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Mainstreaming Slope Stability Management – Hazard and Risk Assessment – to Laos Practitioners

Theme 1

Types of Slope Instability Affecting the Laos Road Network

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Theme 1.1

Landslide Mechanisms

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Landslide mechanism refers to the 'geometry' of the surface(s) along with failure takes place. Landslides are generally classified according to whether they are:

- Slides (failing on discrete surfaces)
- Falls (detached material from steep slopes – frequent in cut slopes)
- Flows (often fast moving movements containing high water content)

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Landslide mechanisms are usually determined by the materials involved:

- **Soil derived from in situ weathering of rock (varies between sand or clay, depending on parent material and degree of weathering)**
- **Soil derived from downslope movement of material over time (colluvium)**
- **Rock (not yet weathered to form a soil and stability is controlled by jointing pattern)**

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In Situ Weathered Soil, contains some of original rock structure

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Colluvium, derived from downslope movement of material

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Rock Slope: Stability Controlled by Jointing

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Common failure mechanisms

Slope Failures

- Plane Failures (in granular soil and rock)
- Wedge Failures (in rock)
- Rotational Failures (most common in clay soils)
- Debris Flows (in granular soils)
- Mud Flows (in clay soils)
- Falls (in soil and rock)

Retaining Wall Failures

- Wall failures above or below the road
- Landslide movements may cause walls to overturn
- Landslide movements may cause walls to lose foundation stability

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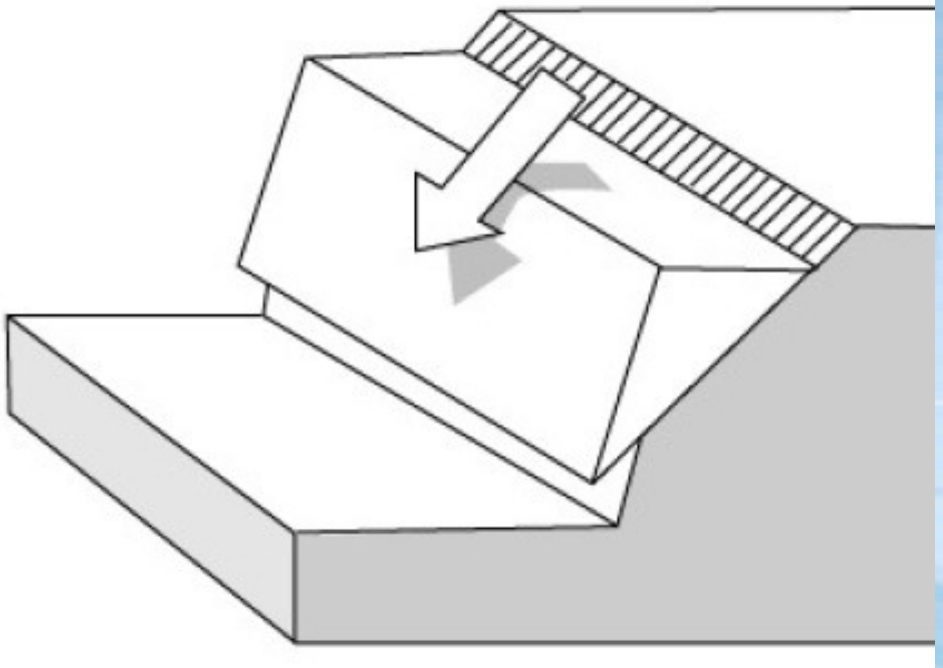
- The most common mechanism of slope failure along the Laos road network is the *plane* failure where movement occurs along a single plane approximately parallel to the slope surface, in either soil or rock.



