8.7 How does Hong Kong cope with landslides?
What damage do landslides bring to Hong Kong?

In Hong Kong, landslides bring about the greatest damage of all kinds of mass movement.

Two major landslides occurred in Sau Mau Ping in 1972 and 1976. The photo shown here is the 1976 landslide which killed 18 people and injured 24 others.

(Acknowledgement: The Head of the Geotechnical Engineering Office and the Director of Civil Engineering and Development, the Hong Kong SAR Government, for the permission to publish the photograph)
What damage do landslides bring to Hong Kong?

The landslide killed 67 people.

Note that the housing block in red circle collapsed during the hazard.
What damage do landslides bring to Hong Kong?

Slope collapsed at Ching Cheung Road in 1997. The road nearby was blocked.

(Acknowledgement: The Head of the Geotechnical Engineering Office and the Director of Civil Engineering and Development, the Hong Kong SAR Government, for the permission to publish the photograph)
When and where do most landslides occur in Hong Kong?

In Hong Kong, landslides have clear temporal and spatial pattern:

- They concentrate in (summers / winters) when rainfall is abundant.
- They occur on both natural slopes (30° to 40°) and man-made slopes (particularly cut-slopes).
What are the causes of landslides on natural and man-made slopes in Hong Kong?

**Causes of landslides**

- **Natural slopes**
  - Rainfall
  - Characteristics of a slope

- **Man-made slopes**
  - Rainfall
  - Characteristics of a slope
  - Human activity on slopes
  - Poor maintenance
What has the government done to prevent landslides?

Measures

Natural slopes

- Engineering measures
- Non-engineering measures
- Restricting development on slopes
- Regular checking of slopes
- Strengthening slopes
- Maintaining slopes
- Public education

Man-made slopes
What has the government done to prevent landslides?

Other measures

- The GEO and the Hong Kong Observatory jointly operate the landslip warning system.

The GEO provides a 24-hour, year-round service to give advice to government departments.

The risks of landslide have been greatly reduced in Hong Kong since the set up of the GEO.
The end
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Rainfall

Are rainfall intensity and distribution of landslides on natural slopes interrelated?

Water is the immediate and direct cause of landslides.
Rainfall

The mean annual rainfall of Hong Kong reaches about 2,200 mm. More than 78% of it falls in summer (between May and September).

Wet south-easterly monsoons and typhoons bring rainstorms.

When large amount of water goes into the slope materials, the friction and cohesion of slopes materials (reduce / increase).

Therefore, the hazard always occurs in wet summer months.
Characteristics of a slope

A Gradient

- The steeper the gradient of a slope, the **larger** the sliding force, and the higher the risk of landslide. Therefore, steep slope is more vulnerable to landslides.

Many slopes in Hong Kong have gradients of more than 30°. They are at risk of landslides.
Characteristics of a slope

**B Geology**

- **Granite and coarse-grained volcanic rocks are vulnerable to weathering in a hot wet climate.**

  - **Feldspar** becomes clay due to vulnerable to chemical weathering.
  - **Quartz** is resistant to weathering but may be loosened after weathering, and easy to be washed away.
Characteristics of a slope

B  Geology

The joints in the rocks allow water to enter them easily and allow chemical weathering to a great depth.

Rapid chemical weathering creates a thick soil on natural slopes, which is ready to slide down the slope when the strength is reduced.
Human activity on slopes

- Construction of buildings and roads: Impermeable concrete is used to cover the slope, which increases surface run-off and the chance of infiltration downslope. Water reduces the coherence of the slope material, and the friction.

- Building squatter huts: Natural vegetation on the slope is removed, leading to soil on the slope being loosened.

- Unauthorized cultivation: Cutting slope without applying appropriate measures to protect the slopes, ploughing on slopes loosens the soil on slopes, surface run-off may erode the loosened topsoil easily. Infiltration causes a rise of water table.
Poor maintenance of man-made slopes

Poor maintenance of the **surface and subsurface drainage system** can cause slope failure.

The landslide at Kwun Lung Lau in 1994 was caused by a leak in a drainage pipe behind the masonry wall. The wall fell as the pore water pressure rose to a level that the wall could no longer bear.

(Acknowledgement: The Head of the Geotechnical Engineering Office and the Director of Civil Engineering and Development, the Hong Kong SAR Government, for the permission to publish the photograph)
A  Engineering measures

The GEO builds structures to prevent debris from rushing into nearby developed areas.

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A Engineering measures

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A  Engineering measures

The GEO builds structures to prevent debris from rushing into nearby developed areas.

Check dam

Other measures such as debris diversion and drainage provision are also used.

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B Non-engineering measures

The GEO makes records of natural slopes where landslides have occurred. Careful land use planning on these slopes is carried out.

For cases where natural slopes are unstable, yet stabilizing works are likely to be very expensive, permanent evacuation or relocation of the facilities nearby may be adopted.
Strengthening slopes

The GEO takes actions to reduce the **stress** and increase the **strength** of the soil on the slope.

Measures adopted to strengthen the slopes:

- Removing large trees from steep slope
- Removal of unstable or overhanging boulders
- Afforestation
- Surface drainage channels
- Soil nail
- Subsurface drainage
- Covering impermeable layers
- Retaining/Protective wall
Strengthening slopes

The GEO takes actions to reduce the **stress** and increase the **strength** of the soil on the slope.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Increase strength</th>
<th>Reduce stress</th>
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<tbody>
<tr>
<td>Removal of unstable or overhanging boulders</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Replacing large trees with grass on steep slopes</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Afforestation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Installing soil nails</td>
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<td></td>
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<tr>
<td>Building protective walls</td>
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<tr>
<td>Covering with impermeable layers</td>
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<td>✓</td>
</tr>
<tr>
<td>Constructing surface and subsurface drainage channels</td>
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<td>✓</td>
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</tbody>
</table>
Afforestation

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Soil nail