DESIGN OF KEECHELUS LAKE AVALANCHE BRIDGES

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Project Location

Image Source: Supplemental EIS

PROJECT DESCRIPTION

- Title: “Snowshed to Keechelus Dam Phase 1C Replace Snowshed and Add Lanes”
- Purposes:
  - Add capacity
  - Improve safety

Hyak CRIP

Image Source: Supplemental EIS

Hyak CRIP

- CRIP- Cost Reduction Incentive Proposal (WSDOT)
  - Change that can be proposed by contractor after contract is awarded
  - Primary goal for WSDOT is cost savings
- Hyak CRIP
  - No change to contract amount
  - Benefits to WSDOT: reduced long term maintenance cost, contractor takes risk of design

Design of Keechelus Lake Avalanche Bridges

- Design for Avalanches
- Design for Seismic Landslides
- Brief Construction Update

Design for Avalanches

Image Source: Supplemental EIS

Design for Avalanches

- Design Approach- minimize impact to piers/ avoid impact to superstructure
  - Position piers to be outside of main portion of avalanche chutes (130’ to 170’ span lengths)
  - Excavate chutes between piers to further direct avalanches between piers
  - Keep superstructure high enough to let avalanches pass underneath

Design for Avalanches

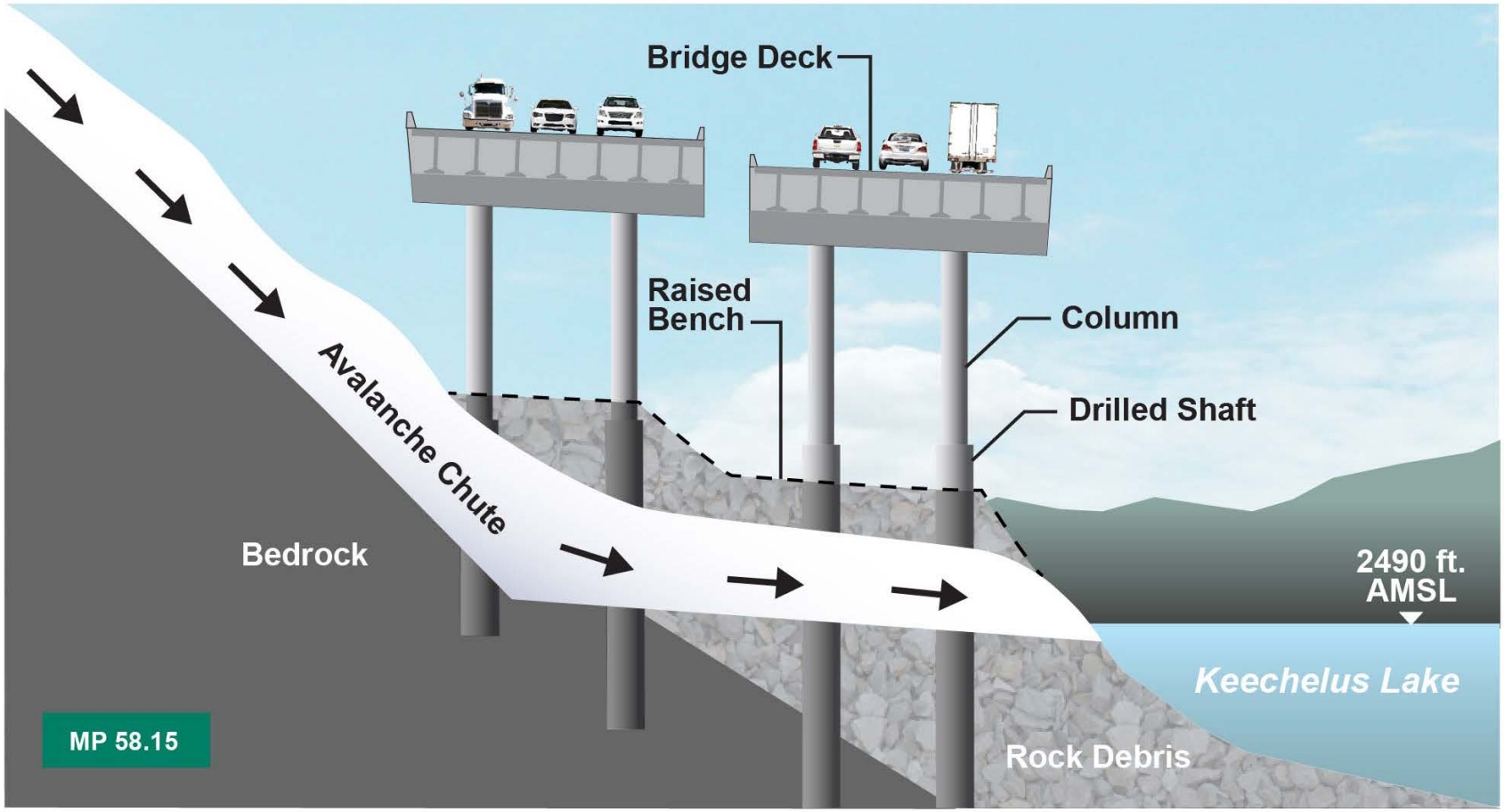


Image Source: Supplemental EIS

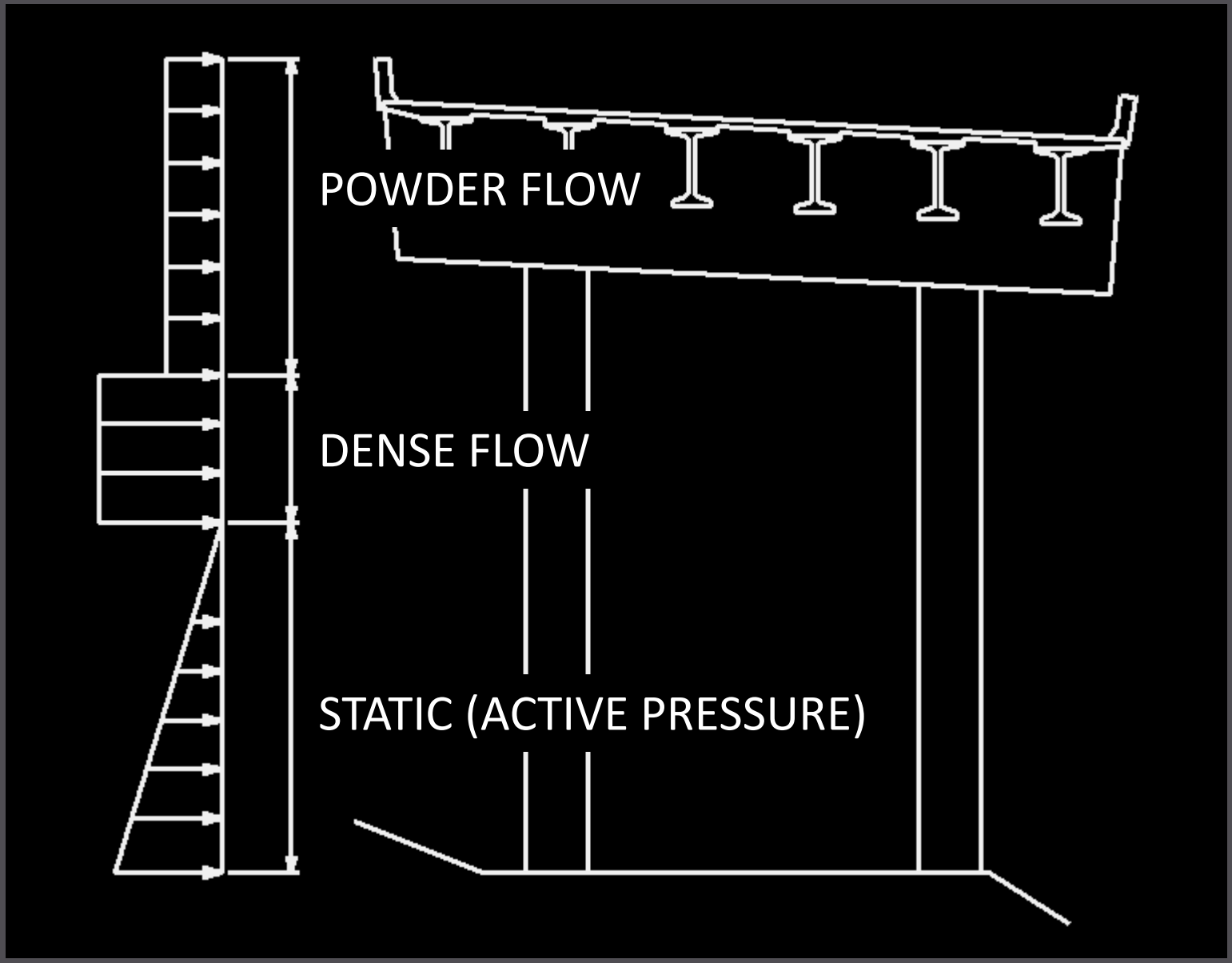
Design for Avalanches

- Design criteria:
  - 100-year dense flow must pass underneath superstructure
  - Bridge piers must be designed for 100-year avalanche impact forces
  - Vehicles are not impacted by powder flow greater than once every 30 years

