



Idealized cross-section of the *Himalaya* showing valley road and ridge road

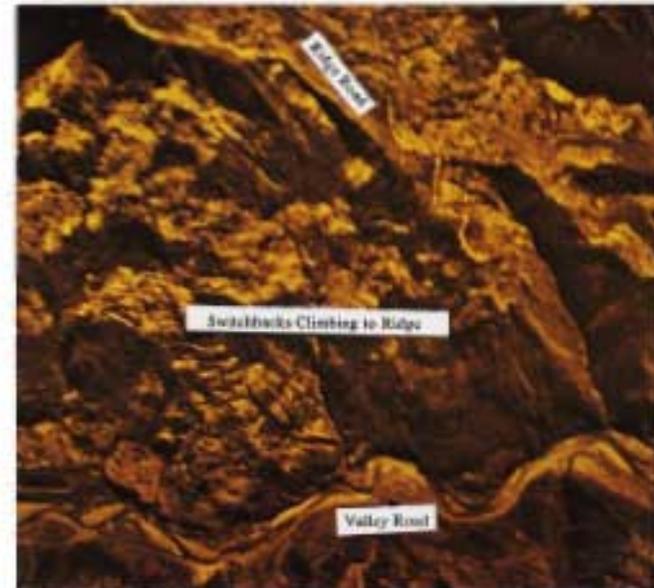
2. MOUNTAIN ROADS

A typical mountain road traverses valleys, mountain passes, and mountain ridges.

Valley road or river road are terms used to describe a mountain road which primarily follows a bank of a river.

A ridge road is one which primarily follows the ridges of the mountains.

Aerial photograph of a mountain road, East Nepal





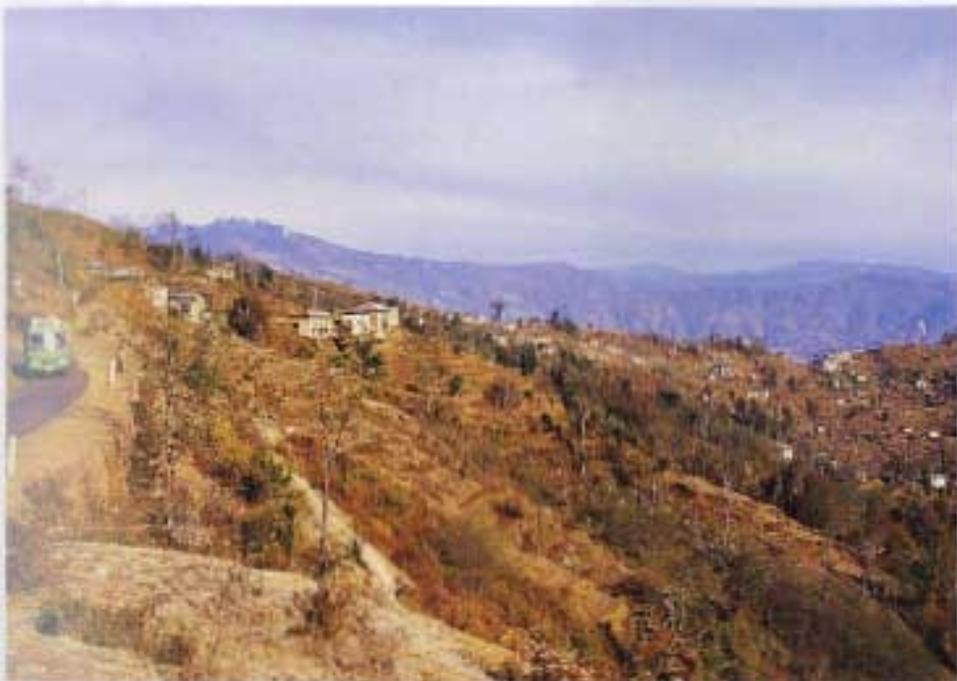
Valley road, an overview



Ridge Road, an overview



Single lane, paved road



Double lane, paved road



Earthen road (dirt road)

Outsloped roads avoid concentrated runoffs.





