DESIGN OF KEECHELUS LAKE AVALANCHE BRIDGES

BY:

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Project Location

Image Source: Supplemental EIS
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

- 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

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
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

POWDER FLOW

DENSE FLOW

STATIC (ACTIVE PRESSURE)
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 Criteria

- Seismic landslide loading was combined at the 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

Plastic Hinge Loading, Mpo, Vpo

Finished Grade

Landslide Loading (Typ)

Drilled Shaft & Rock Socket (Typ)

Bedrock
Design for Seismic Landslides

Small Talus Depths

Drilled Shaft (Typ)

Rock Socket (Typ)

Column (Typ)

Finished Grade

Bedrock
Design for Seismic Landslides

Medium Talus Depths

- Drilled Shaft (Typ)
- Rock Socket (Typ)
- Finished Grade
- Anchor Block
- Ground Anchor
- Bedrock
Design for Seismic Landslides

Large Talus Depths

- Finished Grade
- Bedrock
- Talus Depth
- Ground Anchor
- Drilled Shaft (Typ)
- Grade Beam
- Rock Socket (Typ)
- 65’ Max Talus Depth
- Ground Anchor
- Drilled Shaft (Typ)
- Rock Socket (Typ)
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

PLAN - ANCHOR BLOCK GEOMETRY
Construction Update
Construction Update
Special Thanks

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Questions?