Design for Avalanches

- Avalanche Consultant: Alan Jones, Dynamic Avalanche Consulting, British Columbia, Canada
- Modeling software used to determine impact pressure and height on piers, accounts for
  - Topography
  - Snowfall and snow properties
  - Avalanche Accumulation

Design for Avalanches



Design for Avalanches

- Results
  - Majority of avalanche impact loading was avoided with positioning of piers/ grading chutes
  - Most columns were not controlled by avalanche loading (min. 1% controlled)
  - 4 columns controlled by avalanche loading, max. column reinforcing was 1.7%

Design for Seismic Landslides

General Conditions:

- Loose talus (rock) layer at surface may slide downhill due to EQ
- Steeply sloped bedrock layer below talus
- Depth of talus layer varies from 0’ to 65’

Design for Seismic Landslides

Design Criteria

- Seismic landslide loading was combined at same time with plastic hinging
- Small earthquakes (0.05 g) can mobilize landslide loading, and remain until design earthquake

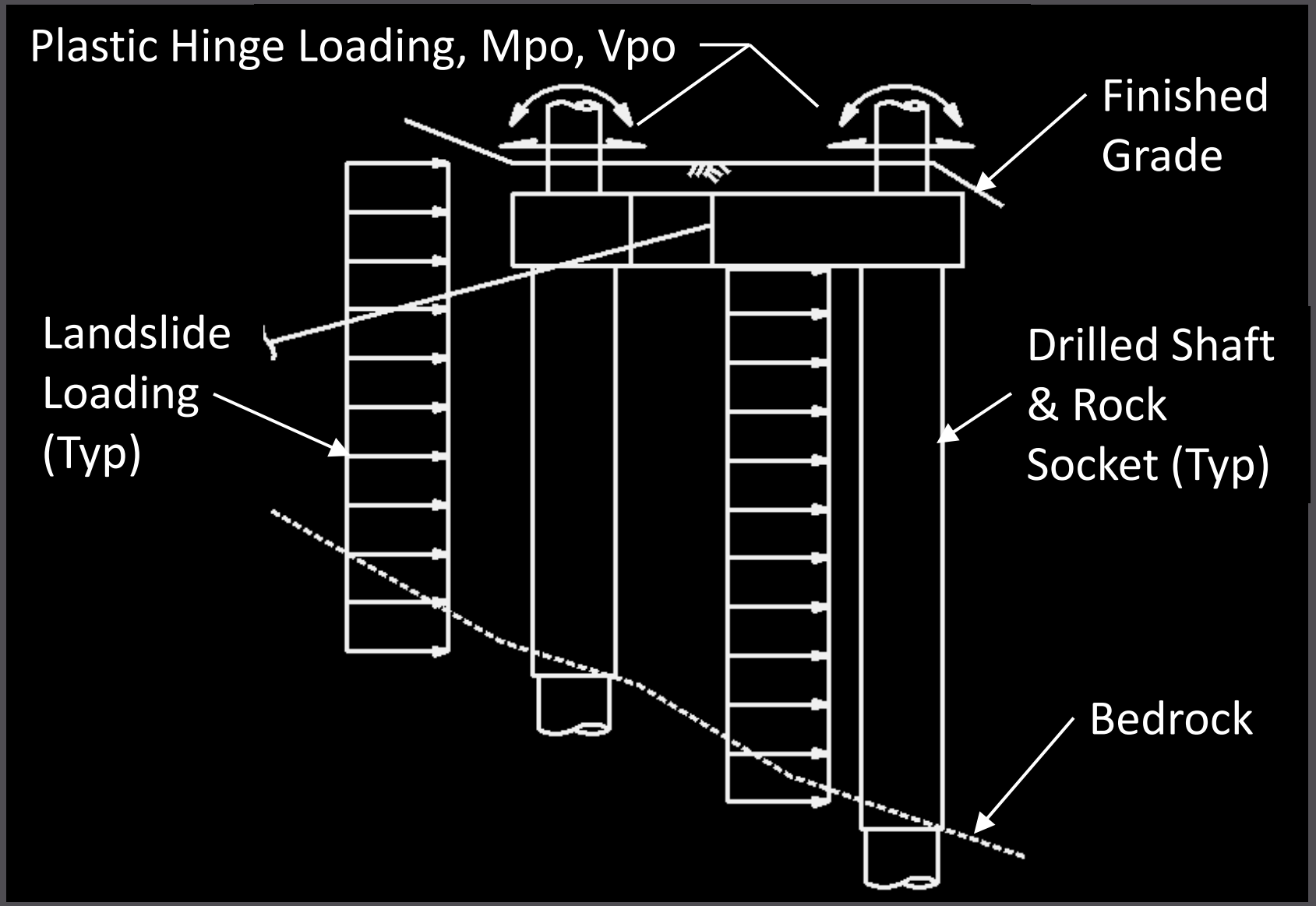
Design for Seismic Landslides

Design Approach

- Each pier custom designed
- Use drilled shafts in talus with rock sockets in bedrock
- Where required, add ground anchors and grade beams