Severe undercutting problems exist in valley roads crossing young streams.

2.1 Valley Roads

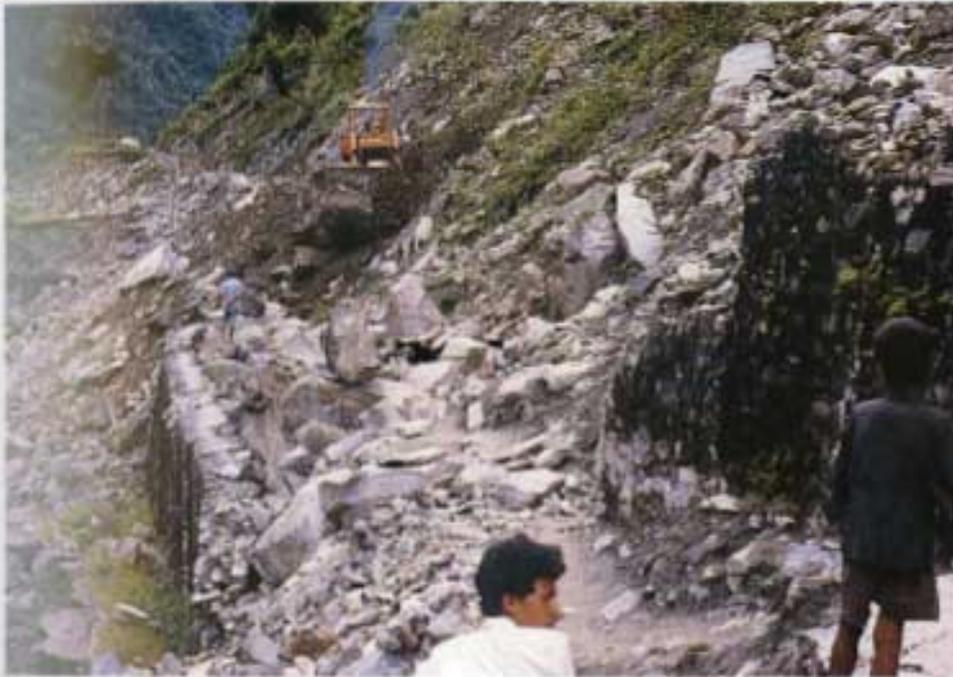
The number and size of culverts, and the size of side drains, are large since the valley roads are at the bottom of watershed.



