Challenges During a Top Down Design and Construction Approach of Foothills Parkway Bridge No. 8

KHALID T. MOHAMED, P.E., PMP
FHWA, WASHINGTON, DC

MOHAMMED ELIAS, PHD, P.E.
FHWA, STERLING, VA

Geohazards Impacting Transportation in Appalachia
Knoxville, TN
August 2016

U.S. Department of Transportation
Federal Highway Administration

OUTLINE

- Introduction
- Project Location
- Foothills Parkway History
- General Geologic Conditions
- Design & Construction Constraints
- Bridge Foundation Design Changes
- Foundation Construction
- Bridge Construction

Challenges?

U.S. Department of Transportation
Federal Highway Administration

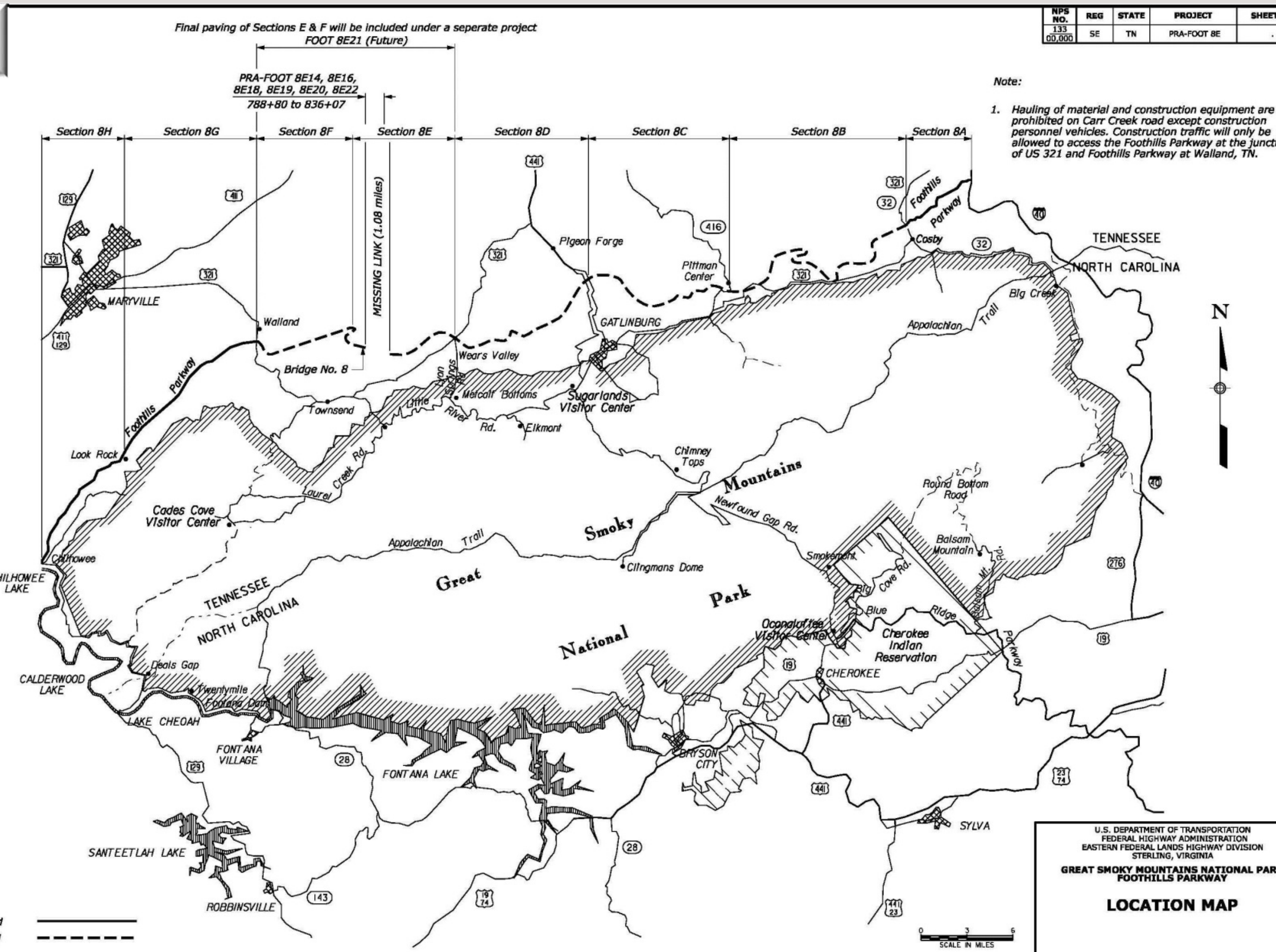
INTRODUCTION

- Foothills Bridge No. 8 is One of 10 Proposed Bridges Along "Missing Link"
- The "Missing Link" section of the Parkway is 1.65-mile long
- Bridge No. 9 and 10 were completed in 2001
