Designing Climate Resilient Buildings

What is Climate Change?

Climate change is the long-term shift in weather patterns

Climate change is the catch-all term for the shift in worldwide weather phenomena associated with an increase in global average temperatures.

a **change** in the world's **climate**

a **change** in the world's **climate** global **climate change** temperature **change**

What are the effects of Climate Change?

- More destructive hurricanes and storm surges
- More frequent and intense heat waves
- Increase in vector-borne diseases
- Rising seas and increase costal flooding
- Changing seasons
- Heavier precipitation and flooding - Increase in extreme weather events

Climate Resilience

Climate-resilient buildings reduces, but may not fully eliminate, the risk of climate-related disruptions.

Risk management requires making trade-offs between risk minimization and cost, where it becomes more expensive and increasingly technically challenging to prepare for events that are very unlikely to occur

Resilience means that the risks have been considered and managed to achieve an acceptable level of performance given the available information, and that capacities to withstand and recover from shocks are in place

This definition of climate resilience focuses on the process used and outcomes achieved to assess whether climate change impacts have been considered and managed

Climate Resilience

Structural adaptation measures

- Changing the composition of road surfaces so that they do not deform in high temperatures
- Building seawalls
- Ecosystem-based approaches using natural infrastructure to design
- Adaptation measures are also key alternatives to be considered alongside structural adaptation measures.

Management (or non-structural) adaptation measures

- Changing the timing of maintenance to account for changing patterns of energy demand and supply,
- Investment in early warning systems or purchasing insurance to address financial consequences of climate variability.
- These measures can also include enhanced monitoring of existing assets to reduce the risk of failure as climate conditions change.