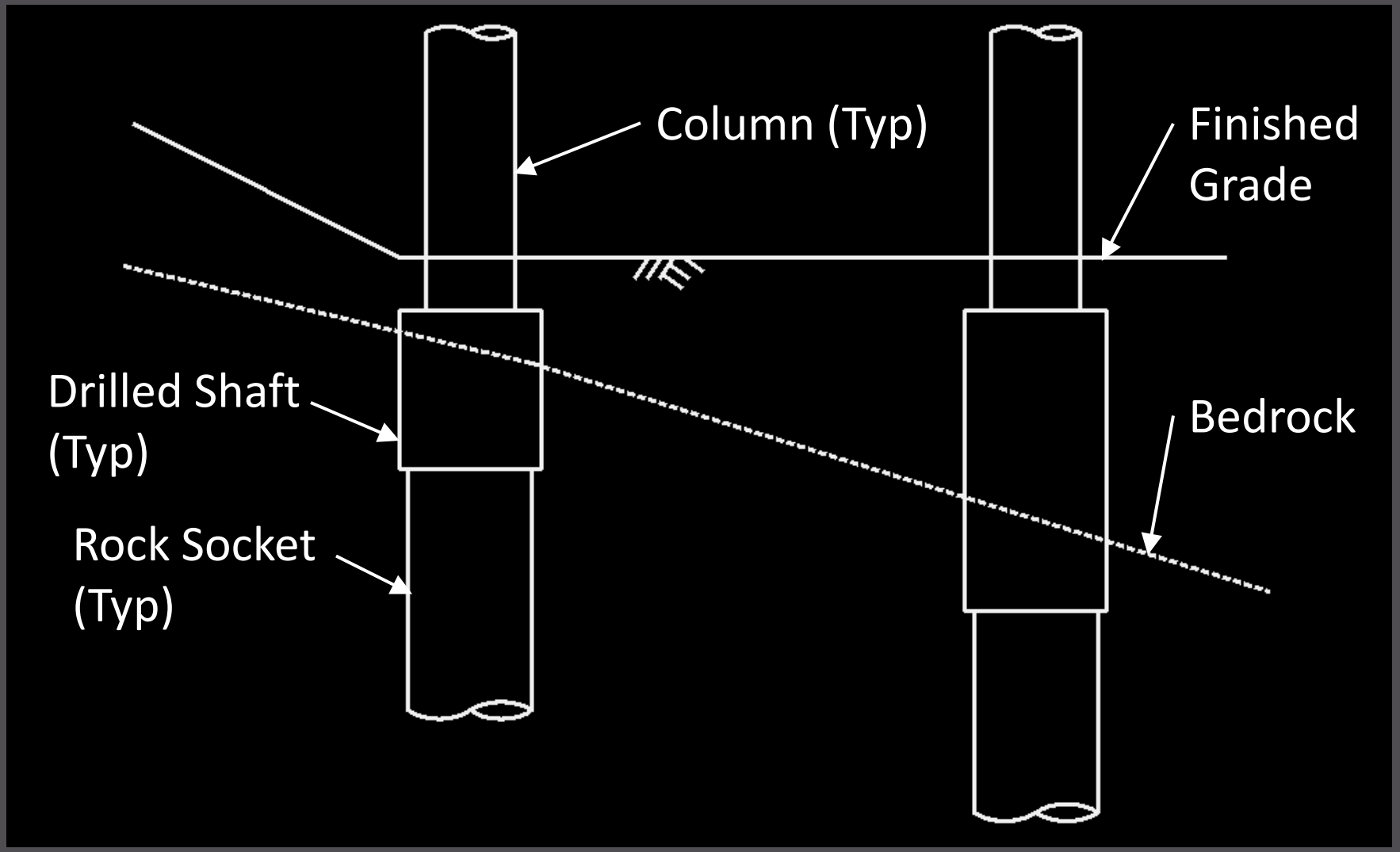
Design for Seismic Landslides

Loading



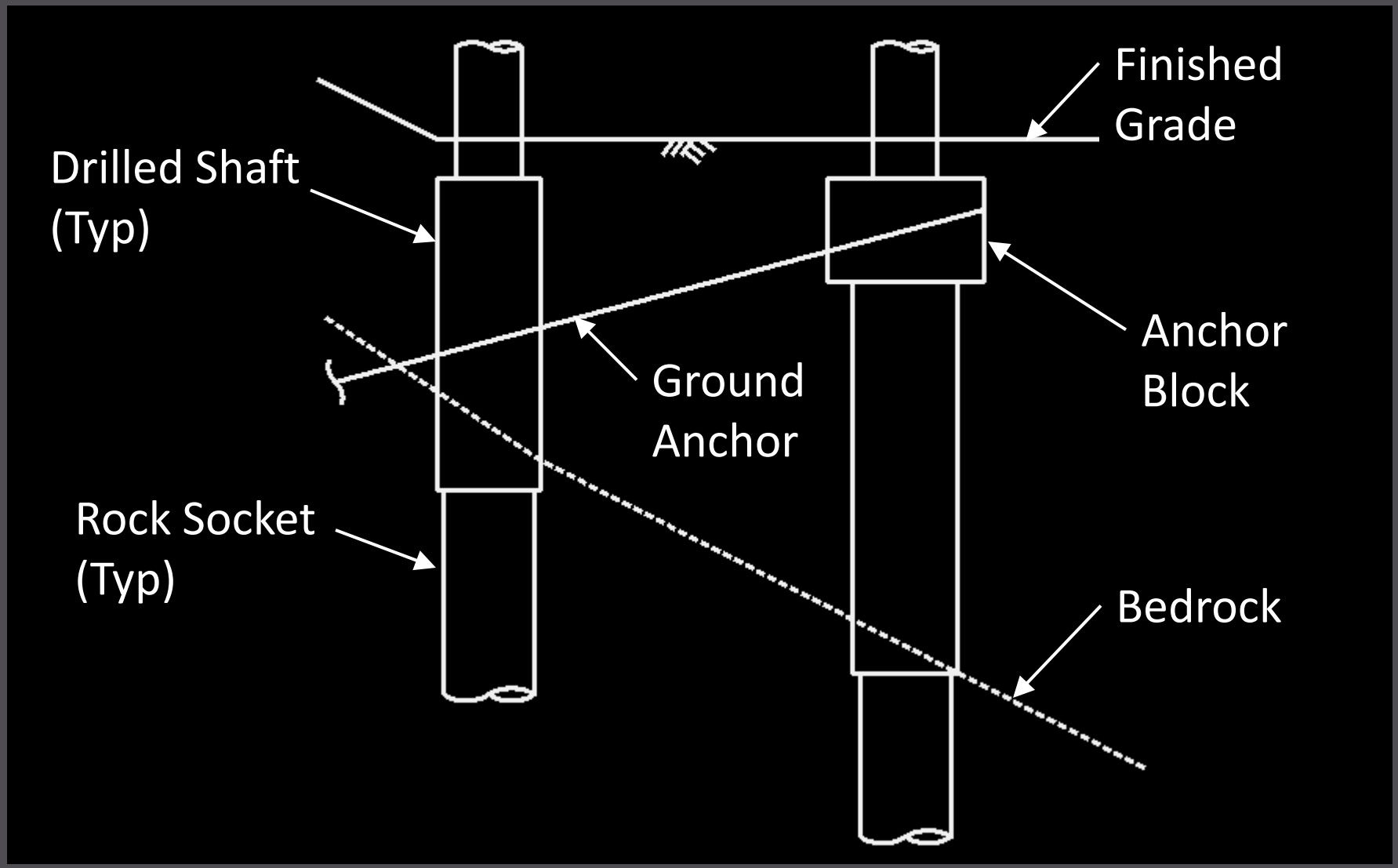
