidecast material should not exceed five feet in depth (measured vertical to the original slope). A more protective method of BCF construction is gaining popularity with many road builders. This method utilizes a hydraulic excavator, instead of a dozer, to pioneer the road bench. The excavator is able to cleanly remove slash, stumps and logs and place them at the base of the fillslope so they are not

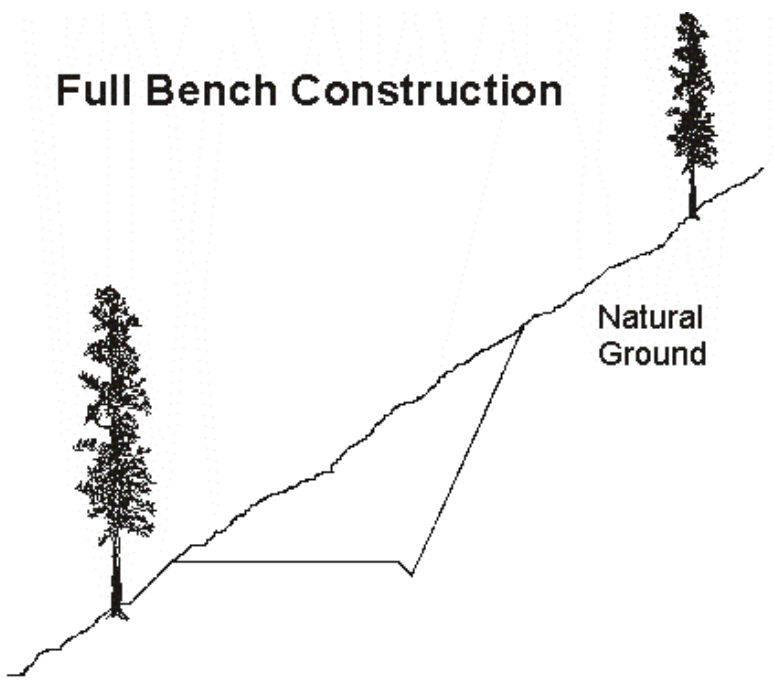
incorporated in the fill. It then grubs or cleans off the organic layer, excavates mineral soil and places it bucket by bucket, beginning at the base of the slope. The powerful hydraulic systems of large excavators permit them to partially compact the fill as it is placed. Waste material carefully placed using this method is more stable and less susceptible to failure than material that is pushed or sidecast by a dozer. Excavators can be used to place free draining fills on natural slopes as steep as 60 percent in some cases. Excavators can carefully set large angular rocks to make stable fill slopes in some cases as steep as 1:1.

Full Bench Construction

Full bench construction typically involves excavation of the roadbed using a hydraulic excavator. A bench is cut into the rock or soil equal to the width of the road plus the width of any ditch that may be required. Normally, no material is sidecast, and excavated waste is used to fill low areas or stream crossings along the road alignment. Usually, only a very minor amount can be safely drifted down the road and compacted on the road bench or feathered over the edge. The most efficient use of the excavated waste is to construct road fills such as in saddles, fills over culverts, or other BCF sections of the road. Excess material can be hauled off-site to a stable storage location.

Full bench road construction is typically reserved for slopes over 55%, or where a road approaches or parallels a stream channel that could be impacted by sidecasting excess material.

Figure 2.



Endhauling of waste material can be expensive, and full bench construction can cost four to seven times more than balanced cut and fill methods. However, full bench road construction on steep slopes without endhauling is very likely to result in sidecast material failing on many sites, with the resultant impacts to downslope stream channels.

Full bench roads often result in tall cut slopes. Several rock and soil types may not support these large cut slopes. Unstable rock, rock structure, including soft or highly fractured sedimentary rocks may not be suitable for full-bench cuts. Cut slopes in these areas can remove critical support at the toe of the natural slope and initiate upslope failure. Silt clays and other unstable earth materials may be unsuitable for tall cut slopes. Special design features must be considered when cut slopes exceed 20 feet in vertical height in these areas. It may not be feasible or possible to build the road where slopes are steep and the rock or soil material is weak. In these cases, alternative road locations should be considered.