A large culvert (right) and causeway (left) on a valley road

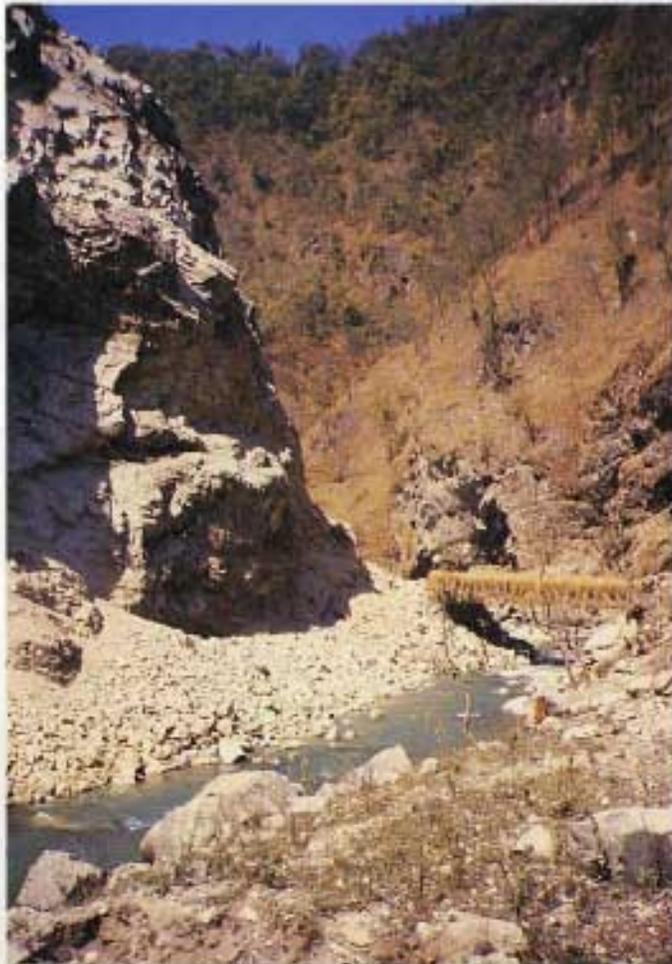


Massive landslides are often crossed by river roads.



Debris fans are crossed by valley roads.

A River road sometimes requires massive rock blasting to gain the road width through the almost vertical rock cliff.



Choice among sharp bend, massive rock cut, and tunnelling in this rocky gorge.

2.2 Ridge Roads



The magnificent panorama of the landscape is observed from the ridge road.

Low runoff and less drainage (water management)
from a road following ridges.



Colluvial terraces of gentler slopes are often favourable for roads through the mid-slope.



Several switchbacks are required on the climb section to quickly get to the ridge from the valley.

2.3 Impact of Natural Processes on Mountain Roads

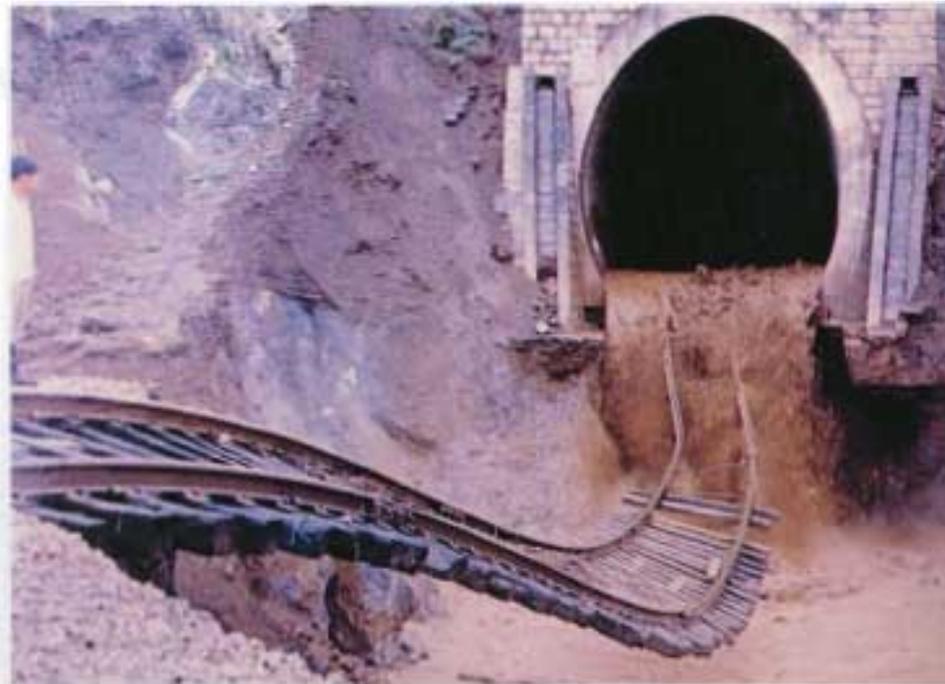
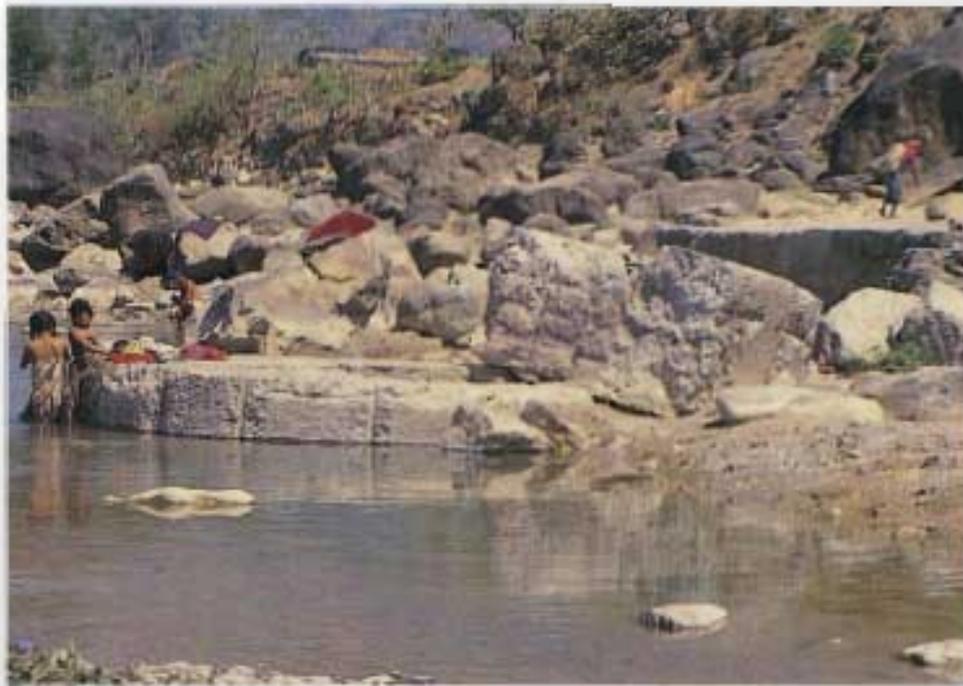