Let's Consider the Effects of Climate Change on……

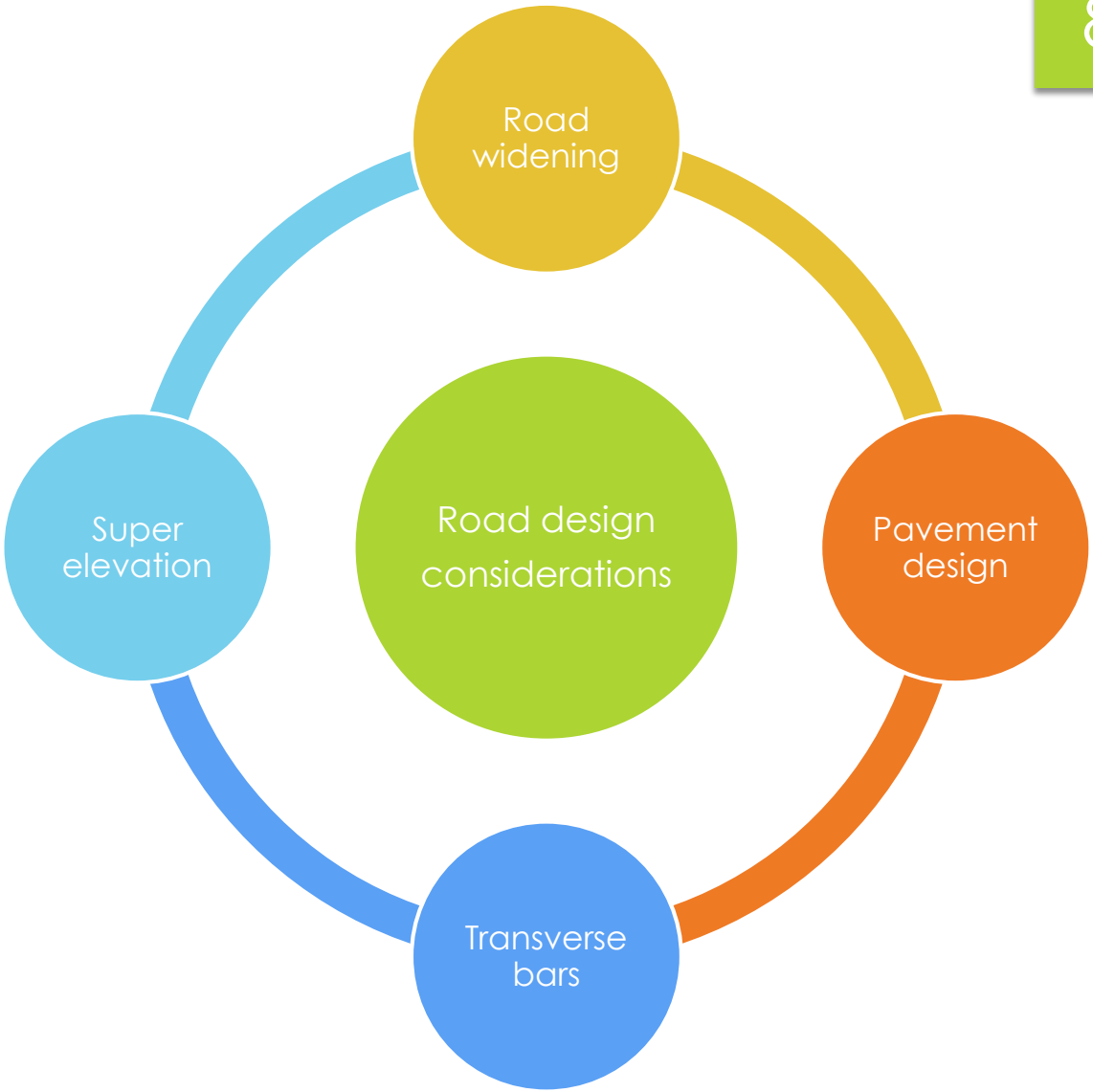
Civil Works

Buildings

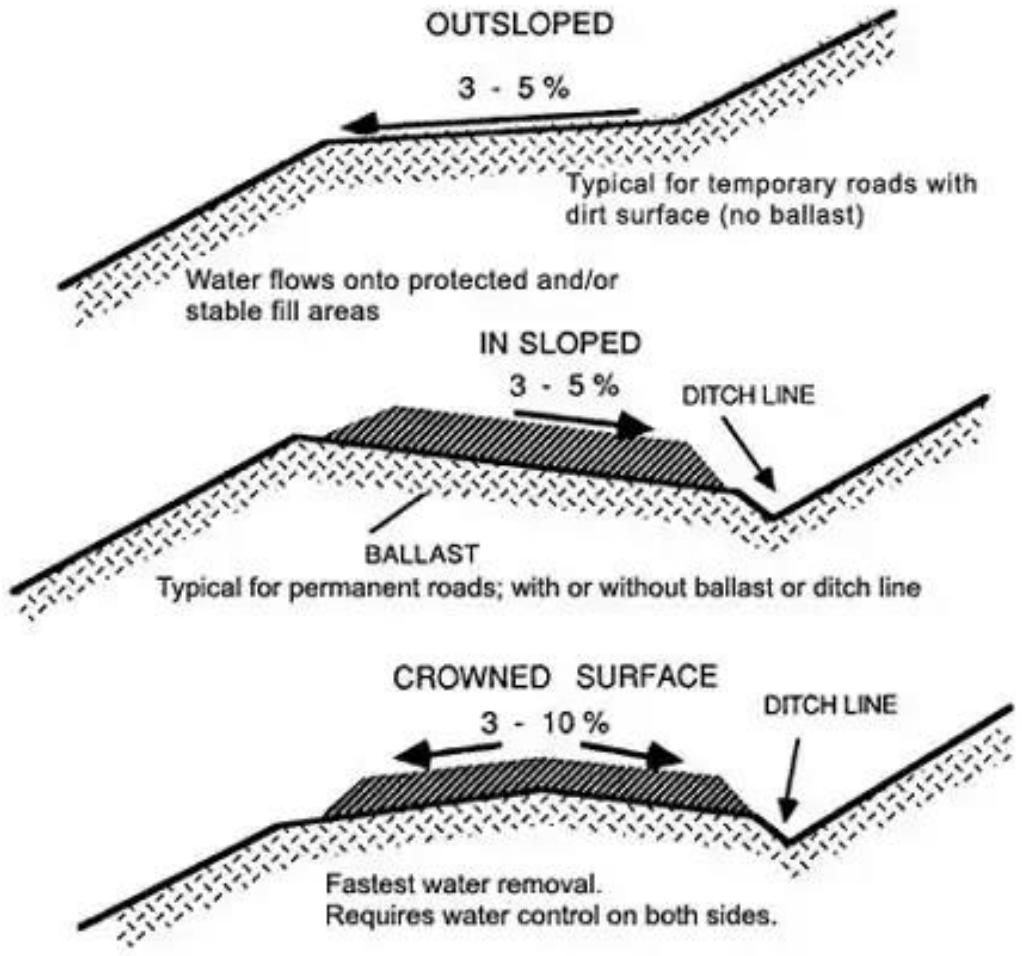
Climate Resilience – Civil Works

Temperature changes	Sea-level rise	Changing patterns of precipitation	Changing patterns of storms
• Melting road surfaces	• Inundation of coastal infrastructure, such as ports and roads	• Disruption of transport due to flooding	• Damage to assets, such as bridges

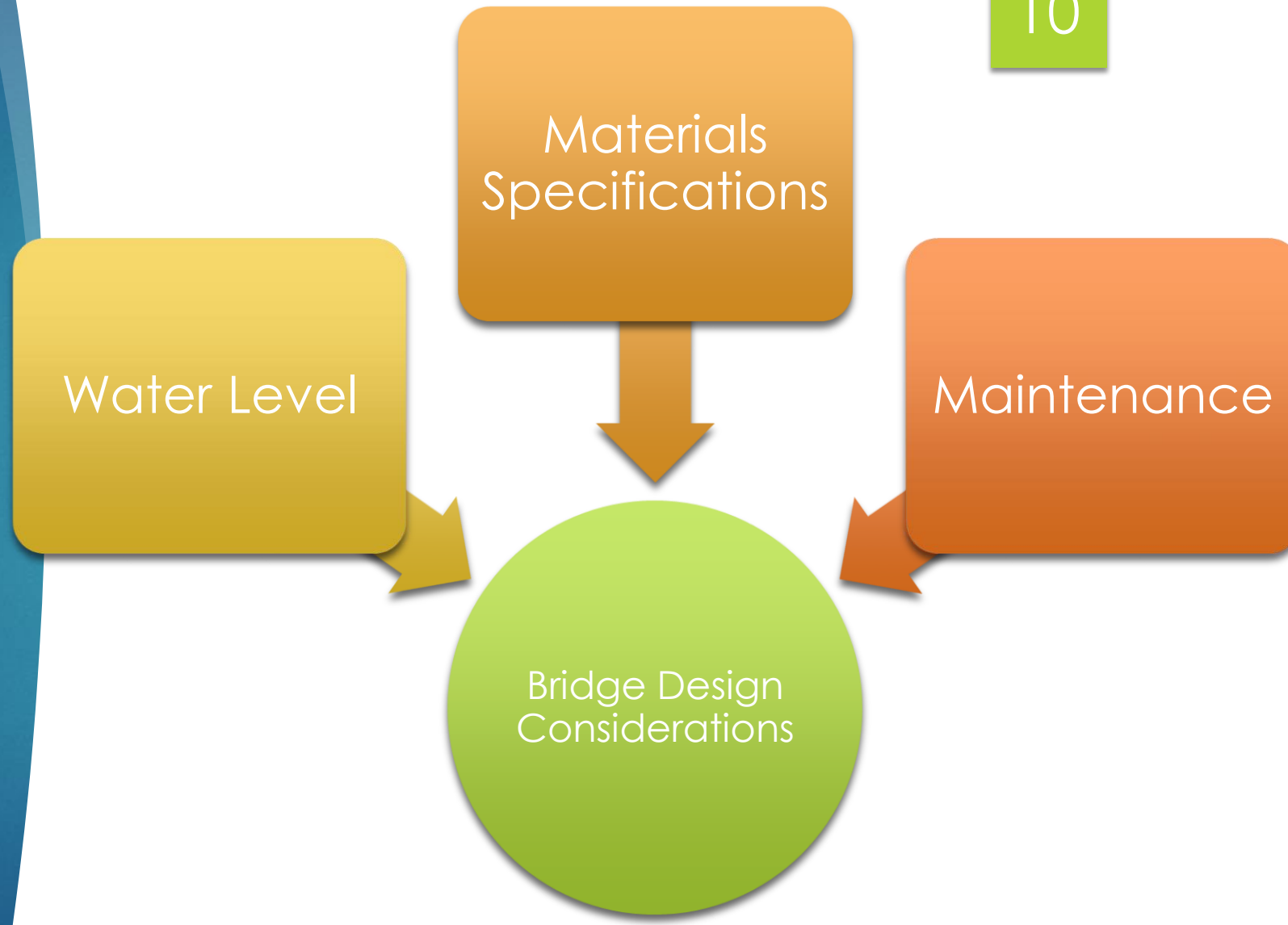
Civil Works


Road widening
Pavement design
Transverse bars
Super elevation
Road design considerations

Civil Works


OUTSLOPED
3 - 5 %
Typical for temporary roads with dirt surface (no ballast)
Water flows onto protected and/or stable fill areas
IN SLOPED
3 - 5 %
DITCH LINE
BALLAST
Typical for permanent roads; with or without ballast or ditch line
CROWNED SURFACE
3 - 10 %
DITCH LINE
Fastest water removal.
Requires water control on both sides.