- Bridge No. 1 was Replaced by a Geogrid Reinforced Limestone Shot rock Embankment
- Bridge 2 Was Completed in 2013
- Remaining Bridges are Under Construction

90 ft High Reinforced Geogrid Limestone Shot rock Embankment

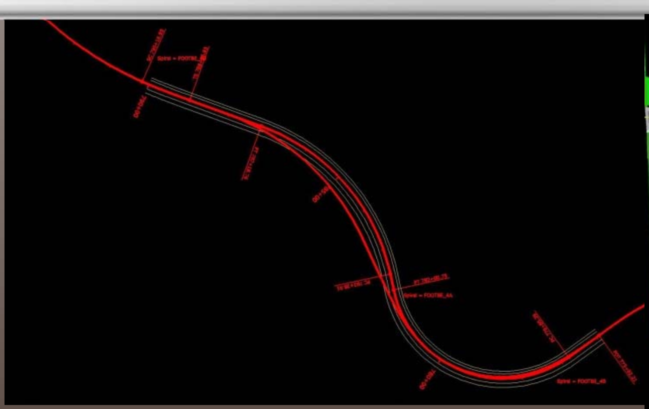
PROJECT LOCATION

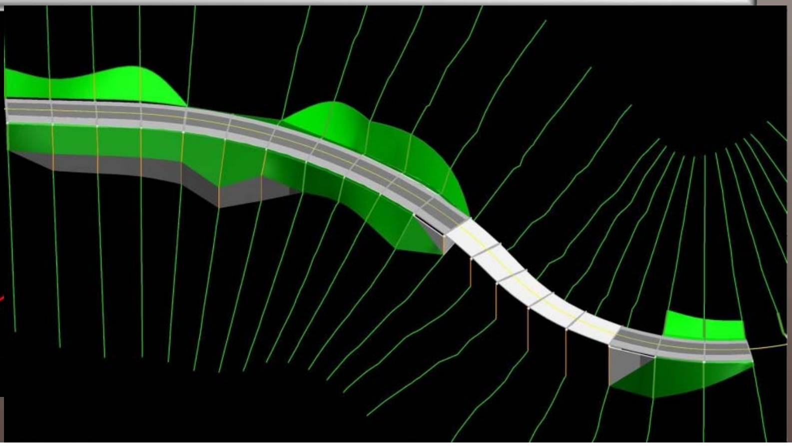
- [Project Location]



FOOTHILLS PARKWAY HISTORY

- The Parkway was Authorized by Congress in 1944
- Structural Fill and Retaining Walls Failures and Acid Drainage Occurred During Construction in The 1980s
- All Projects Were Suspended and The Uncompleted Section Was Referred to as "Missing Link"
- FHWA Began Developing New Alignment in the 1990s
- The New Alignment Included Bridges, Cut Slopes, Retaining Walls and Embankments to Mitigate Environmental Impact (Source: NPS)
- Alignment Centerline
- Design Visualization