Planar failure in rock in which a discontinuity "daylights" the slope face

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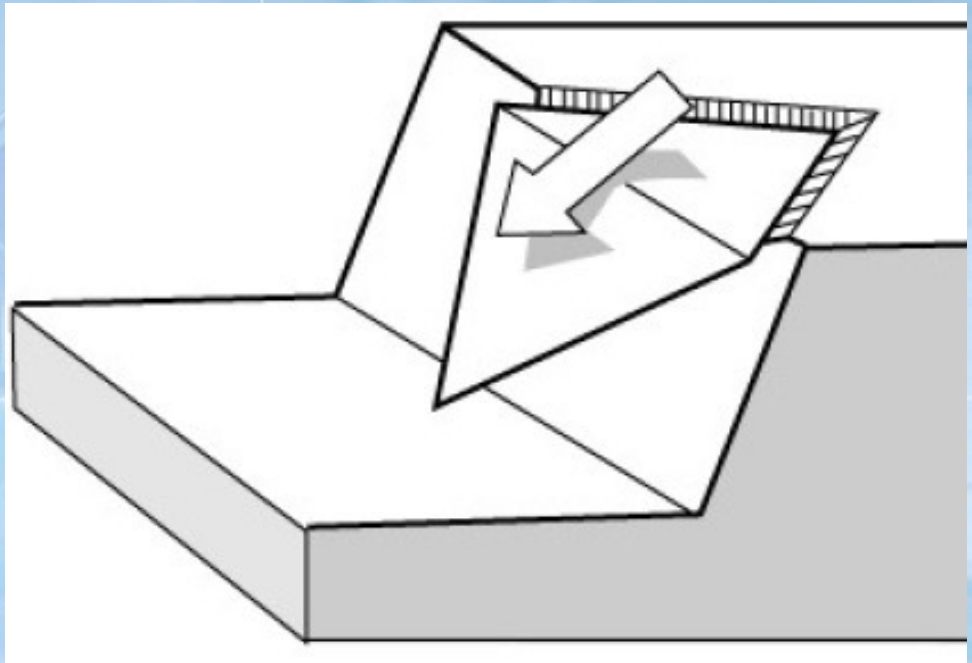
- **Wedge failures occur in rock where two joints intersect and movement takes place along the combined surfaces**



Wedge failure on two intersecting discontinuities with a line of intersection which "daylights" the slope

