Forest Practice Guide

Non-Regulatory

Earthworks Construction
1.3 Bulk Earthworks

The construction of forest roads, in particular harvest access roads suitable for logging trucks, can often involve the movement of large volumes of earth. Construction of roads on steep hill slopes can require large cuts and generate significant volumes of earth disturbance.

Poor construction techniques will result in *sediment* generation, unstable earth formations, and present longer term slope instability and accelerated erosion risks.

Please refer to the 'how to use' section of the introduction at http://docs.nzfoa.org.nz/forest-practice-guides/ for advice on how to use this guide.

Version 2.0, January 2020

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Scope

This guide covers bulk earthworks for the construction of forest roads and *landings*, including side-cast construction, sidling cut to *fill* (cut and bench construction), sidling cut (full bench construction), and embankment *fills*.

It outlines best practice techniques for forestry earthworks construction and should be used in conjunction with FPG EC #1 Planning and Design, and FPG EC #2 Stripping and Clearing. Users of the guide are also referred to the following reference documents:

- National Environmental Standards for Plantation Forestry (regulations 22–35)
- New Zealand Forest Owners Association – New Zealand Forest Road Engineering Manual (2020)
- NZTA Standard Specification F/1 – Earthworks Construction www.nzta.govt.nz/assets/resources/earthworks-const/docs/earthworks-const.pdf
- Guideline for the Field Classification and Description of Soils and Rock for Engineering Purposes: NZ Geotechnical Society, December 2005 www.nzgs.org/library/field-description-of-soil-and-rock-field-sheet

Construction methods

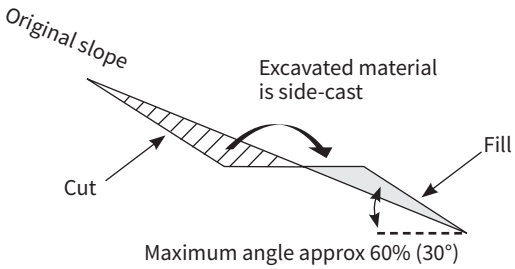
The construction of a single road may involve any combination of the following construction methods, depending on the site characteristic and project requirements. The planning and design process should assess site requirements and specify the methodology in earthworks prescriptions.

1 Cut and side-cast

Cut and side-cast construction is the simplest and lowest cost construction method. Material (*fill*) cut from the hill side is simply pushed (cast) into its final position without benching or otherwise modifying the surrounding terrain.

Cut and side-cast construction will result in loose *uncompacted fill* that is prone to erosion and can create *sediment* issues if the road and *landing* water control is not well-managed.

Cut and side-cast cross section



Where and when to use

Cut and side-cast construction should only be carried out on **flat to rolling contour** and where there is **no risk of *sediment* being deposited in a *water body*** (i.e. not above a *perennial stream* regardless of slope). To mitigate ongoing erosion and *sedimentation* risks, the bare earth (side-cast material) should be *stabilised* or vegetated immediately after construction.

Consideration should be given to the loading requirements of the formation. *Uncompacted fill* may not support heavy logging traffic and collapse under loading. It is important to assess structural requirements of the *fill* during the planning phase – side-cast may not be suitable.

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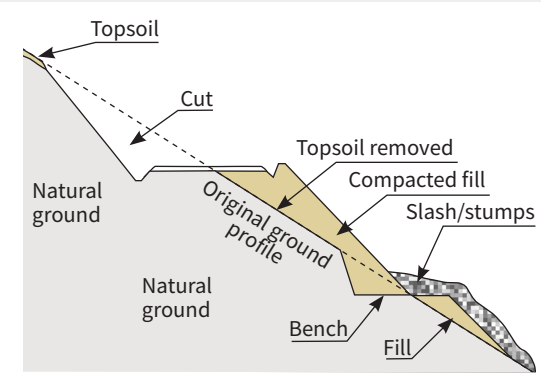
Construction methods continued

2 Cut and benched fill

Cut and benched fill



Cut and bench construction is a common method for constructing roads on moderate to steep hill country, where *fill* side cast onto the natural slope (un-benched) cannot be retained in a stable state.