Civil Works


Materials Specifications
Water Level
Maintenance
Bridge Design Considerations

Civil Works

Drainage

Climate Resilience – Building

Temperature changes	Sea-level rise	Changing patterns of precipitation	Changing patterns of storms
• Increased cooling demand	• Inundation, storm surge and increased flood risk • Changes in land use due to relocation of people living in exposed areas	• Flooding • Prolonged dry season	• Damage to buildings • Deaths and injuries

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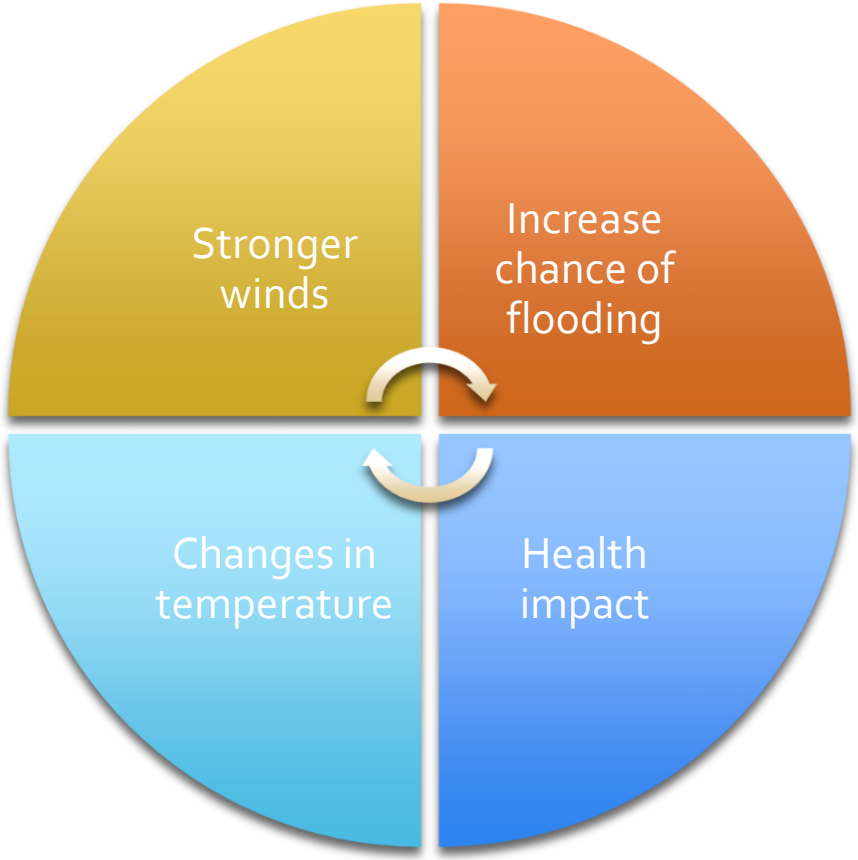
This definition of climate resilience focuses on the process used and outcomes achieved to assess whether climate change impacts have been considered and managed

Design Considerations



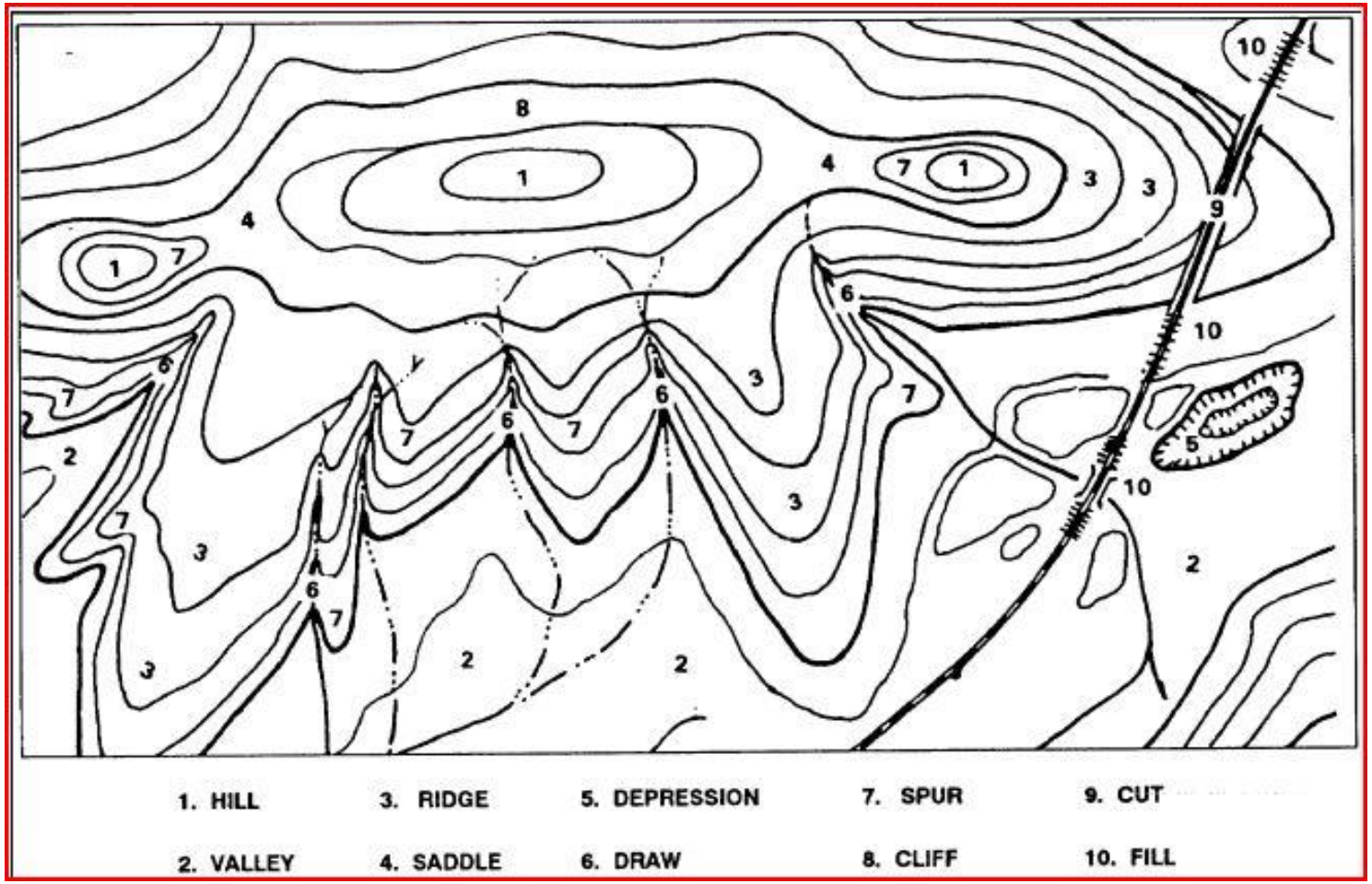
Climate Resilient Housing

Climate resilient design features make buildings resistant to climate vulnerabilities, such that they maintain an acceptable level of functioning and structure

