Introduction to Replacement Bridge Planning and Design

Questa Engineering Corporation
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Introduction

Today's Talk:

- Basic site analysis and investigation
  - Geotech, Hydrology, Roadway, etc.
- Bridge designs types
  - Abutment/Foundation types
  - Bridge Deck types
- Design exercise
- Permits and review processes
- Construction issues
- Retrofits

Why Bridges?

- Bridges have better
  - Flood Control performance
    - Less back water, better conveyance, safer
  - Geomorphic flexibility
    - Maintains sediment transport, vertical movement
  - Fisheries benefits
    - Removes migration barriers, facilitates movement, provides habitat

Multi-Discipline Approach

- Structural Engineering
- Hydrology Science
- Geotechnical Engineering
- Hydraulic Engineering
- Civil Engineering
- Biologic Evaluations
- Planning and Permitting
- Geologic Evaluations

Basic Design Approach

- Investigate the site
  - Survey and geotech
- Layout bridge location
- Bridge Deck and foundation design
- Hydraulic Design
- Approach design
- Permitting
- Construction

Site Survey Data

A GOOD SURVEY IS NEVER A WASTE OF MONEY!!

- Survey site
  - General topographic for 100 feet upstream downstream min.
  - Channel slopes
    - Long profile at 350 feet upstream and downstream
    - Make sure controlling tailwater zones are surveyed
  - Existing structure data
    - Slope, shape, dimensions, top of roadway, top of culvert, apron slopes and wing wall geometries
  - Make sure bridge approach roads are surveyed including edge of pavement, roadway crowns, super elevations
  - Map utilities and nearby structures

Site Analysis

- Site analysis:
  - Layout
  - Geotechnical Considerations
  - Hydrologic/Hydraulic Studies
  - Geomorphic Considerations
  - Biologic issues

Bridge Layout – Structure Positioning

- Right of Way
- Jurisdictional determination
- Alternative alignments
- Approaches
  - Vehicular
  - ADA Requirements
- Traffic/Roadway design

Roadway Design Issues

- Alignments
- Approach elevations
- Vertical Curves
- Will you need embankments or other retaining structures

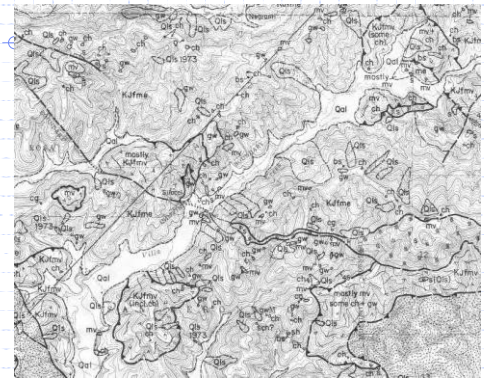
Geotechnical Studies

- Investigative procedures
- Drilling rigs and types
- Constraints
- Report preparation

Types of Geologic Investigations

- Regional gelogic and seismic conditions
- Soil conditions
- Geologic hazards
- Subsurface exploration
- Analysis
- Design recommendations

Local Geologic Map Detail of Cambria Area



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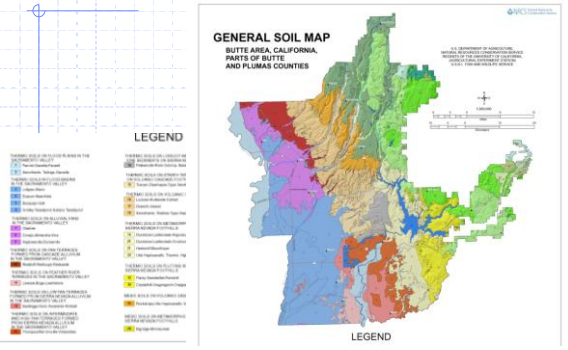
Soils Map



Regional Seismicity and Geology Review

- Alquist-Priolo Earthquake Fault Zone Maps
- Seismic Hazard Zone Maps
- Liquefaction
- Seismic Induced Slope Instability
- Seismic Shaking Hazard Maps
- Regional Geologic Mapping
- Regional Slope Stability Mapping