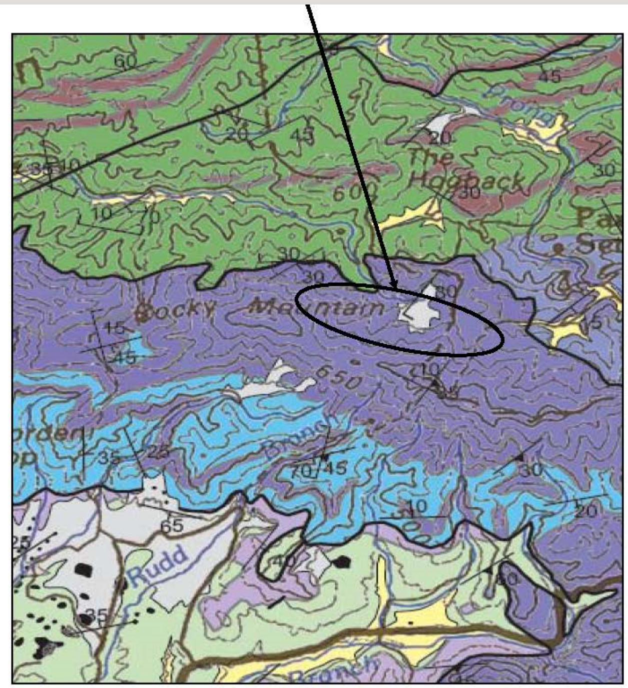




U.S. Department of Transportation
Federal Highway Administration

GENERAL GEOLOGIC CONDITIONS

- The Project is Located in The Foothills of The Great Smoky Mountains in Eastern Tennessee.
- Project Area Appears to be Underlain by Precambrian Rock from The Ocoee Series. (USGS, Philip King, 1964)
- Principal Formations are The Shields and Possibly The Licklog From The Walden Creek Group
- The Shields Formation Consists of Coarse Conglomerate of Quartz and Pebbles and Cobbles and Coarse Grained Pebbly Sandstone Interbedded With Laminated Sandstone
- Project Rock Cores Indicate Conglomerate and Sandstone Predominated at Project Site



Qd	Debris Fans (Pleistocene) Matrix-supported diamicton that form fans and sheets on lower slopes and valleys in the Blue Ridge. Sub-rounded boulders, cobbles, and pebbles, of local rocks are in a matrix of unstratified pebbles, sand, silt and clay. Includes terraces as much as 120 ft above adjacent boulder debris fans and alluvium near Cosby, TN. Thickness 10 to 100 ft.
Zs	Shields Formation (Neoproterozoic) *Dark gray to greenish-gray laminated siltstone and slate, contains beds of limestone and siltstone (Zsl), coarse sandstone and siltstone (Zsa), and coarse conglomerate of polymictic pebbles and cobbles, and pebbly sandstone (Zsc)*
Zsc	
Zw	Wilhite Formation (Neoproterozoic) *Gray to green siltstone and slate with interbeds* Licklog Formation *pebble conglomerate, sandstone, and quartzite.*

DESIGN AND CONSTRUCTION CONSTRAINS

- The Design and Construction of Bridge No. 8 Has to Work With A Number of Constraints: Hence Was *"Top-Down Construction Concept"*

Constraint	Consequence	Result
Limit Ground Disturbance	Select a Foundation type That Requires Minimum Excavation and Equipment	Drilled Shafts Foundation Was Eliminated Due To Equipment Access Need
Avoid Cutting Trees and Vegetation Removal	Had to Use Alternative Systems to Access Substructure Locations	A Platform Was Built to Substructure Locations to Minimize Cutting Trees And Vegetation
Difficult Access	Restriction on Ground Disturbance Severely Limited Establishment of Access Roads	Use Small Equipment That Can Be Air Lifted or Driven on Temporary Platform To Substructure Location.
Steep Train	Design Considerations for Stability. Construction Difficult Access	Foundation Design Was Modified for Added Safety. Smaller Equipment Was Used for Access
Prepare A Plan for Detecting and Treating Pyretic (Acid) Rock	Need to Carefully Plan Excavation, Treatment and Disposal	Testing and Monitoring Plans Treatment Plan (Encapsulation) if Encountered, Disposal As Needed