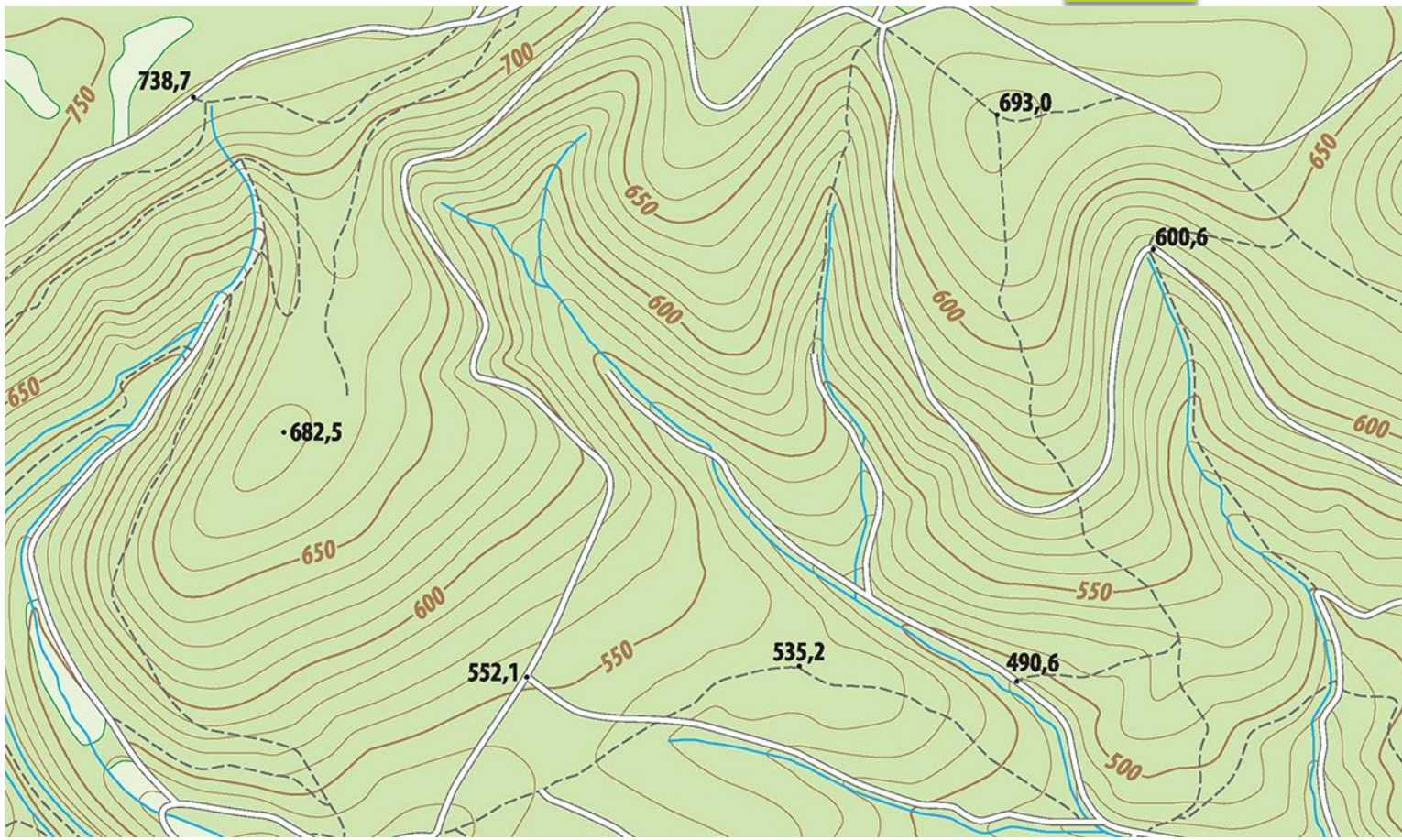
Design Considerations Increase chance of flooding

Complete micro and macro level hydraulic analysis on building sites

Increase chance of flooding Hydraulic Analysis



Increase chance of flooding Hydraulic Analysis



Increase chance of flooding

Avoid building in flood zones; buildings located on a river bed, close to running water, will be vulnerable to flooding.

Elevate buildings which are found in areas that may be remotely prone to flooding

That is watershed analysis should consider from 100-year floods up to 500-year flood events

A full map of the flood prone areas is available at the Land-Use Division at the Ministry of Agriculture and Lands.

Increase chance of flooding

Storm water conveyance should be considered on both micro and macro levels

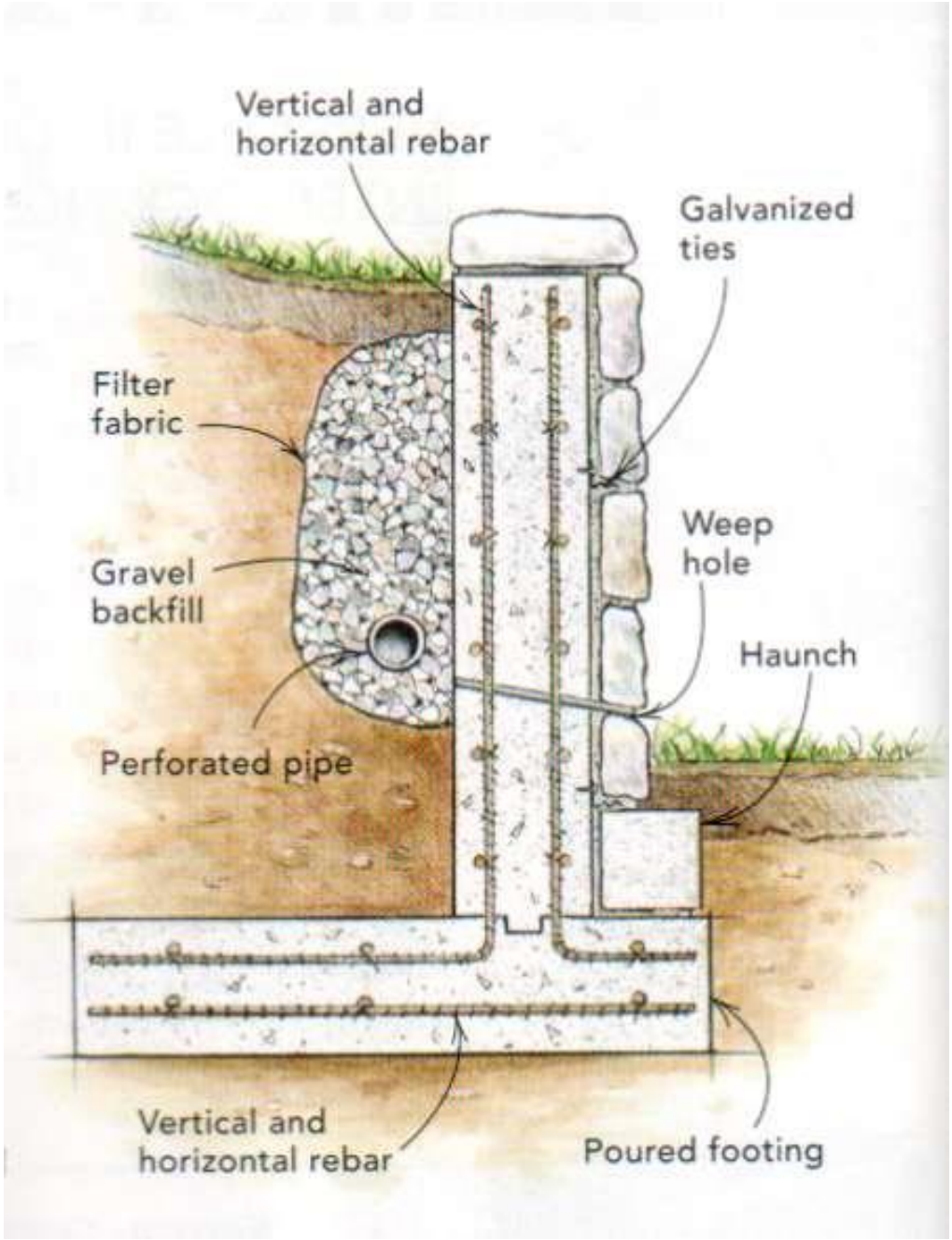
On the micro this would include the immediate surroundings of the structures being built, the conveyance for the structure itself (rainwater guttering)