Waste material should be endhauled and placed at a stable location. Rock pits, wide stable sections of roads, ridges, benches, and the inside edges of landings are typical locations where waste material can be stored. Sites judged to be of uncertain stability should be reviewed by a geotechnical specialist before they are used. Those sites where emerging ground water, thick organic layers, unstable geology, or other instability factors are present could experience slope failure after loading and should not be used.

In most situations, endhaul material is loaded directly into dump trucks by the excavator and hauled to the storage site, where it is spread in layers that can be reworked by a dozer. In some cases, dozers can economically carry (push) waste material to stable storage sites for distances up to 200 feet. The resulting waste pile at the storage site should generally conform to the local topography to provide for natural drainage, and should be mulched and planted with vegetation to control erosion.

Construction on Marginally Stable Slopes

Marginally stable slopes are areas where, because of steepness, geologic conditions and/or hydrologic conditions, improper road construction could cause landslides to occur. Construction in these areas should only be done after the road is carefully located and designed by qualified personnel, such as forest engineers and geotechnical specialists. The operator performing the construction should know and understand all of the design specifications prior to beginning any work.

Road construction on marginally stable slopes may require techniques as simple as full bench end-haul or as complex as a project requiring a large rock buttress keyed into bedrock. Each area will require a unique design that meets the conditions in that area. Therefore, it is beyond the scope of this manual to define all of the design and construction techniques for these areas. However, the following should be considered during the construction phase of these projects:

- Does the design show that slope stakes have been set in the field? If yes, have they been located?
- Does the design show that reference tags have been set in the field? If yes, have they been located?

- Does everyone responsible for the construction of the project have a copy of the design? If yes, does everyone understand the design?
- Does the design specify special equipment? If yes, is the equipment on the site?
- Does the design specify special materials? If yes, are the materials on the site or readily available?
- Does the design specify a certain time of year or other conditions (such as weather)? If yes, is the time of year appropriate and are the conditions being met?
- Does the design specify the use of unusual construction techniques or practices? If so, does everyone have the knowledge, skills, and abilities to perform the techniques or practices?

If the answer to any of the above questions is no, the construction should not proceed until the answer is yes, or there are justifiable reasons for the answer to be no.

The questions above are not a complete list. More could be asked, depending upon the project. The above list of questions is intended to illustrate and to emphasize the importance of constructing projects on marginally stable slopes according to design specifications.

Grading and Compaction

Most forest roads are built by excavating a roadbed out of naturally sloping ground. Grading is the process of excavating and/or filling the subgrade to final grade. Thus, grading is when the bulk of soil excavation and disturbance occurs. For a given road width, the steeper the ground the greater will be the volume of soil that is excavated or displaced during road construction. Road design and layout (flagging, staking and/or reference points on the ground, together with plans, maps and/or design specifications) show equipment operators the correct alignment and the proper cut slope angle and height to be developed along the new road. Operators may be asked to either construct roads using BCF construction methods on gentle terrain, to use cut-and-fill (with true compaction) on moderate slopes, or to employ full bench construction techniques on steep slopes or where the road is near stream channels.

The methods of compaction and where they are to be applied should be specified in the road design specifications. The importance of compacting excavated material cannot be over-emphasized. The specifications for compaction may be as simple as using loaded rock trucks or crawler tractors, or may require special equipment such as vibratory rollers, vibratory compactors, and grid rollers. Always consult the design for compaction methods and specifications.

Subgrade and Surfacing

Before surfacing the road:
The condition of the subgrade is critical to the performance of the road surfacing. The shape of the subgrade plays a central roll in providing road drainage. Do not rely on producing the surface shape (crowned, insloped or outsloped) of the road by shaping the rock surfacing alone. The ditch, if required, should be shaped and clear prior to applying surfacing. The subgrade should be at or near the optimum moisture content for compaction and then shaped and compacted prior to rocking.

During the rocking project:
Process the rock as specified by the contract. It will enhance performance of the road surfacing. Proper mixing, watering, shaping and compaction of the rock should be done to allow the surface rock to set up correctly.