Design for Seismic Landslides

Small Talus Depths



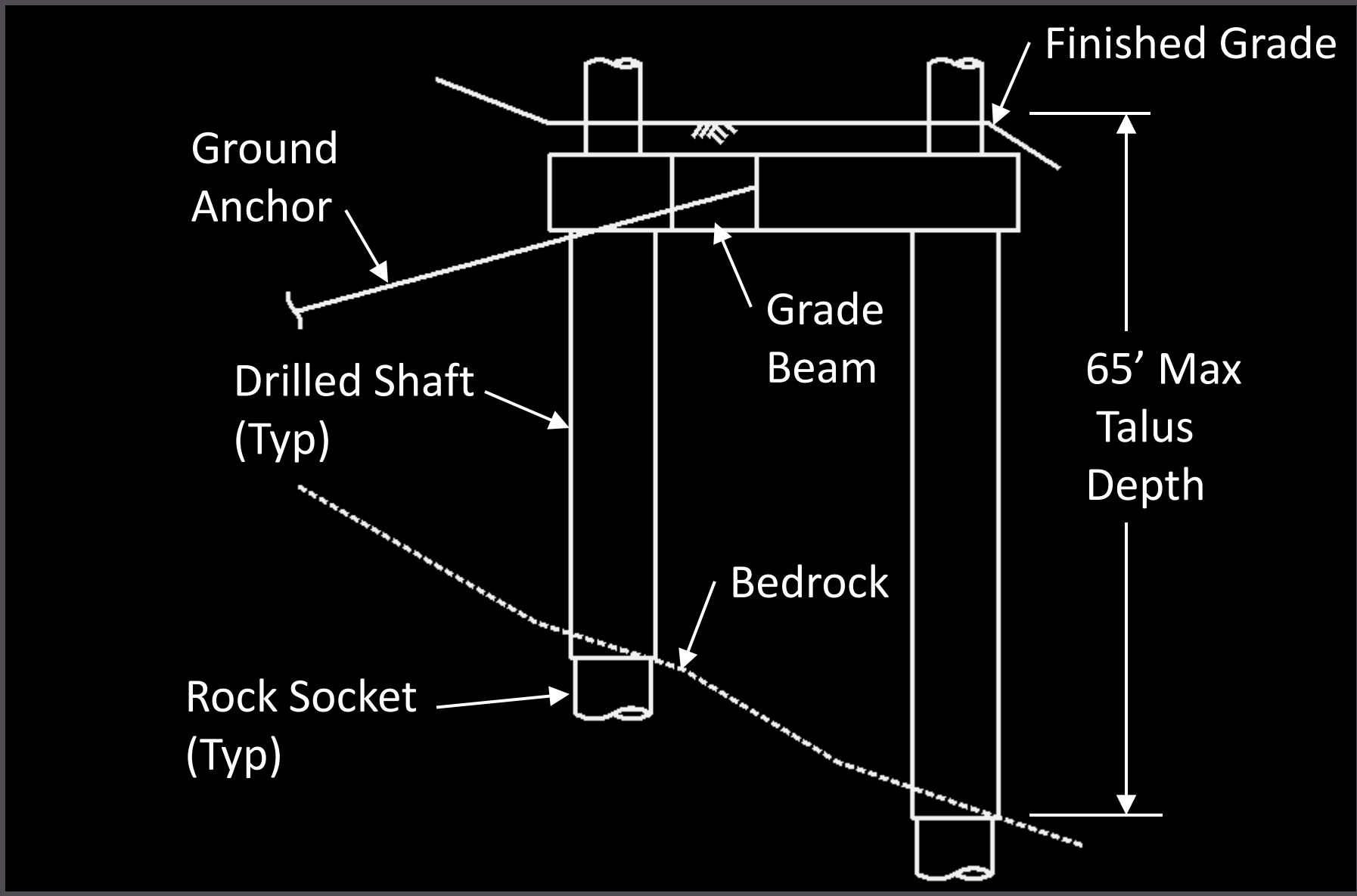
Design for Seismic Landslides

Medium Talus Depths