Retaining walls should be adequately drained

Retaining walls are not meant to stop flooding

Increase chance of flooding Retaining Walls

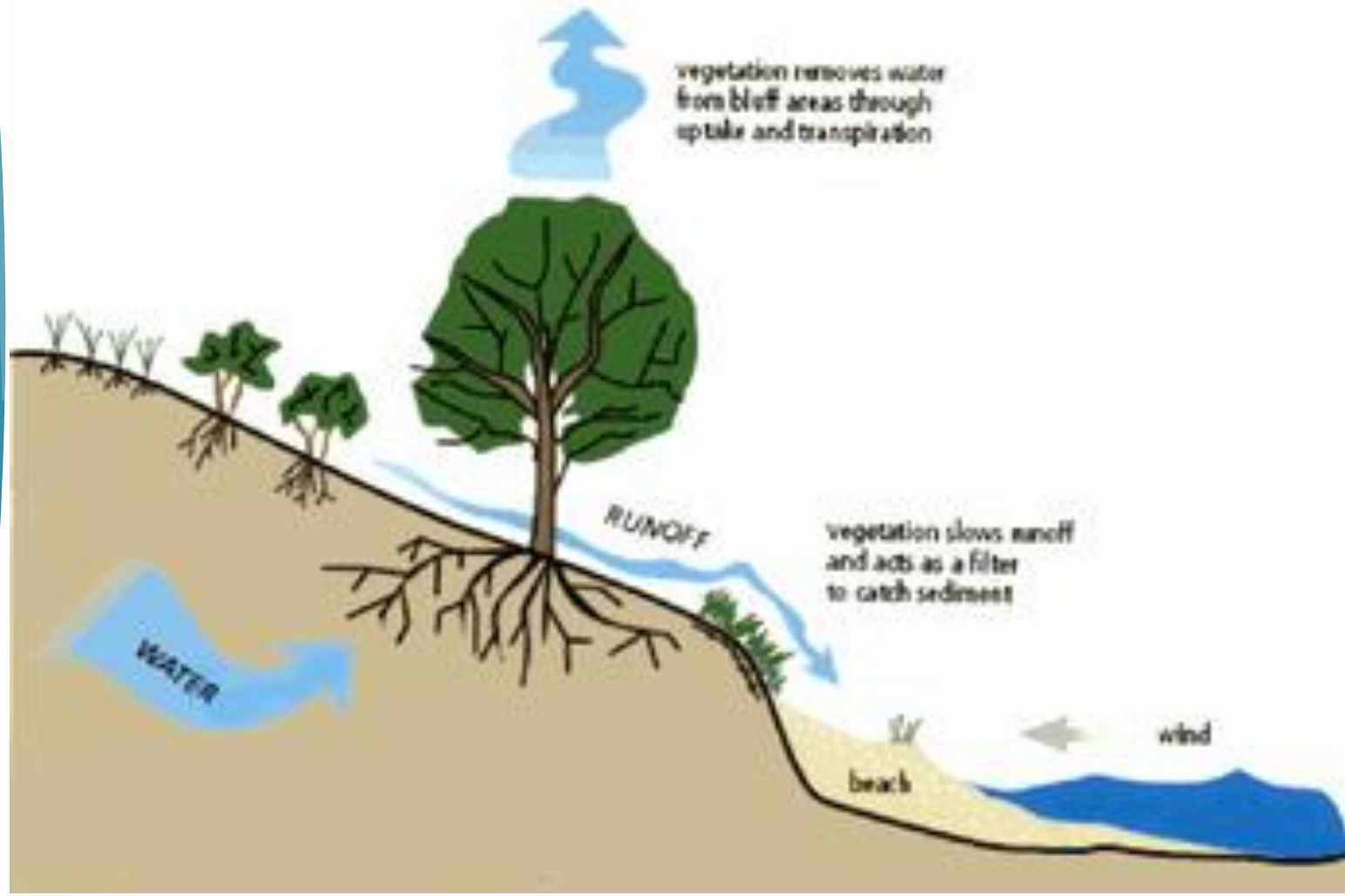
Design Considerations Retaining Walls



Increase chance of flooding Slope Stabilization

- Do not completely remove vegetation at the base of hills
- Complete slope stability analysis