The hill slopes adjacent to a fault are highly crushed and susceptible to severe instability. This road crossing a fault zone has subsided for more than 5 m. Notice the tilted houses to the right of the road, the Illam-Taplejung Road, Nepal.

Hill slope adjacent to the Main Boundary Thrust, the Pokhara-Butwal road in Nepal



Huge slumping and bridge collapse after heavy rainfall (Butwal-Nepalganj Road, West Nepal).



Massive damage to railway track by a large-scale debris flow in China



▲ About one fourth of this road was severely damaged by a glacial lake outburst flood (GLOF) in 1981, Arniko Highway, Nepal.

▼ Slope failure from earthquake and heavy rainfall in 1988, Dharan-Dhankuta Road, Nepal)



Massive landsliding, the Karakoram Highway, Pakistan



River undercutting, the Karakoram Highway, Pakistan



Massive gullying after heavy rainfall in this more than 50m deep colluvium/till washed out several houses, killing their occupants, in 1987; the Lamosangu-Jiri Road, Nepal.

Cloudburst and heavy rainfall (150 mm in one and a half hours) discharging 160 cumecs from this tiny stream in 1987 destroyed the bridge and created landslides; The Lamosangu-Jiri Road, Nepal.





A deep seated rotational slide damages the road.



A landslide cutting off the traffic.