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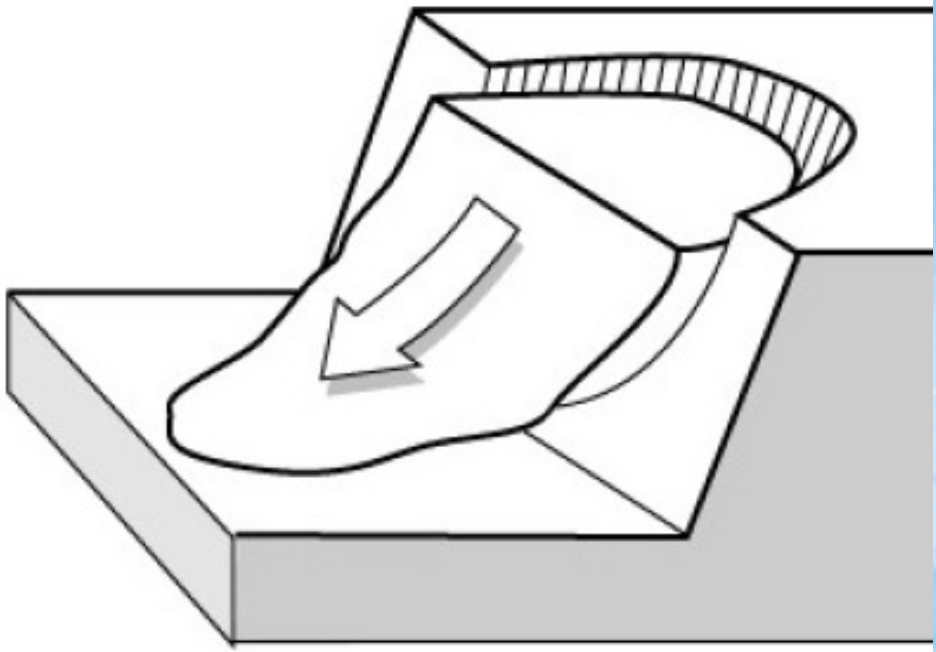
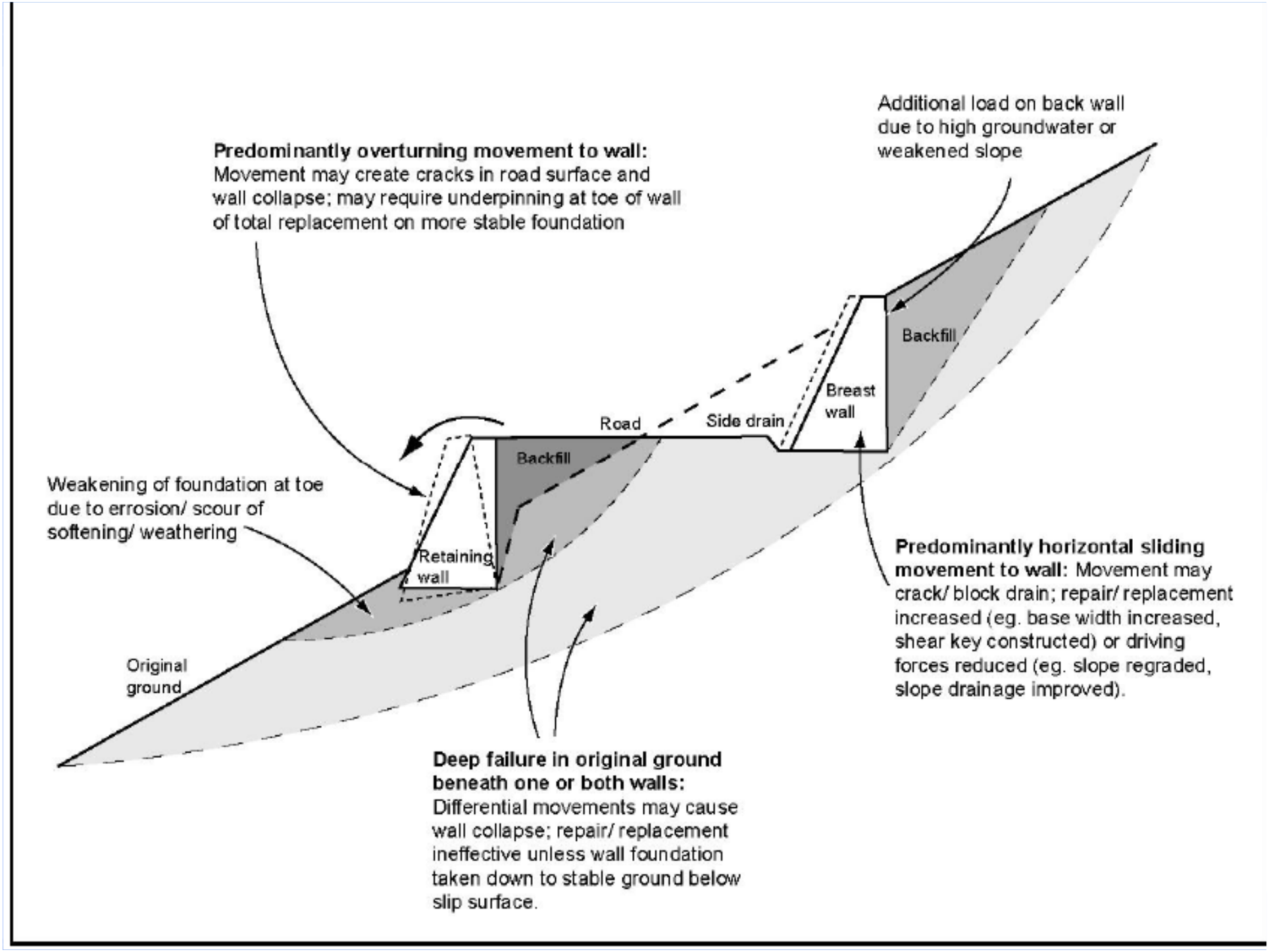
- **Rotational (or circular) failures take place along a concave failure surface and are usually associated with failures in clay soils, such as those derived from completely weathered rock**



Circular failure in overburden soil, waste rock or heavily fractured rock with no identifiable structural pattern


Additional load on back wall due to high groundwater or weakened slope
Predominantly overturning movement to wall: Movement may create cracks in road surface and wall collapse; may require underpinning at toe of wall of total replacement on more stable foundation
Backfill
Breast wall
Road
Side drain
Backfill
Weakening of foundation at toe due to errosion/ scour of softening/ weathering
Retaining wall
Predominantly horizontal sliding movement to wall: Movement may crack/ block drain; repair/ replacement increased (eg. base width increased, shear key constructed) or driving forces reduced (eg. slope regraded, slope drainage improved).
Original ground
Deep failure in original ground beneath one or both walls: Differential movements may cause wall collapse; repair/ replacement ineffective unless wall foundation taken down to stable ground below slip surface.