Design Considerations Slope Stabilization

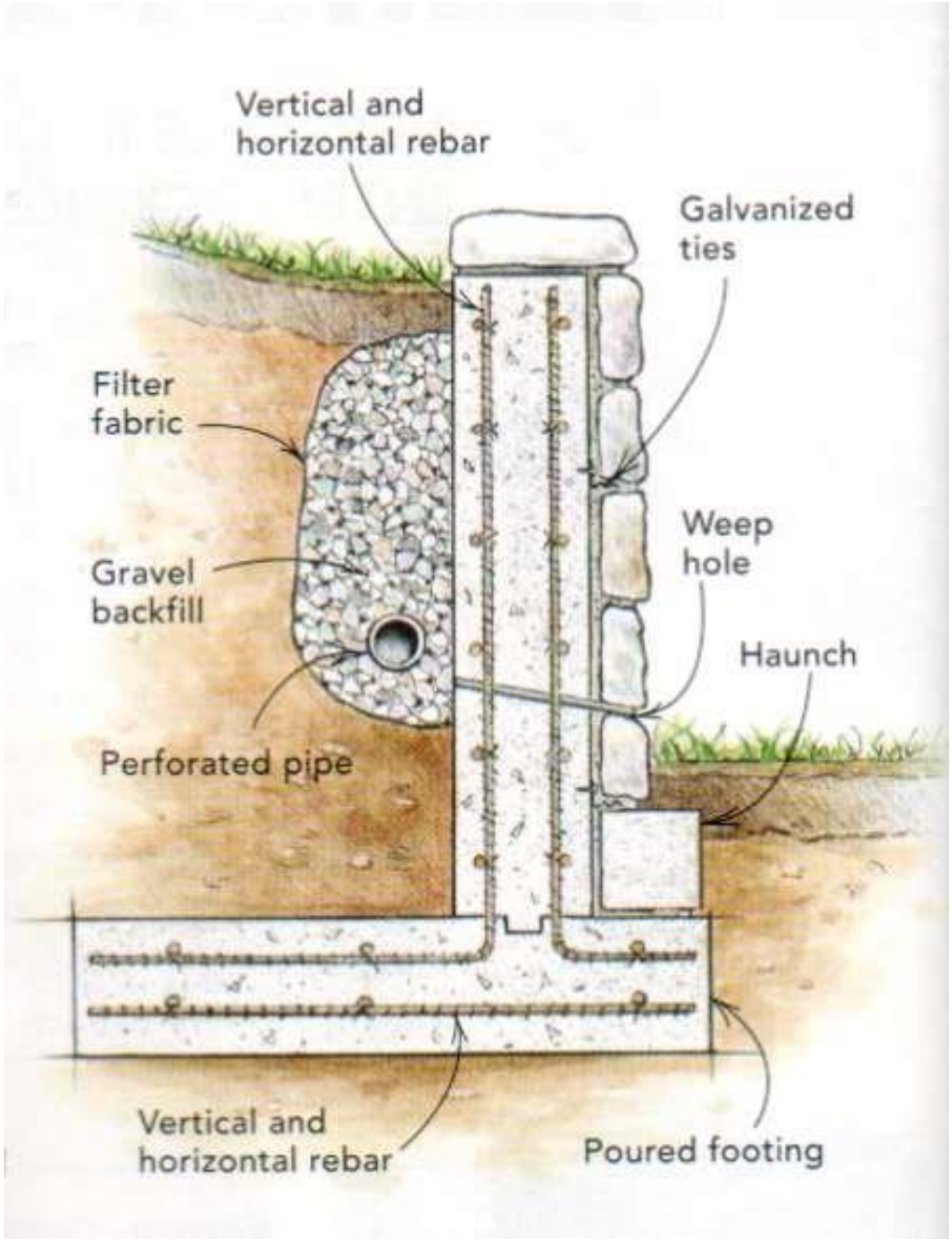


Design Considerations Slope Stabilization

Slope Stabilization

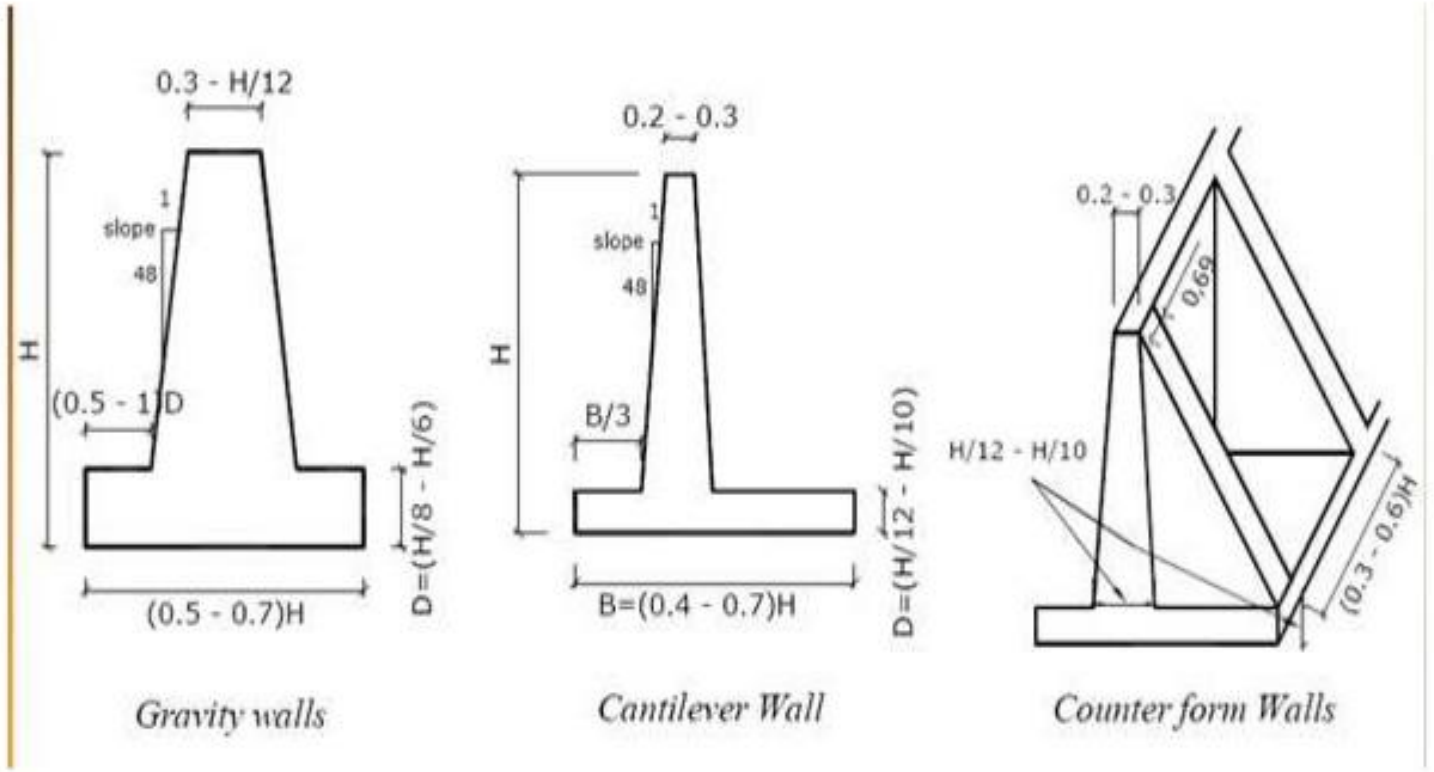
- Soil Type
- Slope Angle
- Addition and Removal of Slope Material
- Vegetation
- Water
- Climate
- Time