DESIGN AND CONSTRUCTION CONSTRAINS (Platform Access)

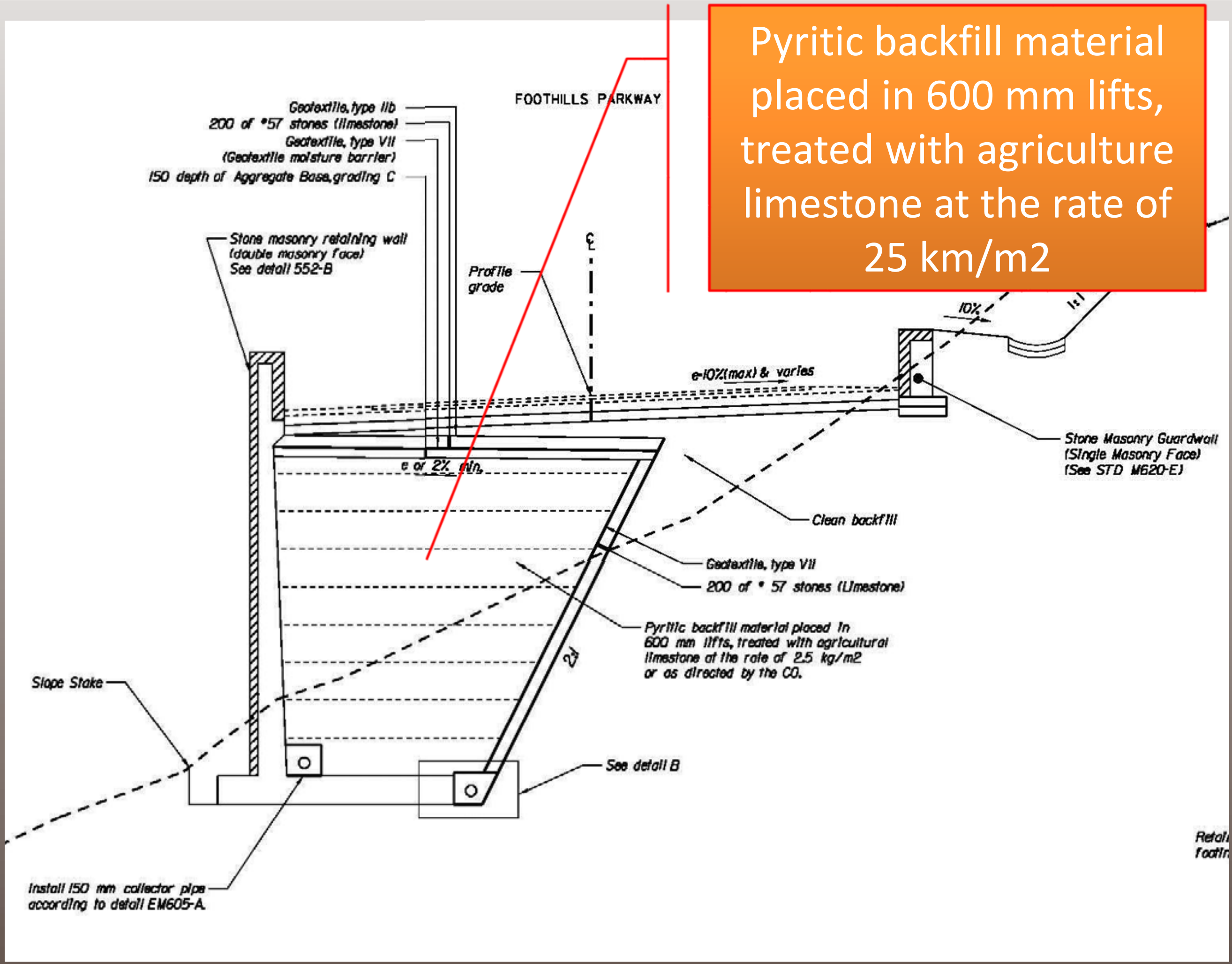
- The Design and Construction of Bridge No. 8 Has to Work With A Number of Constraints: Hence Was *"Top-Down Construction Concept"*