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Theme 1.2

Landslide Depth:

Shallow Vs Deep-Seated

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- Shallow landslides usually occur in soil and weathered rock and tend to have minimal impact on roads
  - Shallow landslides above the road usually result in blockage to side drains and adjacent carriageway
  - Shallow landslides below the road can lead to loss of the road shoulder

- Deep-seated landslides often occur in rock and can have significant impacts on roads
  - Deep-seated landslides above the road can cause road blockage and damage breast walls
  - Deep-seated landslides below the road can give rise to subsidence or loss of carriageway

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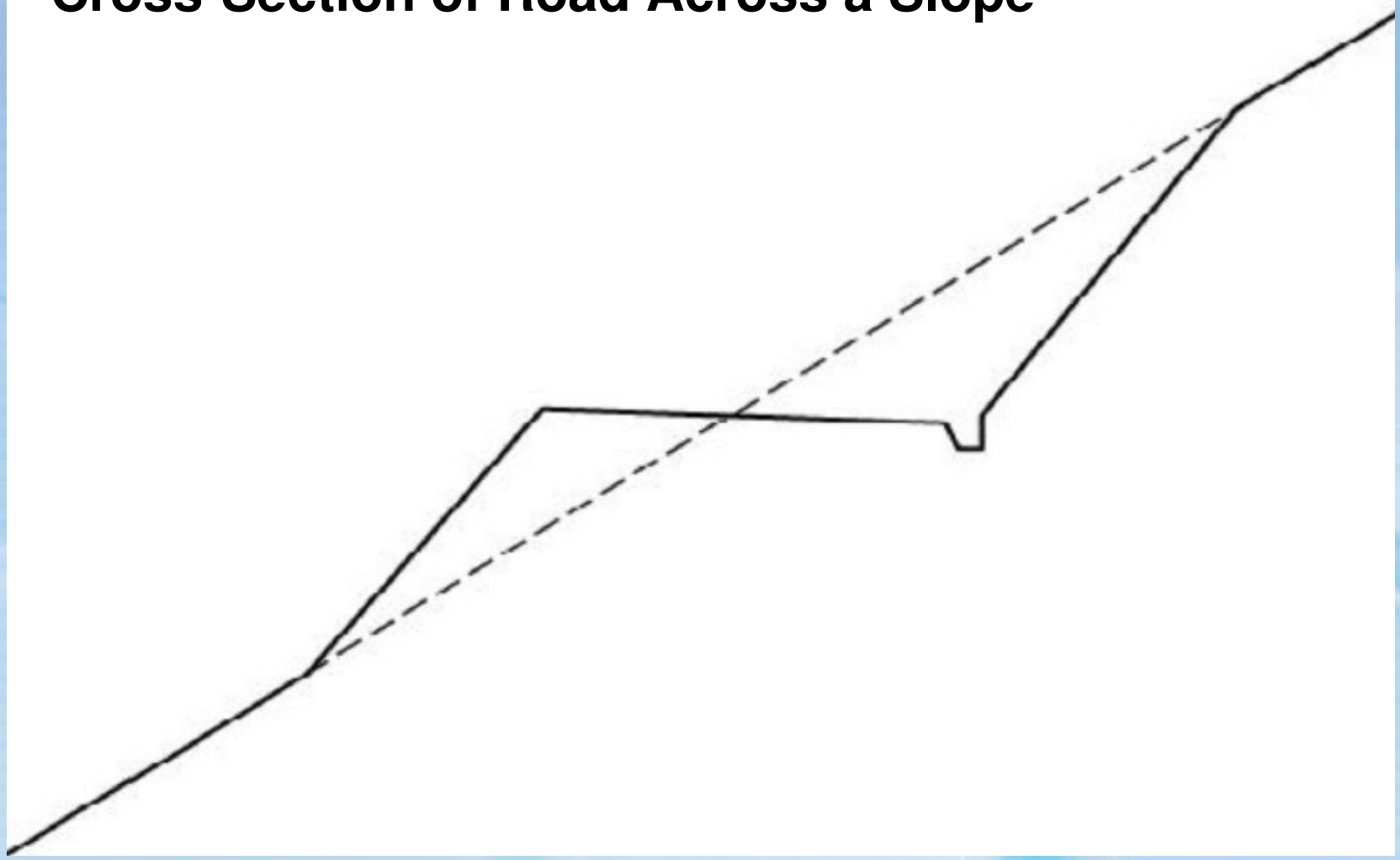
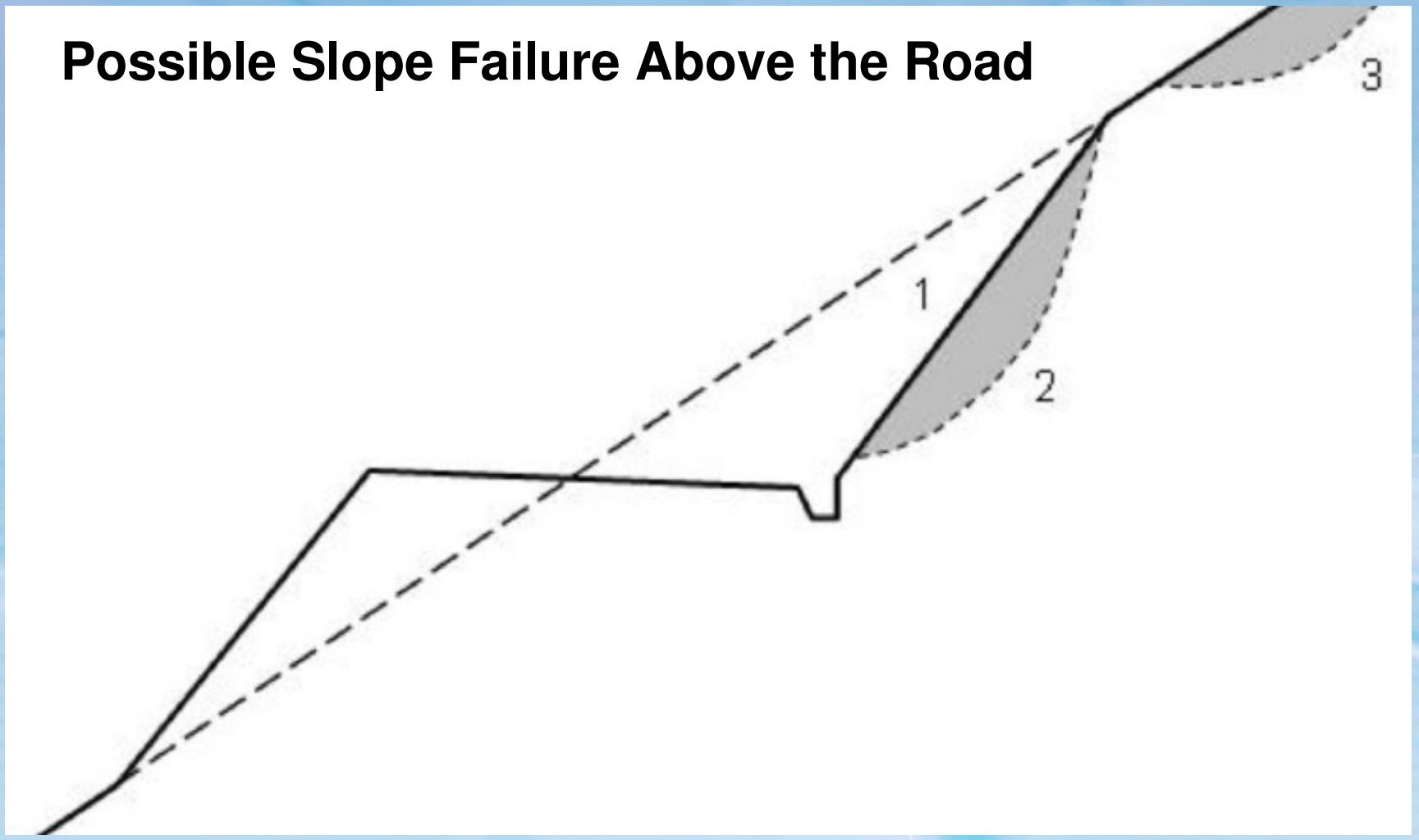
Theme 1.3

Landslide Location & Configuration with Respect to the Road: Above, Below or Through the Road

