

# **CIVIL ENGINEERING CONSTRUCTION**

## **SBC2253**

### **EARTHWORKS**

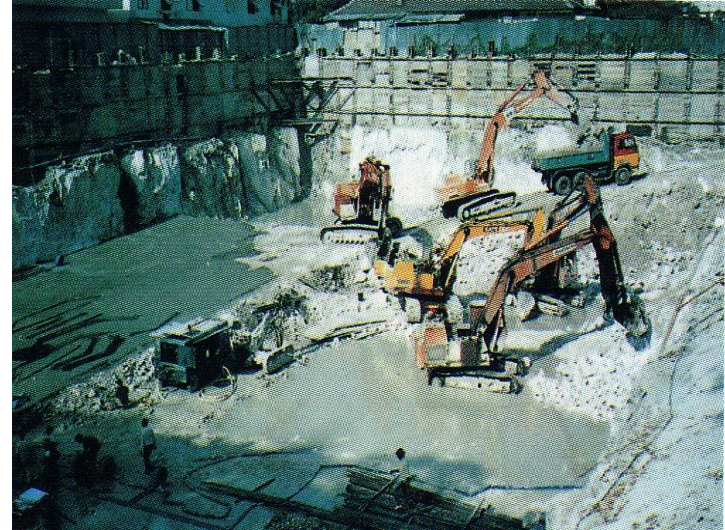
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# INTRODUCTION

- Earthwork: the processes whereby the surface of the earth is excavated and transported to and compacted at another location
- the introduction of the internal combustion engine, electric power and hydraulic power have led to the development of a wide range of earthwork plant (size, capacity and efficiency).
- scale: ranges from small works (the excavation of ditches and trenches for drainage and pits and trenches for foundations) to the large earthworks (highways and dams).

# INTRODUCTION

- carried out at an early stage in a construction project, completion of the earthworks within the scheduled time is often the key to the completion on time of the whole project
- success often depends on:
- an adequate site investigation and preparing practical and satisfactory designs of the earthworks



# INTRODUCTION

- the choice and efficient use of the correct types and size of plant to meet the particular requirements of the site.
- BS 6031 gives recommendations on the design and construction of earthworks in general civil engineering schemes.

# THE DESIGN OF EARTHWORKS

## Site or route selection

- selection factors:
- the availability and cost of the land
- planning, design, construction, environmental and economic considerations (choice of dam sites and the routes for highways and railways)
- the geological conditions and other geotechnical considerations

# THE DESIGN OF EARTHWORKS

## **Environmental and economic considerations**

- the design & construction and the cost of earthworks are generally dependant on:
- the environment in and around the site
- the ground conditions within the site
- the availability of materials for earthworks in the area.



# THE DESIGN OF EARTHWORKS

## Environmental and economic considerations

- the landscape of the area should be taken into consideration, the earthworks should not disfigure but blend into the environment:
  - suitable profiles of earthworks
  - amenity embankments
  - tree planting etc

# THE DESIGN OF EARTHWORKS

## Environmental and economic considerations

- balance the amount of fill arising from cuttings with the amount of fill required to construct the embankments - reduce the cost of earthworks:
  - minimise the quantities of imported materials
  - minimise material to be disposed of off-site
- transportation and minimise disruption of the local environment (especially on larger schemes).

# THE DESIGN OF EARTHWORKS

## Environmental and economic considerations

- consider natural and waste resources in the area, such as are produced from the local mines, pits, quarries, power stations, etc. as fill required to construct the embankments
- to incorporate lower quality local materials than to import higher quality materials from some distance away - reduce cost transportation and minimise disruption of the local environment (especially on larger schemes).



# DESIGN OF CUTTINGS AND EMBANKMENTS

## Excavations

- carried out either as
- part of the permanent works (e.g. cuttings) or
- a temporary expedient in the construction of the works (e.g. for foundations and drainage)
- the sides of the excavations are required to remain stable during their design life, can be achieved by:
  - excavating the material to a stable slope angle
  - by retaining or supporting the material.

# DESIGN OF CUTTINGS AND EMBANKMENTS

## Slope

- the stability of slope (natural and cut) is controlled by:
  - the nature, distribution, density and strength of the materials that form the slopes
  - the groundwater conditions or porewater pressures
  - external or surcharge loadings,
  - the strength and disposition of any discontinuities.