Design for Seismic Landslides

Large Talus Depths



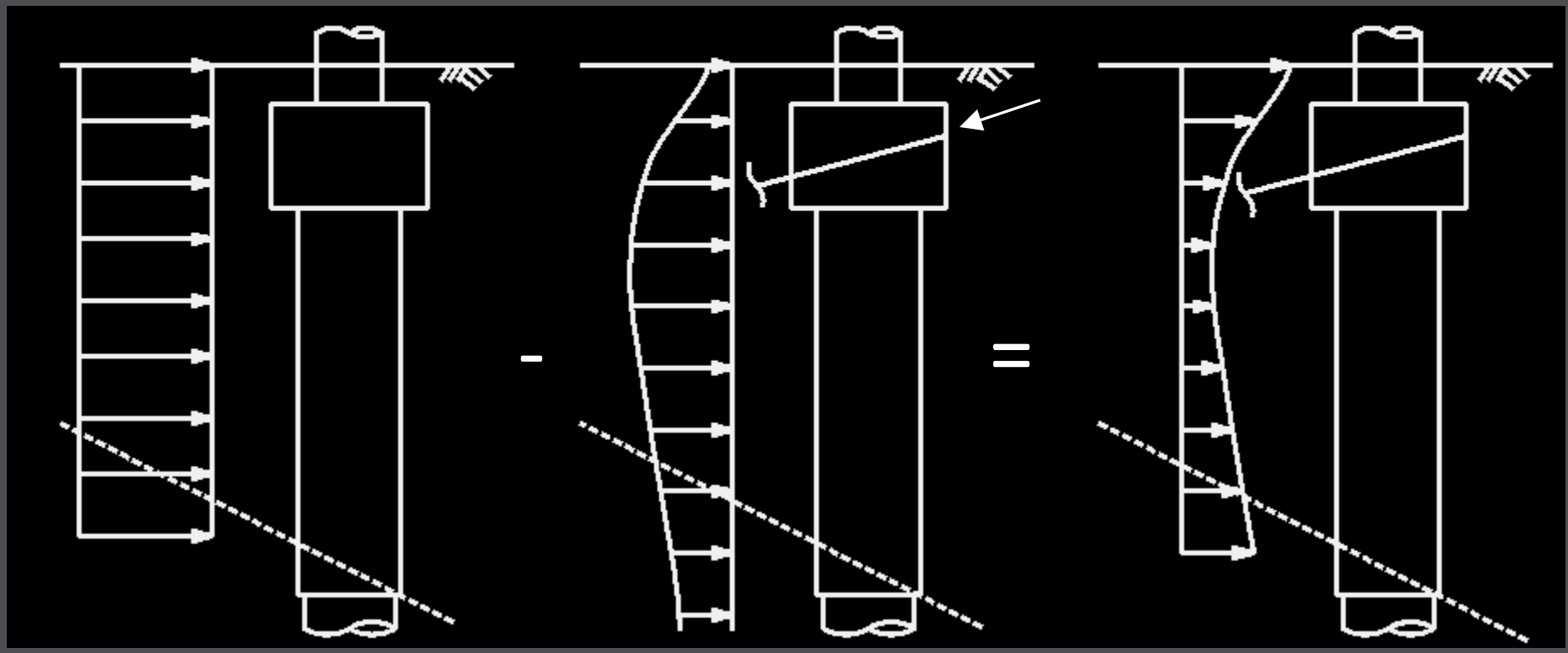
Design for Seismic Landslides

Tensioned Ground Anchors Help Mobilize Landslide Pressure

(1) Total LS Load

(2) Initial condition after tensioning ground anchors (DFSAP or LPILE)