U.S. Department of Transportation
Federal Highway Administration

DESIGN AND CONSTRUCTION CONSTRAINS (Pyritic (Acid) Rock)

- Acid Rock Plan
  - *Encapsulation*
  - *Treatment With Lime*
  - *Disposal*

Pyritic backfill material placed in 600 mm lifts, treated with agriculture limestone at the rate of 25 km/m2



U.S. Department of Transportation
Federal Highway Administration

BRIDGE FOUNDATION DESIGN (1996)

- The 1997 Consultant's Geotechnical Report Considered Spread footings and Micropiles.
- Design Accounted for Slope angles Varying from 38º to 40º at Substructure Locations.
- Depth to Bedrock Varied from 0 to 0.2 m (0 to 1 foot).

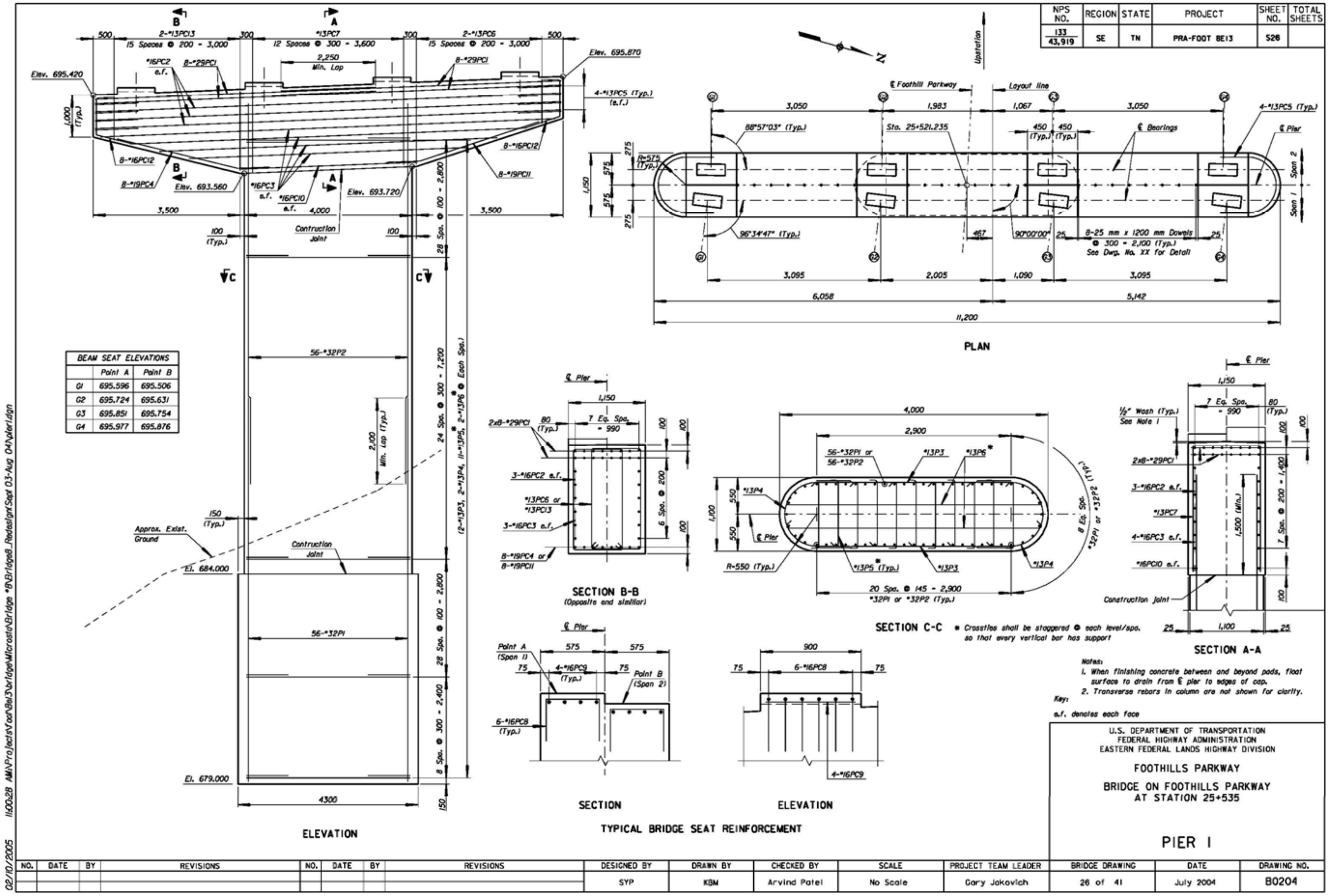
BRIDGE FOUNDATION DESIGN (1996)