# DESIGN OF CUTTINGS AND EMBANKMENTS

## The effects of cutting

- reduces the total stresses in the slope which leads to a reduction of the pore pressures - increases the stability of the slope in the short term.
- pore pressures will tend to rise to a new equilibrium value and the materials in the slope may weaken, leading to a reduction in the stability of the slope



# DESIGN OF CUTTINGS AND EMBANKMENTS

## The effects of cutting

- occur rapidly in granular soils and well jointed rocks and there will be little difference in the long and short term stability - analyses of the stability of slopes carried out by **effective stress methods**
- occur slowly in cohesive soils and rocks due to low permeability (weeks or even decades) - **total stress methods** of analysis are used for the short term stability and **effective stress methods** for the intermediate and long term.

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# DESIGN OF CUTTINGS AND EMBANKMENTS

- weathering and erosion of slopes should be allowed for in the design
- factors of safety applied to the design of slopes depend on:
  - the extent and reliability of the knowledge of the ground conditions
  - the consequences of failure
  - a good level of investigation, a factor of safety of between 1.3 and 1.4 would be appropriate

# SCOPE OF EARTHWORKS

- Site clearing (Pembersihan tapak)
- Cutting and excavation (Pengorekan dan pemotongan)
- Transport and moving (Pemungggahan, Pengangkutan dan Penuangan)
- Compaction (Pemadatan)
- Sloping (Pencerunan)





# Types of Excavation works

- Bulk excavation
- Under water rock excavation
- Dumping work of support
- Embankment



# The Design of Earthworks- Site Clearance





# Site Clearance & Earthwork



# Bulk excavation

- Cutting (*Pemotongan*)
- Cut and fill area (Pemotongan dan penambakan)
- Shallow cut and (Pemotongan dan penambunan cetek)
- Basement and large pits
- Basement and pits
- Rock excavation
- Hand excavation (Pengorekan tangan)

# Rock excavation

- Pneumatic breaker
- Hand (tukul dan baji)
- Pneumatic breaker and plug+ liquid
- Pneumatic breaker and blasting



# Compaction

- Increased bearing capacity
- Reduce compressibility
- Reduce permeability
- Improve stability
- Heavy/highway vs. building foundation compaction operations

# Compaction

## Five factors affecting compaction

1. Physical & chemical properties
2. Moisture content
3. Method of compaction
4. Amount of compactive effort
5. Thickness of layer or “lift” being compacted

# Compaction

## Methods of Compaction

1. Static weight
2. Impact
3. Vibration
4. Manipulation or kneading
5. Percolation

# Consolidation

- Primary consolidation results from the expulsion or extrusion of water from the voids in fine-grained soil
- Causes settlement in structures and embankments over a period of time
  - Methods of accelerating consolidation include placing a surcharge and/or installing sand columns or wick drains
- Secondary consolidation is the rearrangement of cohesive soil grains

# Earthwork

## Clearing & Grubbing

- removal of trees, shrubs, and other vegetation
- removing stumps and root mat at least 2' (600mm) below subgrade
- less removal required for embankment heights > 5'
- topsoil striping
- muck excavation

# Earthwork

Prior to starting any earthwork:

- verify location of underground utilities through “Miss Utility” or local “one-call” system
  - check for utilities not included in one-call system
  - dig test pits to confirm actual locations
- note location of aerial utilities for equipment and truck clearances
- confirm that all applicable permits and approvals have been secured

# Earthwork

Prior to starting any earthwork:

- Install all required E&SC devices
- Review soil borings and other geotechnical information
- Observe existing drainage patterns
- Plan access and excavation patterns
- Determine handling of spoils
- Verify original ground surfaces (compare against existing contours or cross sections shown on the plan)

# KEYS TO SUCCESSFUL EARTHWORK OPERATIONS

1. control surface and subsurface water
2. maintain optimum moisture range by drying, mixing , or wetting
3. identify and monitor cut & fill quantities
4. good layout (horizontal & vertical control)
5. minimize handling - minimize stockpiling



# KEYS TO SUCCESSFUL EARTHWORK OPERATIONS

6. optimize haul lengths
7. minimize cycle time
8. proper selection and sizing of excavators and haul units
9. alternate haul unit wheel paths
10. experienced personnel in the field

# EROSION & SEDIMENTATION CONTROL DEVICES

Types:

- Silt fence – plain or reinforced
- Construction entrances
- Stone or rock check dams
- Earth berms
- Sediment traps – single or multi-stage
- Dewatering devices
- Straw-coconut blankets
- Seeding & mulching – establish vegetation