Design Considerations Slope Stabilization



Slope Stabilization Mechanical

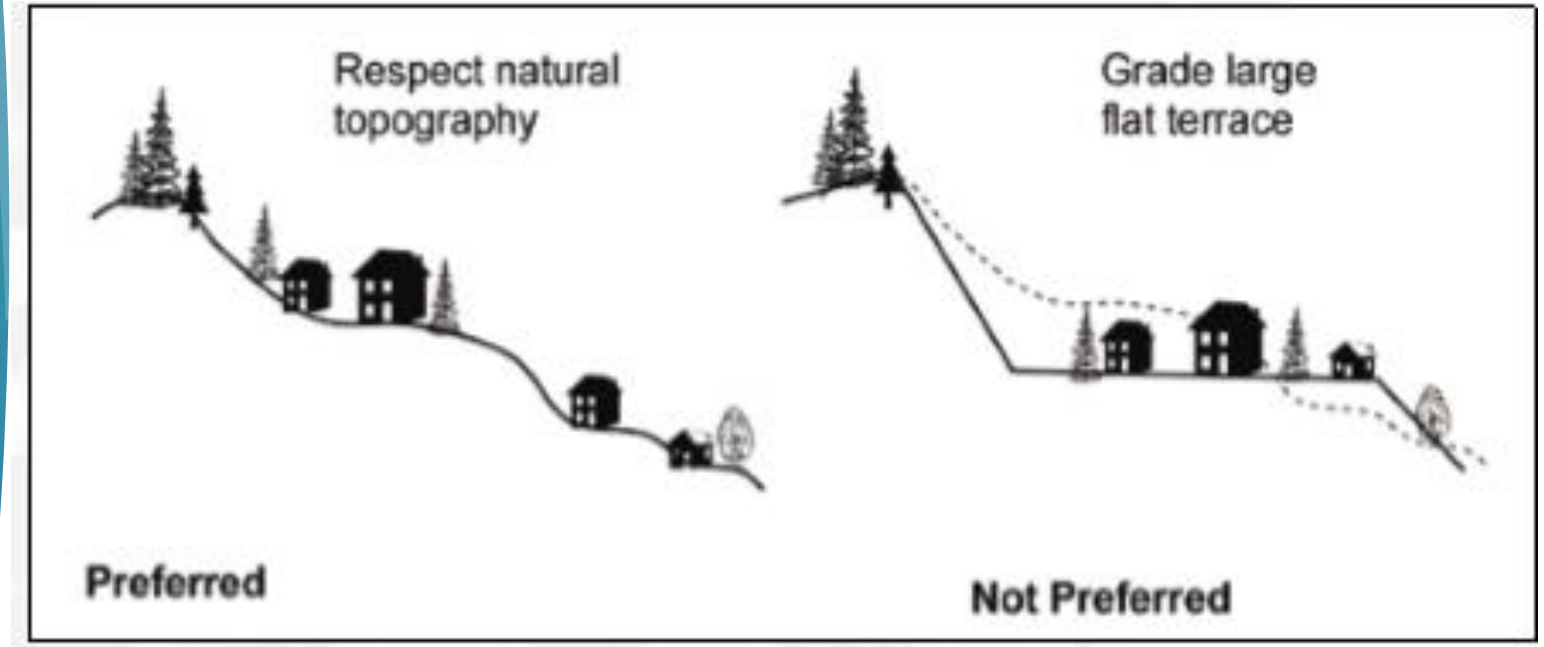
Typical dimensions of different types of retaining walls



Slope Stabilization

- Developments to adhere to natural site contours
- Development to be planned in a manner to leave natural vegetation protected
- Grading large flat terraces on hill side sites should not be allowed
- Reduce impervious paving

Slope Stabilization



Slope Stabilization

Erosion control measures are especially important for construction on slopes; absence of such measures often trigger landslides and failure of storm drainage systems (manmade/natural)

Design Considerations Costal Zones

When building near to the sea, flood prone mitigation techniques should be considered and the building needs to be built according to regulations pertaining to the high water mark.

As per OECS Building Code 2015 " ***No Building shall be erected on a site which Cannot be put into such a condition as to prevent any harmful effect to the building or to its occupants by storm or flood waters***."

There is also the high risk of the aggressive environment affecting the structure.

The materials used should be able to resist the saline conditions. The concrete mix should adhere to specifications for this environment.

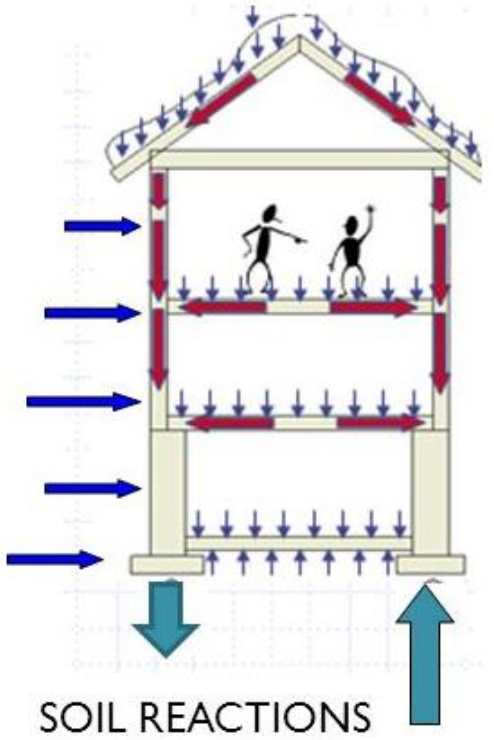
Design Considerations - What are the effects of Climate Change?

- More destructive hurricanes and storm surges
- More frequent and intense heat waves
- Increase in extreme weather events
- Rising seas and increase costal flooding
- Changing seasons
- Heavier precipitation and flooding

Design Considerations Resilient Buildings (Design Loads)

Foundation must resist

- Dead Load
  - Weight of building
- Live Load
  - Weight of Occupants
  - Weight of Furniture
  - Weight of Equipments
- Lateral Load
  - Wind
  - Seismic



Design Considerations - What are the effects of Climate Change?

Officially, from 1924 to 2018, 34 Category 5 hurricanes have been recorded

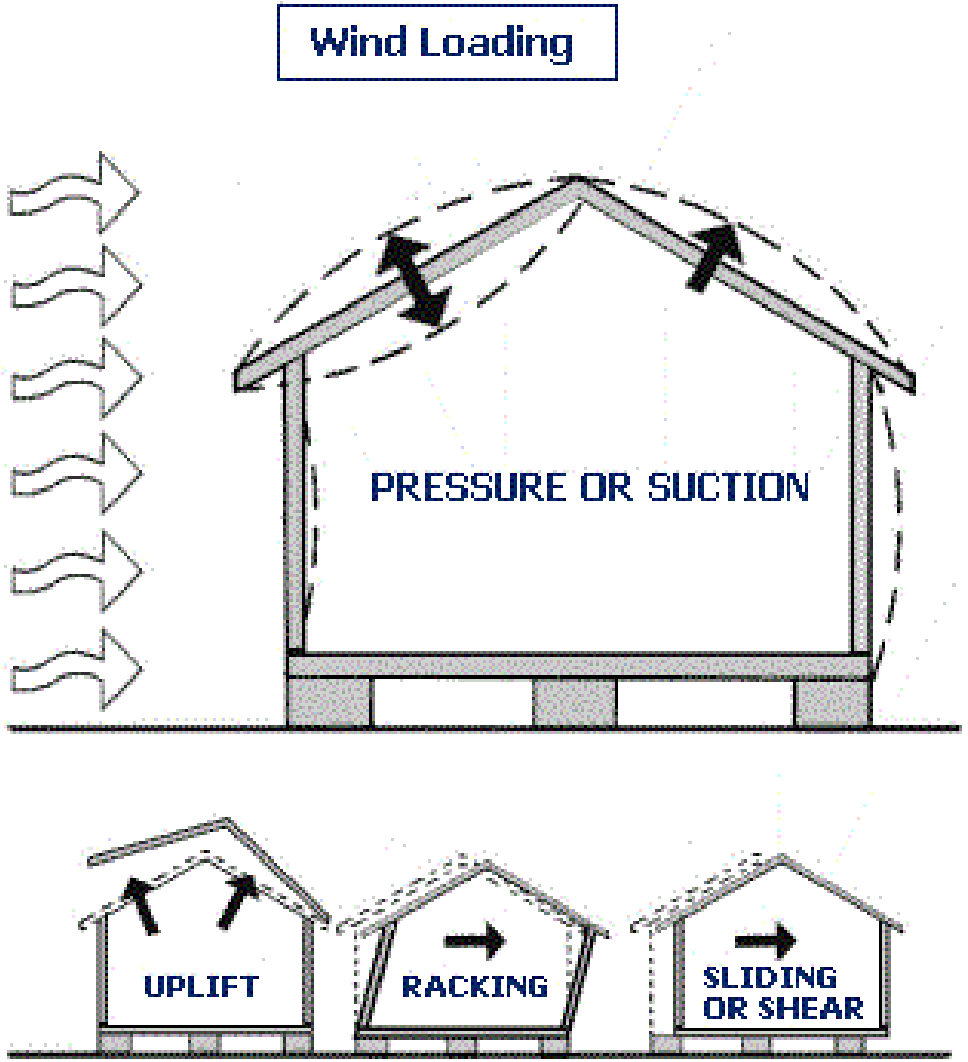
the decade with the most Category 5 hurricanes is 2000–2009, with eight