There are several rocking accountability methods available to assure that operators comply with project requirements. Rock is a very valuable resource and accounting for the volume and quality of rock is important to make sure the State gets its value.

The "depth measurement" method works well when is it easy to verify the new surfacing from the existing road surface. Un-surfaced roads and roads that will be re-surfaced with a continuous new lift of rock are good candidates for depth measurement. Rock spikes driven into the surfacing or digging test holes in the surfacing and measuring depth can be utilized. Re-surfacing projects that are applying very thin rock lifts or spot-rock are not good candidates to be measured by depth, due to the varying road segment lengths and depths of rock of road being surfaced. An advantage of depth measurement is that it does not require that some one monitor the project 100% of the time. Depth measurement may be performed during and at completion of road rocking.

"Rock checking" works well for many types of rocking projects. Rock can be placed where needed only. Rock checkers can direct or monitor the rocking project. Rock checkers track the number of loads of rock and make sure trucks are full. The main drawback with this method is that it is labor intensive and rock checkers are not always available when they are needed.

"Rock Load Receipts" can work if rock is purchased from commercial sources and the other two methods are not suitable for accountability. The provider of the rock submits the number of loads of rock provided for the project. One disadvantage is that the state has little control over the volume of rock in each load.

Erosion Control

Soil erosion and stream sedimentation can occur during and following road construction. Some erosion is the result of poor road location and design, but some clearly occurs as a result of the road construction phase. Proper construction practices will reduce erosion and stream sedimentation. However, even when roads are properly located, designed and constructed, they will still need erosion control measures to minimize soil loss and sediment production.

Both mechanical and vegetative measures are needed to minimize erosion from roads and landings under construction. As mentioned in the design section; effective erosion

prevention is also achieved through proper road design and location, preplanning of cuts and fills, minimizing soil exposure, compacting fills, endhauling loose fill materials from steep slopes and streamside areas, developing stable cut and fillslopes, mulching to control surface erosion for the first year. Seeding and planting will provide for longer-term erosion prevention.

Perhaps the best tool for preventing erosion is to keep vegetation removal and soil disturbance to an absolute minimum during construction. Clearing and grubbing should be limited to the minimum needed to construct the road prism. Cuts and fills on gentle and moderate slopes should be balanced to minimize the amount of excavation and soil exposure.

Most construction activities should be conducted during the dry season. Even during the dry season, construction activities should be suspended if rainy weather is occurring. Soils that are saturated with water and would become muddy when disturbed should be allowed to drain before construction resumes.

All road drainage structures (ditches, outsloping, culverts, waterbars, dips, etc.) should be in place as soon as possible during the construction of the road. In any event they must be in place before the start of the rainy season. Surface water drainage must also be provided for sites associated with road construction such as waste areas, borrow areas and rock pits. All drainage water should be filtered through natural vegetation before it enters streams.

Construction of roads near running water may require silt fences, hay dams or other filtration methods in ditches and streams to prevent eroded material from getting into the water. These structures should be put in place as soon as possible during road construction.

Areas of bare soil, which could deliver sediment to waters of the state, should be mulched and/or seeded before the start of the rainy season. This includes unsurfaced road grades, cut slopes, fill slopes, waste areas, borrow areas, and rock pits.

When the road construction project is partially completed at the start of the rainy period (mid-October), the project should be left in a condition that will minimize erosion and the sedimentation of streams during the rainy period. Drainage measures should be performed on uncompleted subgrades such as smoothing the surface, outsloping, waterbarring, and installing dips. Mulching and/or grass seeding should be done on all cut and fill slopes that are completed and on any other areas of bare soil where erosion and sedimentation could affect water quality. Silt fences and/or hay dams should be used near streams to prevent sedimentation. The road should be barricaded to prevent unauthorized use.

Shallow failures or small slumps on the cut slope or fill slope should be repaired and stabilized. Where the material is blocking a ditch, it should be excavated and removed. Where fill slopes are indicating failure, the fill material may need to excavated and end hauled to a waste area site. To prevent further failure or slumping of cut or fill slopes, rock buttressing or retaining walls may be needed. A geotechnical specialist or engineer should be consulted if these measures are needed.