# Keystone



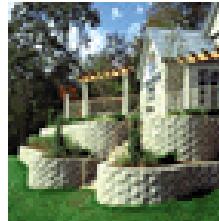
Commercial



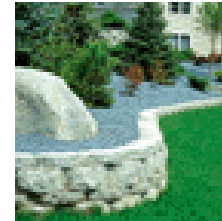
Industrial



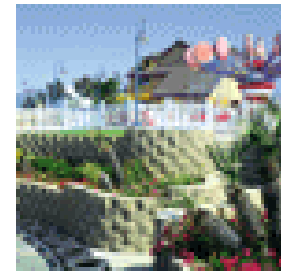
Institutional



Large Residential



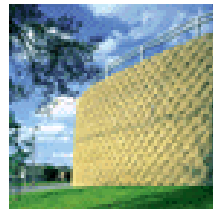
Small Residential



Parks



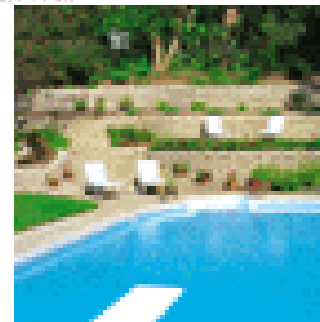
Large Residential



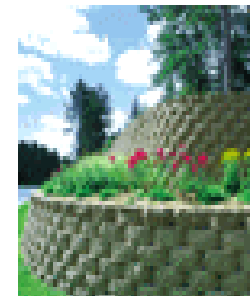
Large Walls



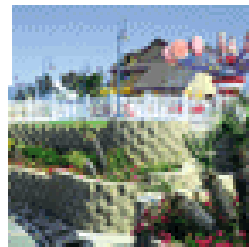
Golf Courses



Swimming Pools



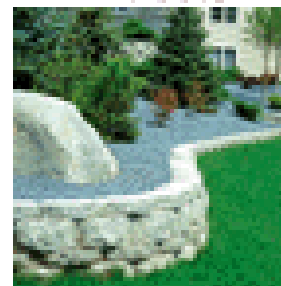
Terraces



Parks



Golf Courses



Small Residential



Industrial





# Retaining Wall



# □ Construction Activity

## R.C Wall





R.C Wall