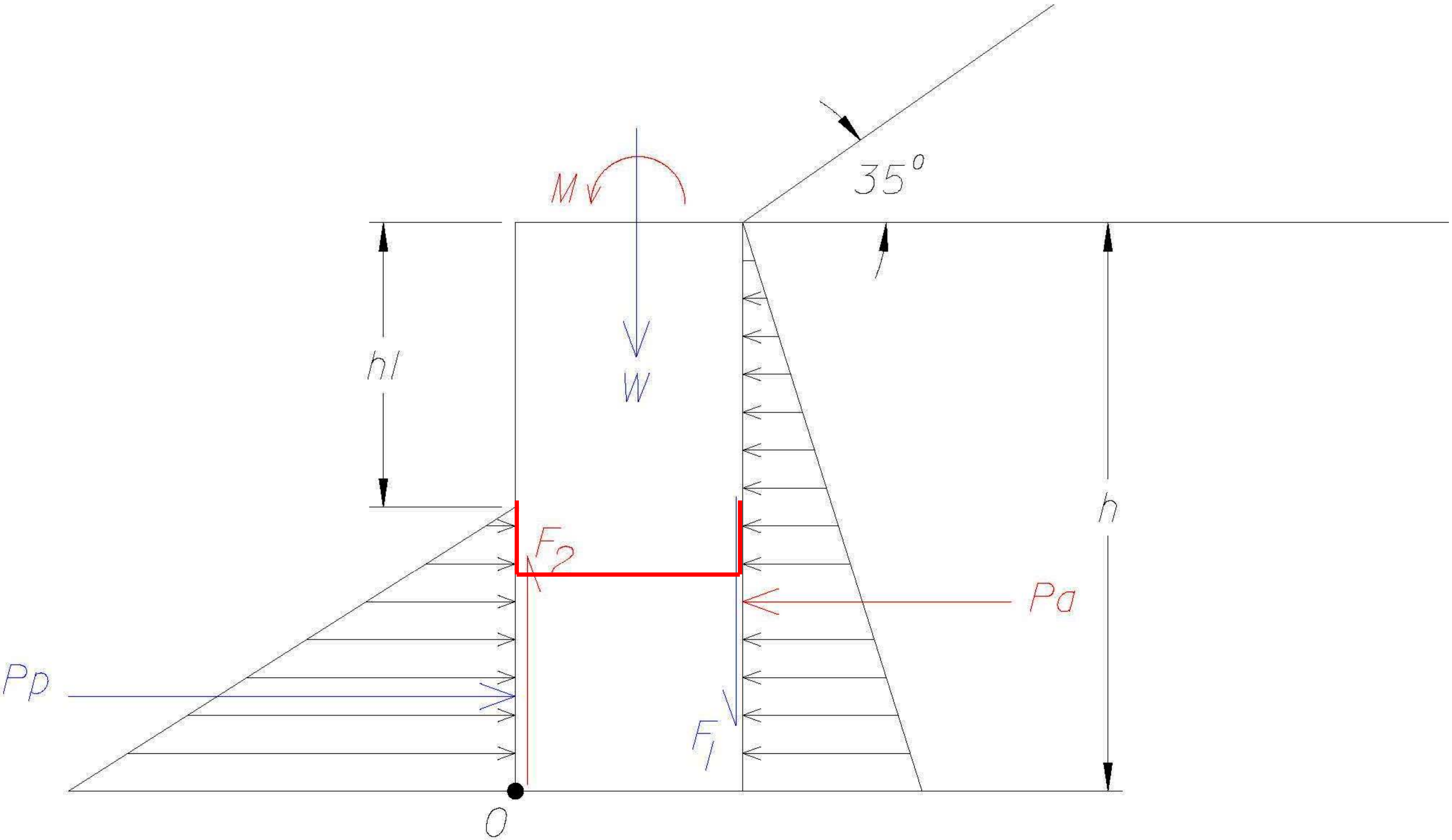
- RQDs at depths 0 to 5 m Varied From 70% to 100%.
- RQD & RC below 5 m is 100% at All Substructure Locations.
- Allowable Bearing Capacities of 1.0 to 1.95 Mpa (10 to 20 tsf) were Recommended By Consultant Based on Competent Rock Conditions.