A level bench (or multiple benches) should be established to provide a base for constructing structural *fill*. The bench location should be established in relation to the finished road formation level and the safe *fill batter* slope with a view to balancing cut and *fill* volumes.

Benches should be constructed wide enough for the safe and effective operation of *compaction* equipment.

A typical cross-section confirming cut and fill *batter* heights and slopes should be developed during the planning and design phase – refer to FPG EC #1 Planning and Design. The design process should assess whether or not the slope is suitable for cut and bench construction.

Where it is anticipated that subsurface water will be encountered within the bench formations, special provision should be made for the installation of sub-soil drainage.

With cut to fill construction, the *fill* zone will typically be part of the trafficked road formation and therefore needs to be structurally competent. The *fill* should be spread and *compacted* in layers of uniform quality and thickness, parallel to the *camber* and grade for the full width of the cross-section. The thickness of each layer should be limited to ensure that the specified compaction is achieved for the full depth of each layer.

On steep slopes, fill *batters* formed using cut and bench construction can produce significant areas of exposed soil. Bare earth should be *stabilised* or vegetated immediately after construction to minimise the risk of *rill* erosion. Surface water controls need be established above the slope to direct stormwater *run-off* away from the *fill* to prevent scour and *rill* erosion, and *fill* saturation and slumping. Downstream *sediment* controls should be installed to contain *sediment* generated from the fill *batter* and prevent discharge to a *water body*.

An example of a well-constructed fill *batter* slope, note *flumes* controlling the discharge of stormwater *run-off* and downstream *sediment* retention pond.

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Construction methods continued

Where and when to use

Cut and bench construction is only effective where the fill *batter* can safely stand (hold) at a slope steeper than the natural ground slope. It is appropriate:

1. On slopes that are too steep for side-cast and/or where side-cast formation is required to support logging traffic (therefore requires *compaction*).
2. On moderate to steep slopes up to 35 degrees. However, the practicable limits may often be less (c.30 degrees) depending on soil characteristics and the fill *batter* slope that can be safely achieved.

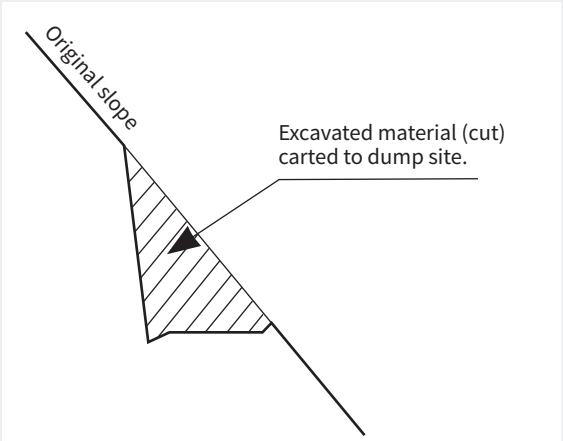
Note: The recommended *fill* slope for most soils is 1:5 H to 1.0 V (33 degrees). Specialist advice should be sought if constructing *fill* slopes greater than this on steep slopes.

3 Partial cut and benched fill and end haul

On steeper slopes, a combination of cut and benched *fill* and end-haul should be considered. This can provide a practical and cost-effective solution for earthworks in steeper terrain. Refer to the sections before and after for detail.

4 Full bench (end haul construction)

Cross section of full bench construction



Full bench construction involves establishing the full road formation width into the hill slope. This is carried out using end-haul construction methods, where cut material (spoil) is carted away to a dump site.

Full bench roads are major engineering works that can generate large volumes of spoil (e.g. a 6-metre-wide formation cut into a 35-degree slope will generate c.15 m^3 of spoil per m).

Full bench construction requires careful planning to optimise road location and volume of material to be cut (refer to FPG EC #1 Planning and Design). *Batter* pegs or flags should be set out at regular intervals to provide the necessary level of construction control.

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Construction method continued

Cut batter slopes – Large (visible) cut *batters* are a characteristic of full bench road formations. The cut *batter* height will be a function of the hill slope and soil properties (governing steepness of the cut *batter*). The following table provides recommended cut *batter* slopes for different soil types.