Concrete crib wall -





Concrete crib wall

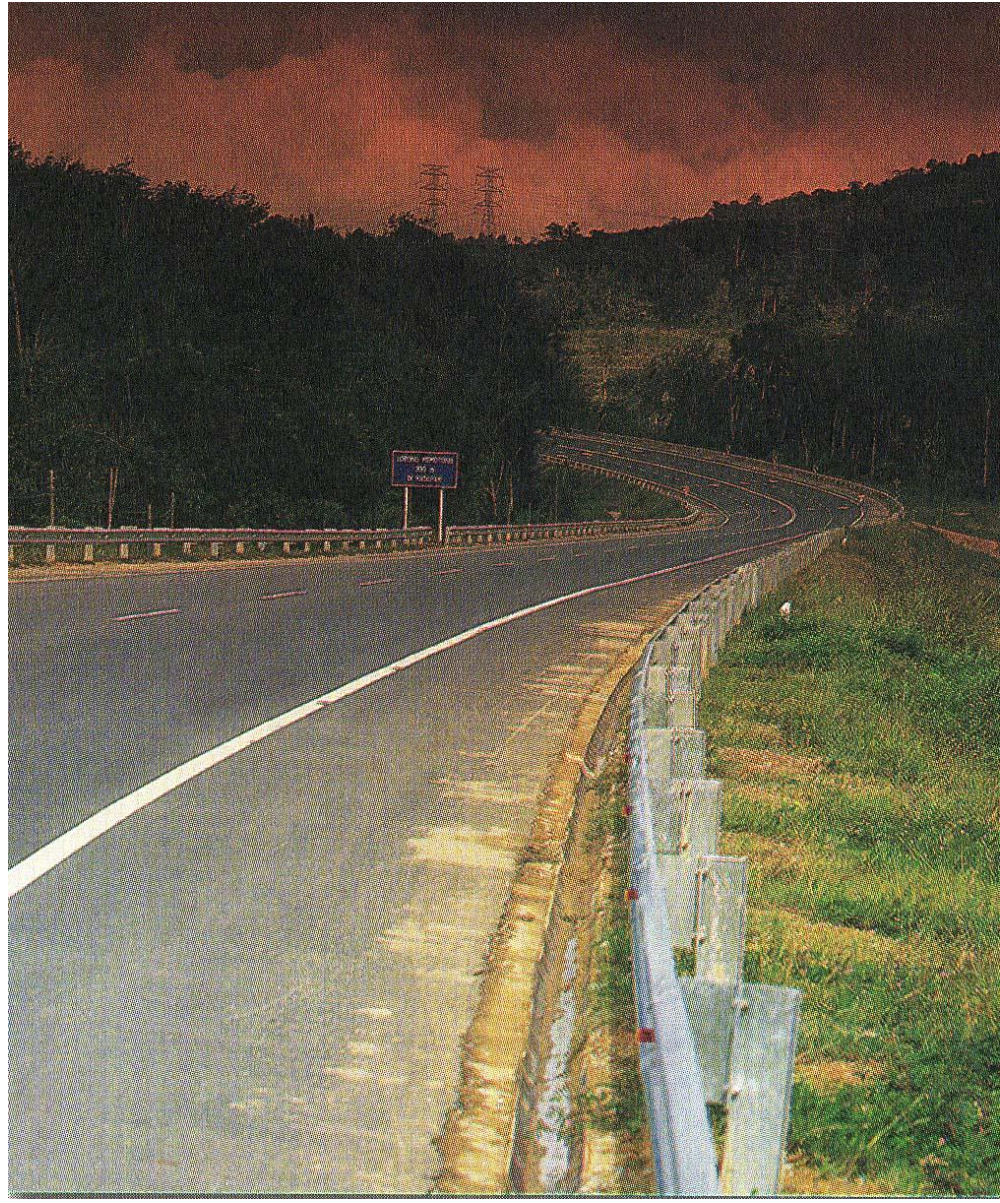
# Slope Stability

- Function of the natural angle of repose, density, surface and subsurface water flow.
- Early stabilization of surfaces is critical i.e. seeding, mulching, erosion blanket.
- Upward tracking of slopes slows sheet flow .
- Eliminate points of concentrated flow using berms or using slope drains as outlets.
- Slopes can be “softened” if space permits.
- Difficult slopes may require riprap, gabions, or other measures for permanent stabilization .

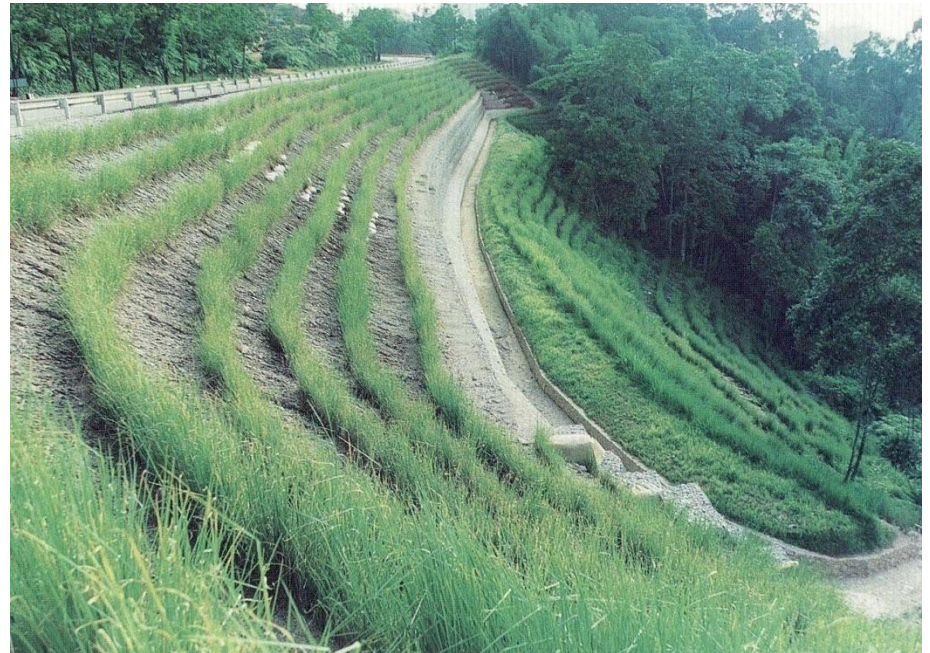
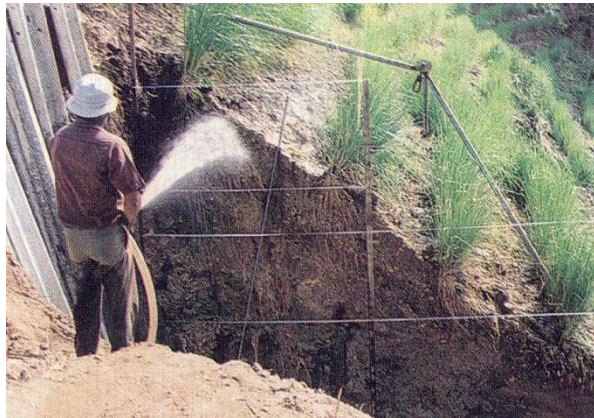