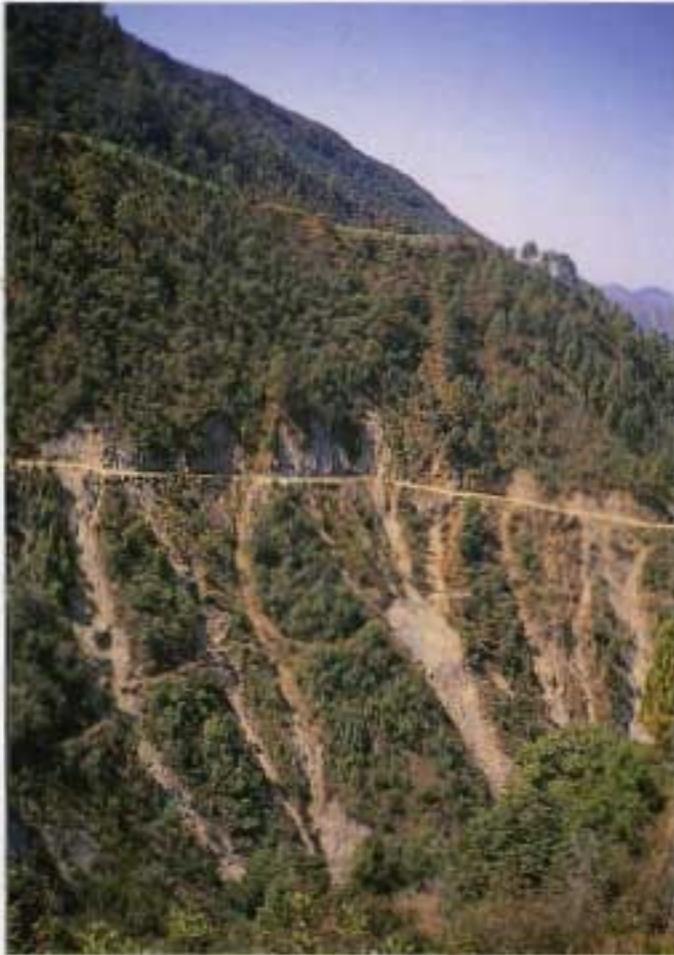


Washouts at several stretches closes the road, forcing transportation of goods by porters.



A complete washout of the road by the river

2.4 Impacts of Road on the Environment



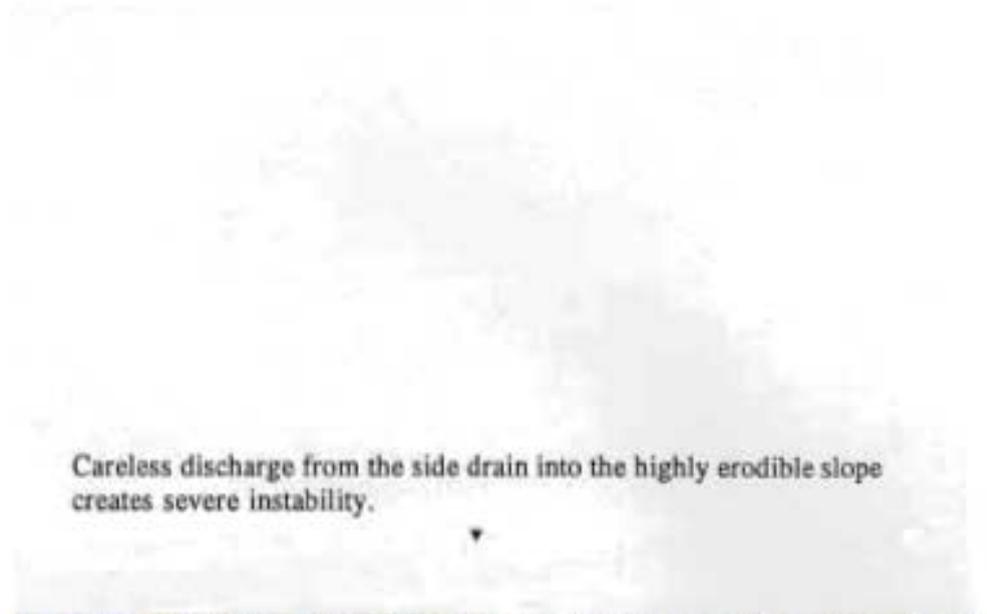
Devegetation and scars from indiscriminate side casting

Landslide from indiscriminate cutting into mountain slope





High runoff discharging onto unstable slope triggers a major landslide.