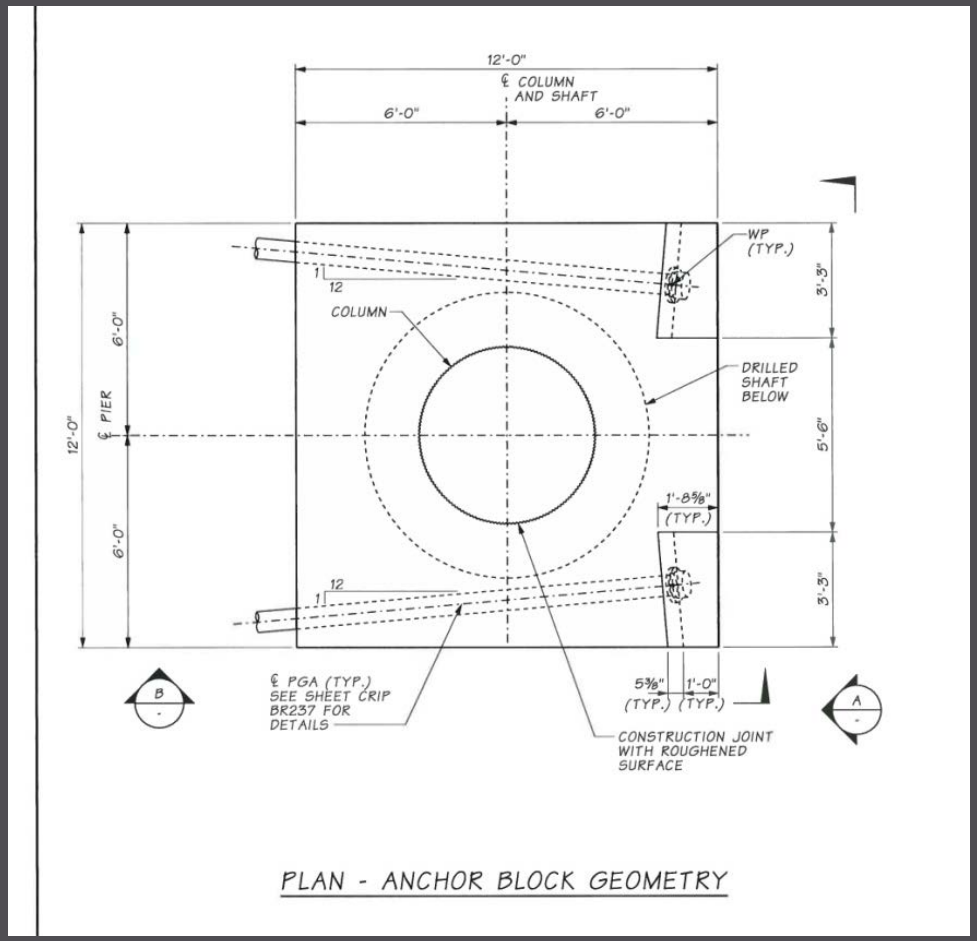
(3) Net LS Load (GSTRUDL)

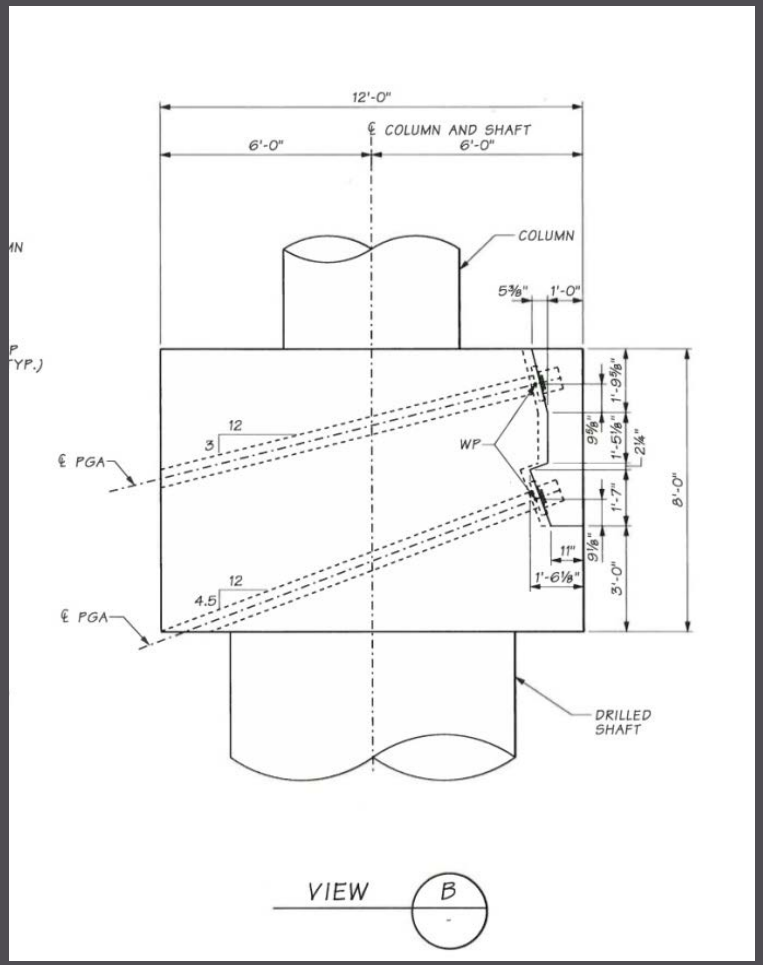


Design Loading = (2) + (3)

Design for Seismic Landslides

Anchor Block Details





Construction Update

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Special Thanks

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- Matt Gipner, WSDOT South Central Region
- Lou Tran, WSDOT Bridge and Structures

Questions?