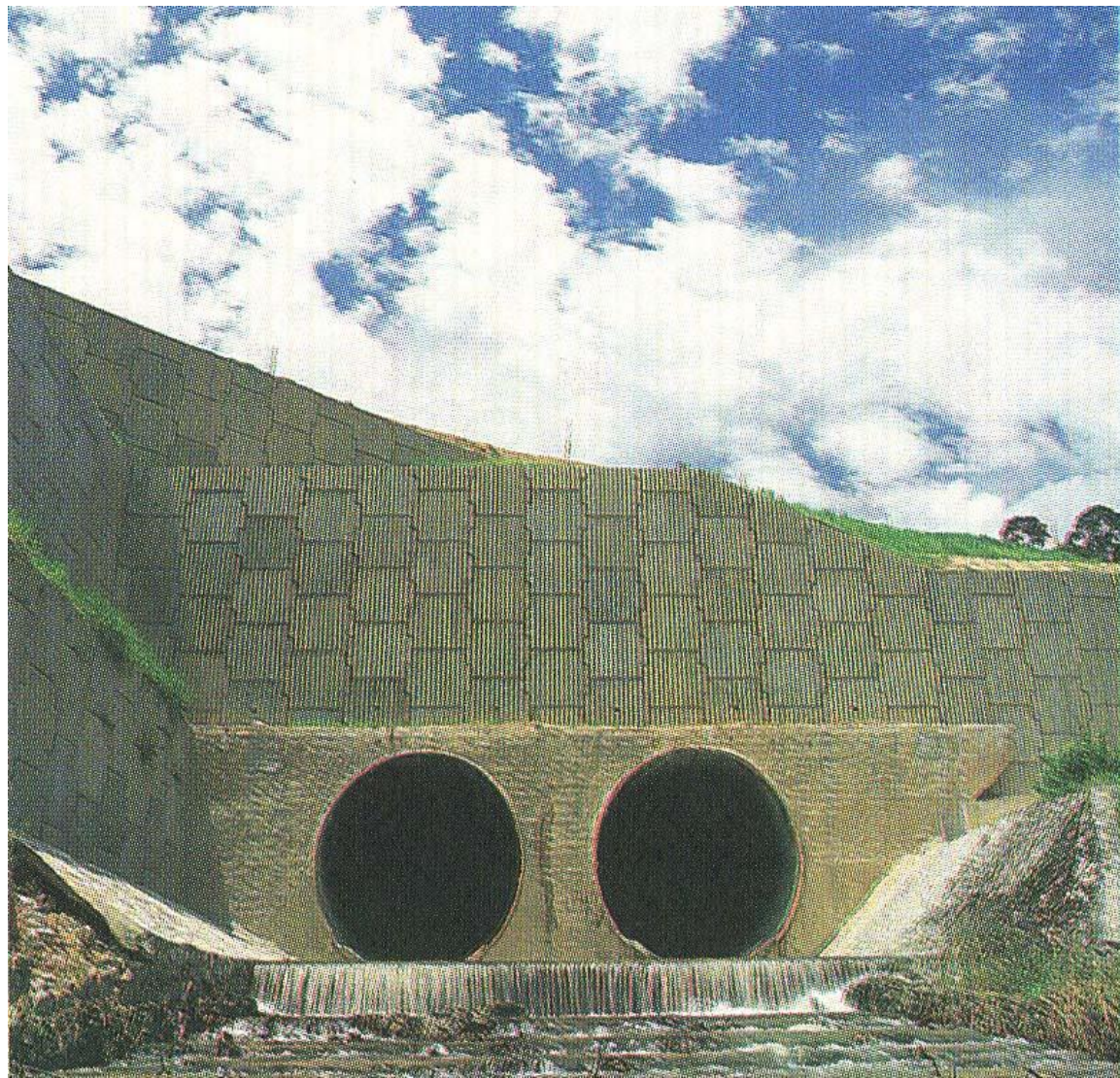




# Retaining wall









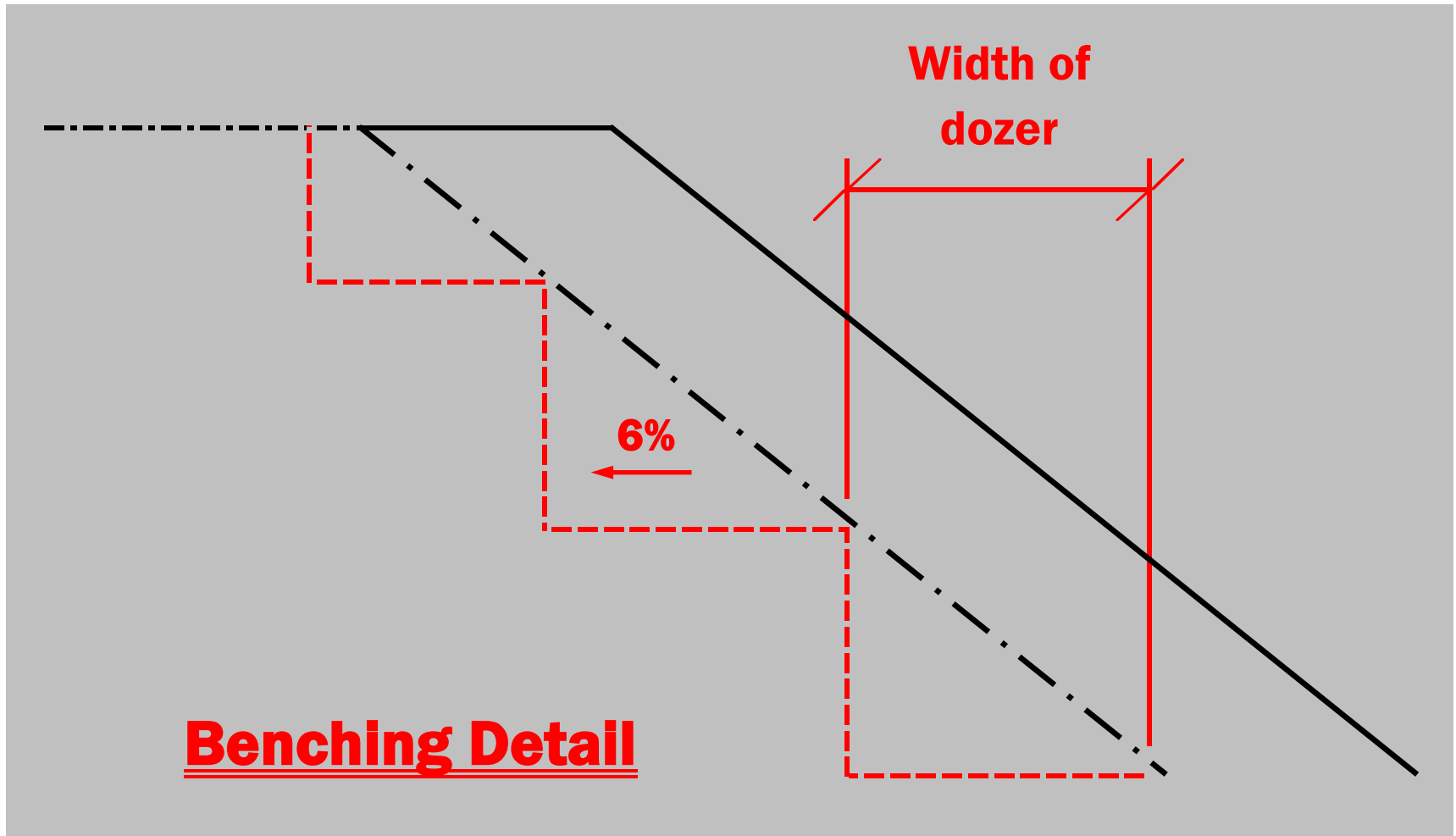
# Slope Protection



**Spot Turfing & Gabion Wall**

# Benching

- Benching is used to properly patch or extend a slope.
- Benching is also used to temporarily support equipment for other work elements.
- Bench detail must be wide enough to support a dozer % slope in towards the roadway to resist sliding.