BRIDGE FOUNDATION DESIGN CHANGES (EFLHD, 2005)

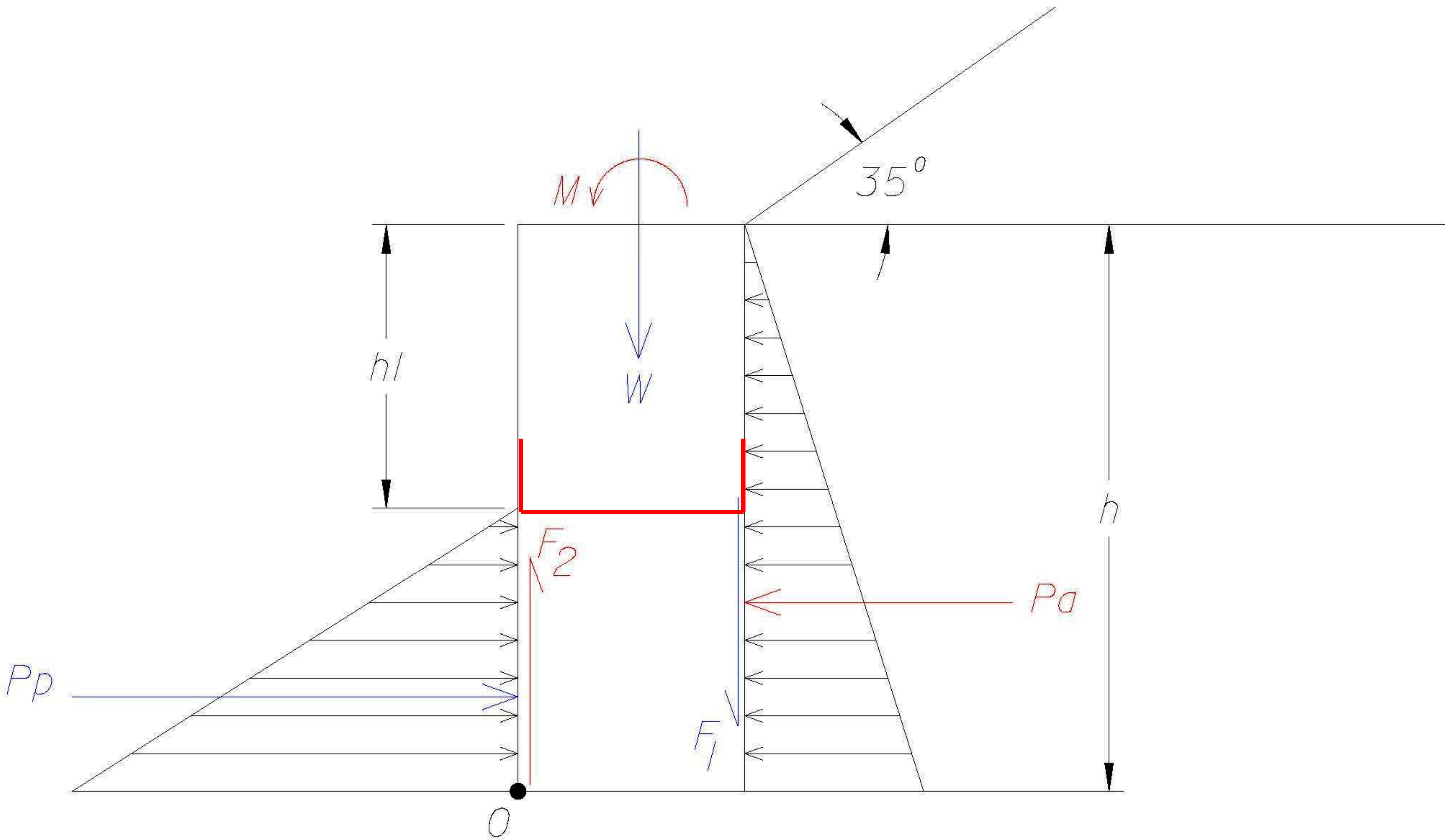
- **Abutment Footings** were Stepped Up to Avoid Deep Excavations Into Competent Rock (~ 9 m (30-ft))
- Structural Engineers Used a Vaulted Abutment Design for Added Stability
- The Vaulted Abutments Consisted of Breast, Back and Side Walls
- One of The Many Advantages Is Providing Additional Lateral Stability On a Steep Slope