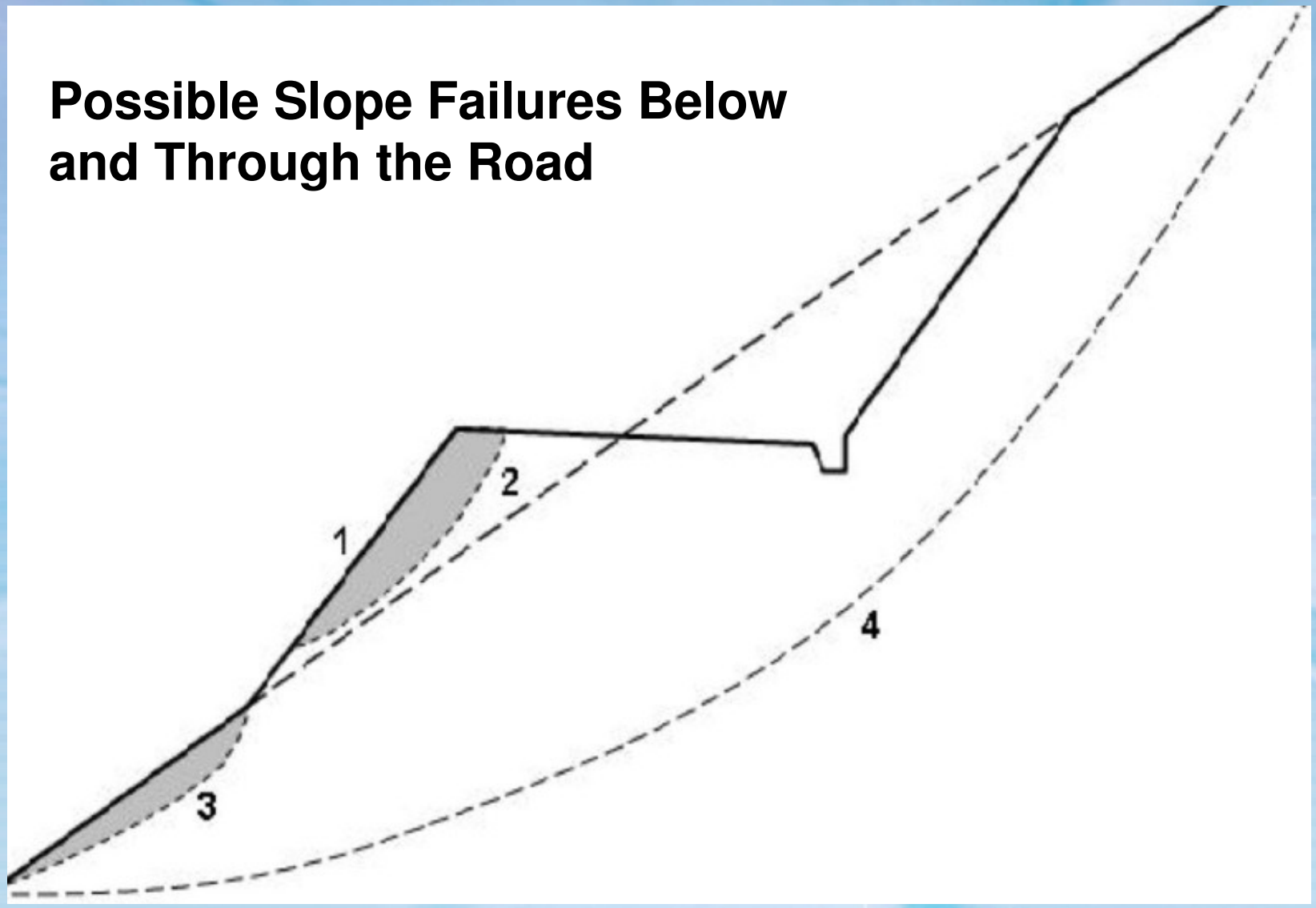
Cross-Section of Road Across a Slope



Possible Slope Failure Above the Road



Possible Slope Failures Below and Through the Road



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Theme 1.4

Typical Outcomes

Above Road Plane Failures in Rock and Soil in Over-steep Cut Slope

Above Road Plane Failures in Soil in Over-steep Cut

Fill Slope Failure on Steep Slope Below Road Exposing Road Shoulder Edge

Below Road Failure in Fill or Natural Slope

Through – Road Failure Leading to Subsidence of Road Surface

Rock Fall

Damage to Breast Wall by Cut Slope Failure

Road Fill Retaining Wall Failure Due to Landsliding on Slope Below