# Site Clearance





# Site Clearance



## Site Clearance and compaction





# Compaction



# Road drainage





# ☐ Earthworks Activity



# Cutting









# Cutting and levelling





# Cutting and levelling





# Cutting and levelling





# Cutting and levelling





# Cutting and levelling





# Cutting, compact and levelling



# Cutting, slope and levelling





# Compacting, cutting and levelling



# Compact , cutting and levelling









# Pengorekan Dan Pengarasan











BAHAYA... jalan di Kilometer 32, Jalan Bentong-Kuala Lumpur yang runtuh, semalam. — Gambar oleh Zain Ahmad

# Air punca tanah runtuh







# Soil Behavior

- Soil Density (wet or dry)
- Soil Compaction
- Consolidation
- Moisture Content
- Stability
- Compressible Soils
- Expansive Clays

# PLANT AND MACHINERY FOR EARTHWORKS

- Bulldozer
- Scrapper
- Grader
- Tractor shovel
- Face shovel
- Backactor
- Dragline
- Clampshell
- Multi purpose excavator
- Trencher
- skimmer



# Equipment Functions

- Excavating
- Loading
- Hauling
- Placing (dumping & spreading)
- Drying
- Ripping
- Boring or tunneling
- Compacting
- Grading
- Finishing

# Equipment Classifications

- Function
- Configuration
- Power Units -- Gas vs. diesel vs. gas turbine
- Running Gear -- track (crawler) vs. wheel (rubber tire)
- Activation - conventional (gears, pulleys, cable) vs. hydraulic

# Diesel vs. Gas Power Units

Advantages of diesel over gas

- Less need for servicing
- Longer life
- Lower fuel consumption
- Lower- priced fuel
- Lower fire hazard
- Low CO emissions



# Running Gear

## Tracks

- greater traction
- less ground pressure
- better on steep grades
- not prone to damage from surface
- drawbar pull

## Wheels

- greater mobility
- greater speed
- does not scar or damage paved surfaces
- encounters rolling resistance
- rimpull force

# Excavation Equipment



# Excavation Equipment

- Hydraulic Excavators
- Backhoes
- Draglines & Clamshells
- Telescoping-boom Hydraulic Excavators
- Dozers/Tractors/Rippers
- Front End Loaders





# Excavation Equipment



- Scrappers (pans)
- Trenchers
- Boring/Tunneling
- Motor Graders
- Auto Graders
- Compaction Equipment
  - Rollers & Tampers