Cut batter slopes[1]

Material type	Maximum cut slope
Sand	1.5 h – 2.0 h to 1.0 v (67% to 50%)
Pumice	1.5 h – 0.25 h to 1.0 v (100% to 400%) Depending on cementation
Ash	0.5 h – 0.25 h to 1.0 v (200% to 400%) Some slumping accepted
Clay, loose gravel, topsoil	0.75 h to 1.0 v (133%)
Compacted gravelly, clay boulder and earth mix	0.75 h to 1.0 v (133%)
Tight cemented gravels, papa, mudstone	0.5 h to 1.0 v (200%)
Average rock	0.25 h to 1.0 v (400%)
Solid rock	Vertical

A knowledge of local geotechnical conditions is important. Materials should be assessed and cut *batters* specified before work commences.

Large cuttings may pass through layers of different soil types with variable soil strength. Cut *batter* slopes should ensure any weak basement layer can support upper layers.

Where cut *batters* exceed 5 m, or the soil profile is variable, specialist advice should be sought.

End haul dump sites – A critical element of full bench construction is establishing a site to safely dispose of the cut material. Disposal areas should be identified during the design and planning phase and indicated on the operational prescription provided to the earthworks contractor. Ideal locations for dump sites include shallow basins and areas of flat to gentle contour that are away from *water bodies*, and for operational efficiency, as close as possible to the work site. Avoid slip zones and visible earthflows, and areas above sensitive receiving environments (*water bodies* or neighbouring property) that could be at risk from *sedimentation*.

Dump sites should be treated as *fill* zones and cleared and stripped of vegetation and logging debris prior to the placement of *fill*. Erosion and *sediment* controls also need to be established to prevent /contain *sedimentation*. The long-term stability of the *fill* must be considered and, where necessary, *fill* should be placed and *compacted* in layers to prevent slumping.

On completion of the operation, the *fill* site should be reinstated by contouring into the natural ground and vegetating.

Haul roads – should be designed, constructed and maintained to support the safe passage of dump trucks for the duration of the construction operation. Where necessary to prevent the generation and transportation of *sediment* haul, roads should be surfaced.

Where and when to use

Full bench (end haul) construction should be used where slopes are too steep to contain *fill* constructed using cut to bench methods and/or where there are unacceptable consequences of a *fill* failure (e.g. slumping and discharge of *sediment* to a *water body* or significant natural area).

Full bench (end haul) construction should be considered for slopes greater than 35 degrees.

1 NZFOA Forest Road Engineering manual (2012), page 68.

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Drainage control

Water is one of the main enemies of earthworks construction. All earthworks should be carried out in fully drained conditions with no free water on the working surfaces.

Temporary drainage controls should be constructed to direct stormwater away from areas of operation and/or to drain water whenever it is seen to pond. Temporary drainage will frequently include *cut-off* drains to deflect stormwater *run-off*, temporary diversion of natural drainage *(ephemeral flows)* away from the work site, and sloping the cut and *fill* surfaces to prevent ponding and infiltration.

Any materials that have become too wet or soft should be removed and dried or replaced. All *fill* surfaces should be graded and rolled at the end of each day's work to prevent ponding and erosion.

Precaution should also be taken to control stormwater *run-off* from the construction site to ensure *sediment* is not discharged into a sensitive area.

It is considered good policy to leave a low bank *(bund)* on the outside of sidling cuttings. This practice not only provides traffic with additional safety but enables stormwater *run-off* to be led to a suitable discharge position instead of spilling over and causing fill *batter* erosion.

National Environmental Standards for Plantation Forestry

Relevant regulations for earthworks are 25 – 35.

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Examples

Dozer constructing a pilot roadway.

Example of well constructed road.

The construction of a track or road above the *river* requires careful planning and site management. End haul construction should have been carried out to avoid discharge into the *stream*.

Poor construction practice. The *fill* material has not been contained and has spilled up to 60 m down the slope. End haul construction or a configuration of cut + bench/side cast + endhaul should have been carried out to lessen the amount of spoil.

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Fill on top of woody debris is unacceptable practice. The *fill* is highly likely to move.

New earthworks formations need to be surfaced to prevent erosion.

Contact

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