Careless discharge from the side drain into the highly erodible slope creates severe instability.





A culvert outlet is directed towards an existing building, flooding the latter.



Side casting during construction

Indiscriminate bulldozing, apparently the easiest method of quick road opening, destroys downhill slope.



Indiscriminate blasting triggers major rockslides.

2.5 Risk to Road from Inadequate Technology Applied

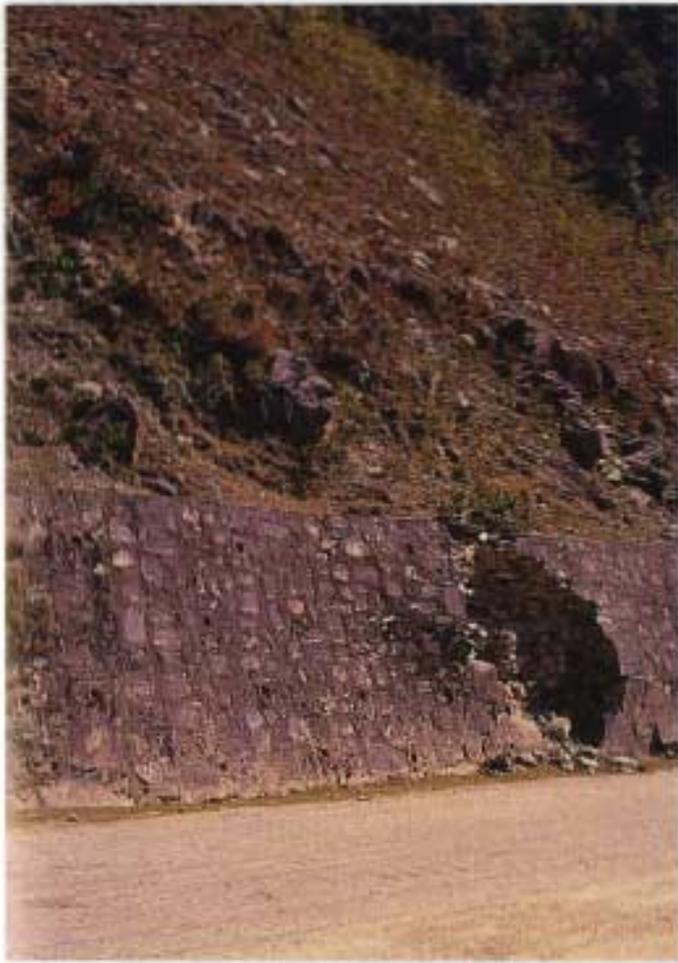


Revetment wall failure due to inadequate foundation



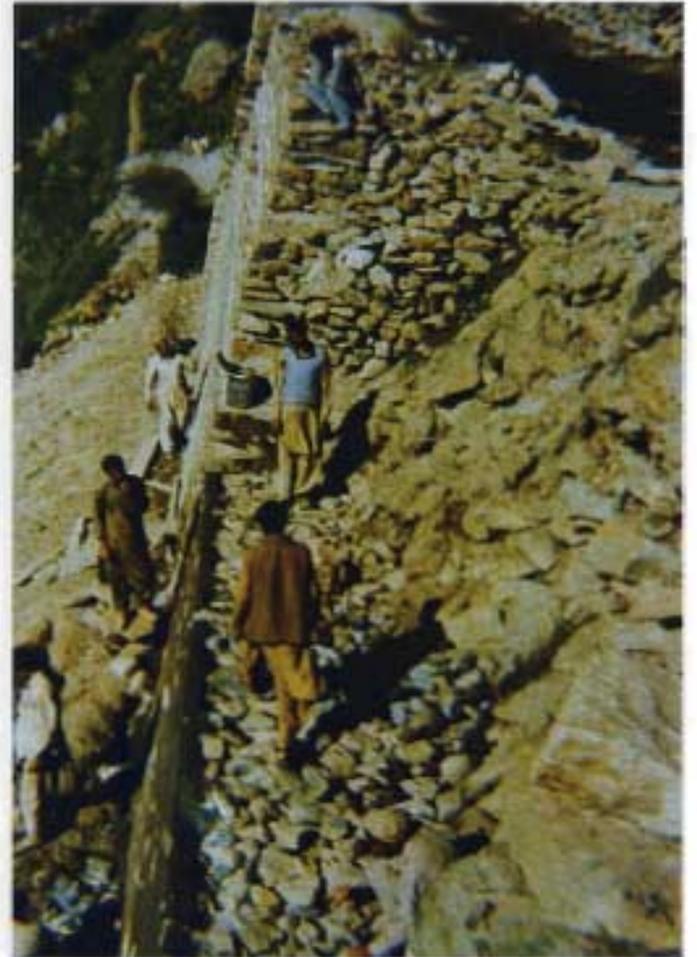
▲
Gabion spur failures, first by scour and then by rupture of wires