BRIDGE FOUNDATION DESIGN




M
W
35°
hl
h
F2
Pa
Pp
F1
O

BRIDGE FOUNDATION DESIGN CHANGES (FFLHD, 2005)



BRIDGE FOUNDATION DESIGN CHANGES (2005)

- ***Piers 1 & 2 Foundations***
  Embedment Depth Into Bedrock Was Modified for Additional Lateral Stability
- Foundation Embedment Depth Was Extended to 5 Meters (~16.5 ft) Below Ground Low Point Into 100% RC & RQD Competent Rock
- The New Design is Similar To A Socketed Shaft That Can be Constructed Using Small Equipment
- Drilled Shafts Were Not Selected Due To Equipment Access Requirements

BRIDGE PIERS FOUNDATION CONSTRUCTION

- Contractor Had Difficulty at The Beginning Excavating Foundations.
- Contractor Was Successful After Attempting Different Methods
  - Jack Hammer
  - Chemical Disintegration Of Bedrock
  - Drill and Blast
- Drill And Blast With Jack Hammer Was Successful Method In Excavating Foundation

U.S. Department of Transportation
Federal Highway Administration

BRIDGE PIERS FOUNDATION CONSTRUCTION

- Contractor Had Difficulty at The Beginning Excavating Foundations.
- Contractor Was Successful After Attempting Different Methods
  - Jack Hammer
  - Chemical Disintegration Of Bedrock
  - Drill and Blast
- Drill And Blast With Jack Hammer Was Successful Method In Excavating Foundation

U.S. Department of Transportation
Federal Highway Administration

BRIDGE 8 CONSTRUCTION

- Bridge Construction Progressed Successfully After Resolving Initial Problems
- Coordination and Communication Between Design and Construction Assisted in Quickly Resolving Problems
- Construction Was Completed Successfully Using A Top-Down Process With Minimum Impact on Environment

BRIDGE 8 CONSTRUCTION

- Bridge 8 Was Completed Successfully After Resolving Initial Problems
- Coordination and Communication Between Design and Construction Assisted in Quickly Resolving Problems
- Construction Was Completed Successfully Using A Top-Down Process With Minimum Impact on Environment

BRIDGE 8 CONSTRUCTION

- Bridge 8 Was Completed Successfully After Resolving Initial Problems
- Coordination and Communication Between Design and Construction Assisted in Quickly Resolving Problems
- Construction Was Completed Successfully Using A Top-Down Process With Minimum Impact on Environment

BRIDGE 8 Design & CONSTRUCTION

Thank You!

Questions?

U.S. Department of Transportation
Federal Highway Administration