Between 2003 – 2018, there has been 12 category 5 hurricanes

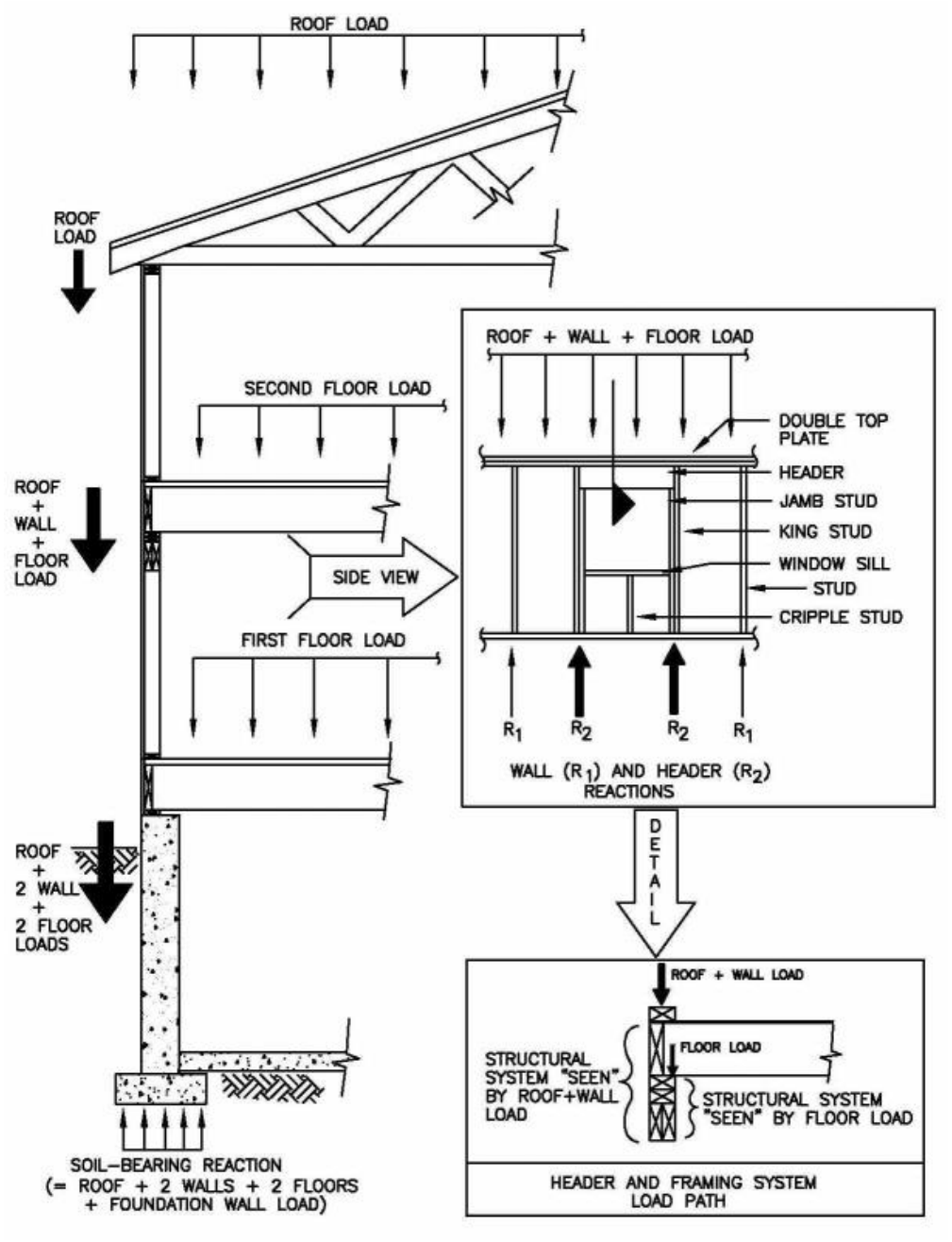
35% of the category 5 hurricanes occurred

Between 2003 – 2018,

Design Considerations Resilient Buildings (Load Transfer)



Design Considerations Resilient Buildings (Load Transfer)



Design Considerations Resilient Buildings

Ensure a continuous load path for the structure, by guaranteeing there are proper connection between elements, this may be done by employing hurricane straps, proper anchorage and laps of reinforcement.

Poorly mixed concrete will adversely affect its strength. During hot weather (temperatures in excess of 29 degrees C), steps shall be taken to reduce concrete temperature and water evaporation by proper attention to ingredients, production methods, handling, placing, protection and curing.

Designing elements based on the loads prescribed by the OECS Building Code 2015.

Design Considerations Resilient Buildings

TABLE 1604.5
OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES

OCCUPANCY CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
II	Buildings and other structures except those listed in Occupancy Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing elementary school, secondary school or day care facilities with an occupant load greater than 250. • Buildings and other structures containing adult education facilities, such as colleges and universities, with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident patients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000[1]. • Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Occupancy Category IV. • Buildings and other structures not included in Occupancy Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.
IV	Buildings and other structures designated as essential facilities, including but not limited to: • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Occupancy Category IV structures. • Structures containing highly toxic materials as defined by Section 307 where the quantity of the material exceeds the maximum allowable quantities of Table 307.1(2). • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water storage facilities and pump structures required to maintain water pressure for fire suppression.

Design Considerations Resilient Buildings

Basic Wind Speed for Category II Buildings: Grenada 154 miles/hour

Basic Wind Speed for Category III and IV Buildings: Grenada 133 miles/hour

In order to take into account climate change, all of the wind speeds shall be increased by factors of: (i) 1.13 for most buildings or for Category II Buildings (ii) 1.10 for critical facilities or for Category III and IV Buildings

Climate Resilient Buildings

Climate resilient design features make buildings resistant to climate vulnerabilities, such that they maintain an acceptable level of functioning and structure

Climate Resilient Buildings – Secret Ingridient

Climate Resilient Buildings – Secret Ingredient

	With Insurance	Without Insurance
Home Valuation	EC$300,000.00	EC$300,000.00
Insurance/yr.	EC$1,800.00	Nil
Total Insurance after 10 yrs.	EC$18,000.00	Nil
Cost of Damages	EC$45,000.00	EC$45,000.00
Total Borne by Home Owner	EC$318,000.00	EC$345,000.00
Difference	**EC$27,000.00**	

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