# Hauling Equipment

Dump truck



# Hydraulic excavator





# Excavation Equipment

## Scraper



# Excavation Equipment



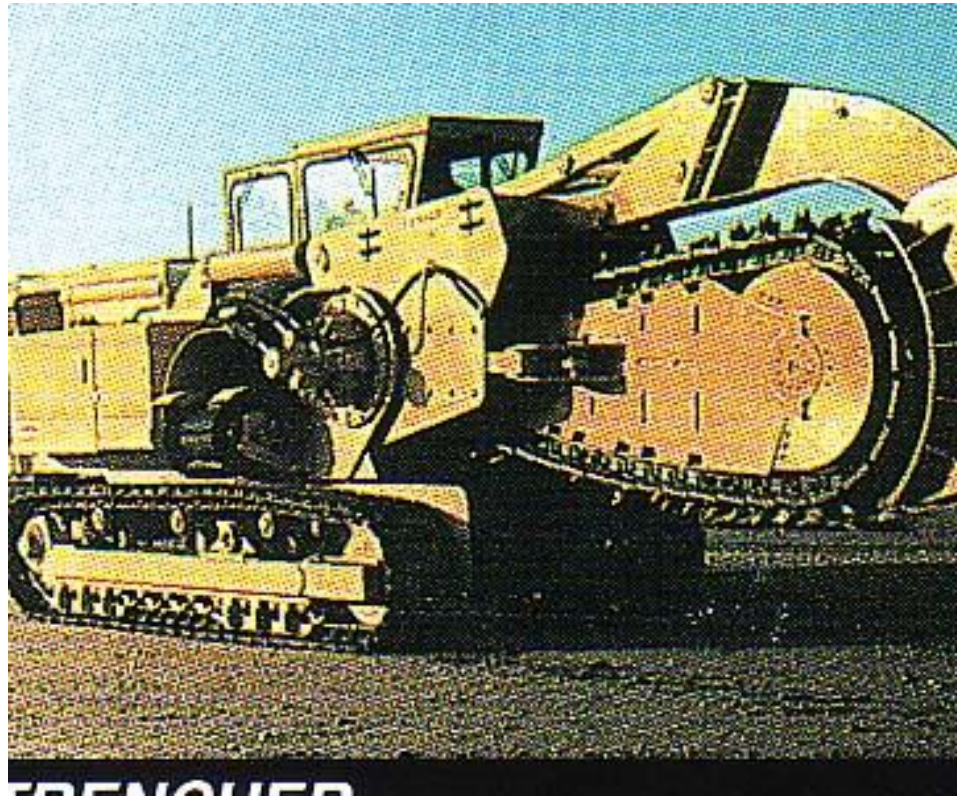


# Multi purpose excavator Backhoe





# Trencher



# Face shovel



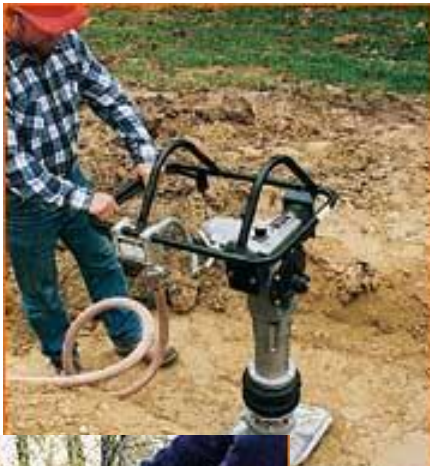


# Grader





# Compaction Equipment





# Tractor shovel



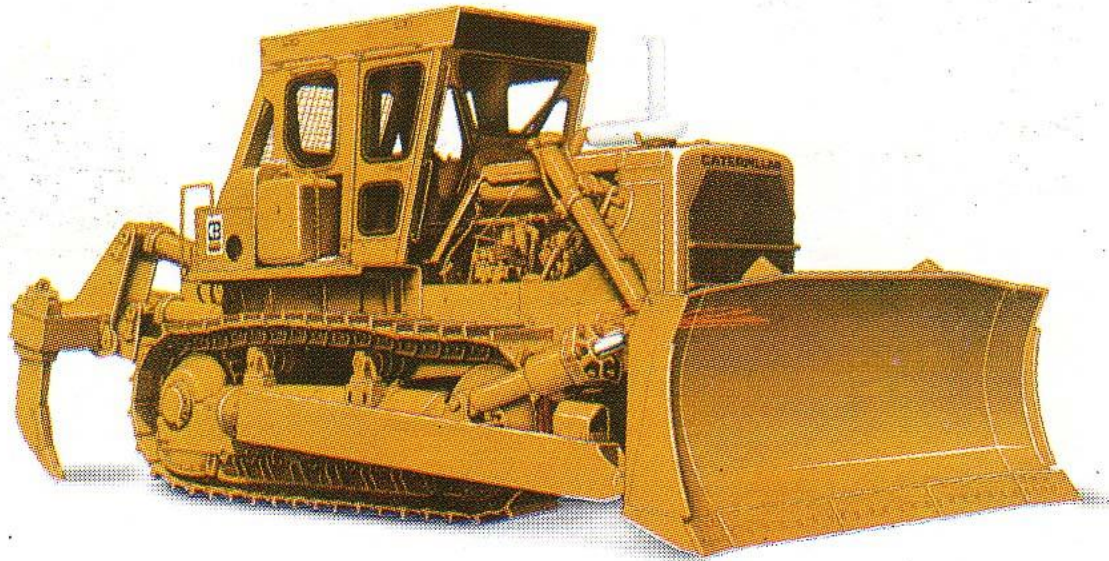


# Bulldozer





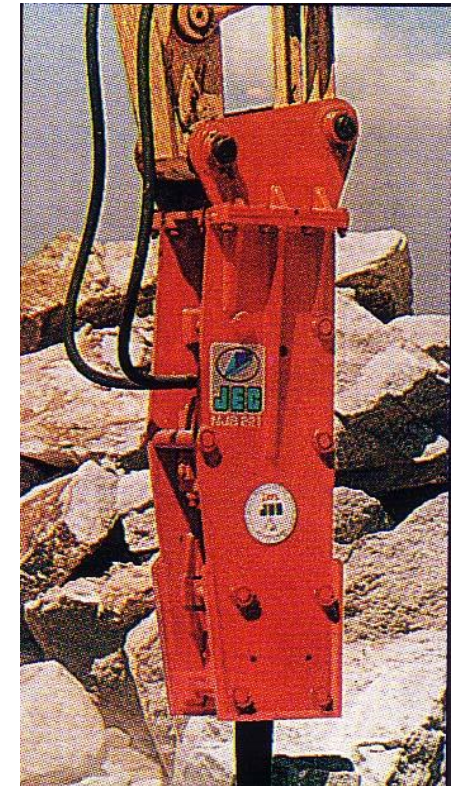
# Bulldozer with breaker





# SKID STEER LOADER

Jack hydraulic  
breaker



**THANK YOU**