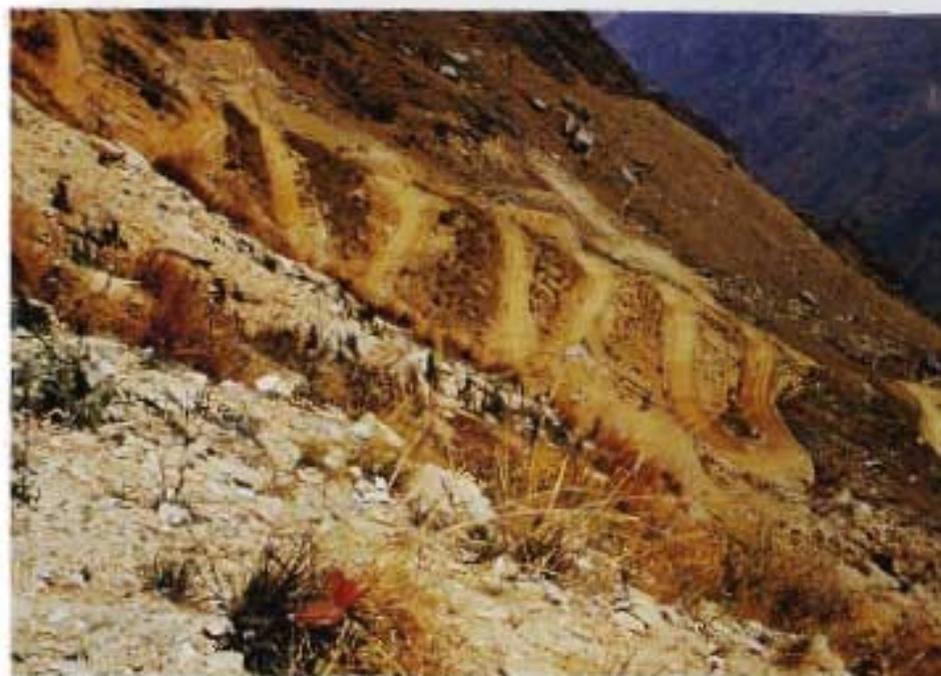


▲
Breast wall failure from hydrostatic pressure

▼
Dry stone masonry without proper bonding leads to early failure of the wall.



Lack of protection at the outfall of drainages undercut the road.



Stacks of parallel switchbacks offer no scope for widening, are extremely difficult to maintain, and are stressful for drivers.



Daylighting of dip slope leads to planar rock failure.



2.6 Risk to Road from Human Activities Adjacent to Roads



▲
Agricultural farming at the edge of road slopes



▼
Irrigation canal above the cut slope

Indiscriminate quarrying for the cement factory has caused aggradation by more than 2m in one year and damaged the road.



Spurs deflecting the flow from the left bank to save the power plant threatens the road on the right bank.