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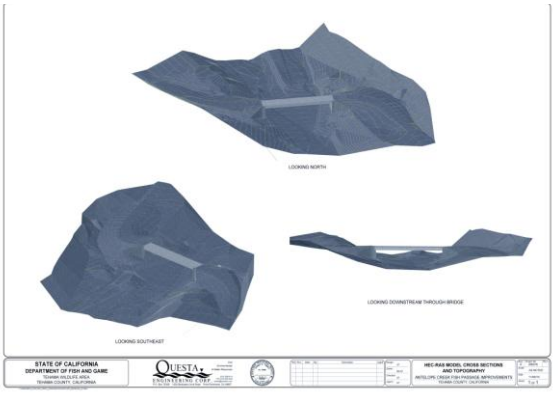

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Drilling, Logging and Sampling of Boreholes

- Exploratory holes 10 feet into bedrock or required depth in soils
- Soil sampling at depth intervals to collect samples for analytical testing
- Perform Standard Penetration Test (SPT) sampling for strength characteristics (I.e. Blow Counts/ft)
- Determine groundwater levels

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Drill Rigs

- Type of rig depends upon many factors;
  - Depth of hole,
  - required rock penetration,
  - potential for hole collapse,
  - sampling requirements, and
  - access restrictions

Drill Rigs

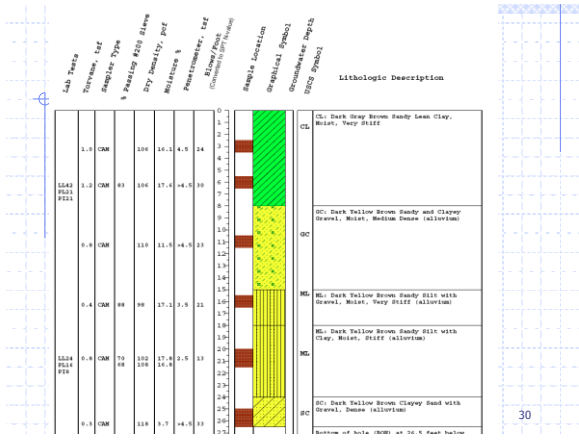
- Portable Augur Drill Rig
- Truck/track mounted Augur Drill Rig
- Mud or Air Rotary Drilling
- Cone Penetration Testing

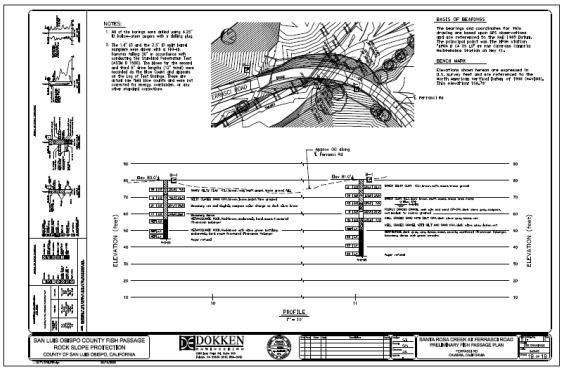
- Re: Specialized drilling services may take time to schedule

Types of Drilling

Reviewing Boring Logs

- Logs of test borings show summaries of data
  - Soil density
  - Soil material
  - Blow counts
    - Fewer blow counts - looser less dense material
    - High blow counts - solid denser soil conditions
  - Groundwater levels





Foundation Type Feasibility Review and Laboratory Testing Request

- Review Logs of Boreholes and Determine Feasible Foundations based on subsurface conditions
- Determine Samples and Testing Protocol for Soils Laboratory

Geotechnical Engineering Analysis

- Foundation bearing capacity
- Site seismic design criteria
- Pier Friction Capacity
- Liquefaction Analysis
- Site Geology and Soil Conditions
- Geologic Hazards

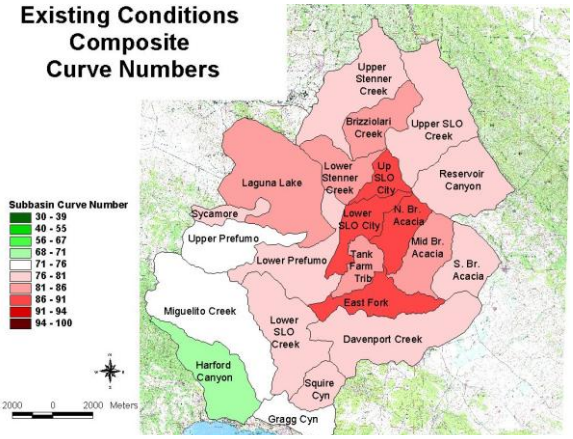
Session Break

H & H Investigations

- Hydrology data
- Hydraulics analysis

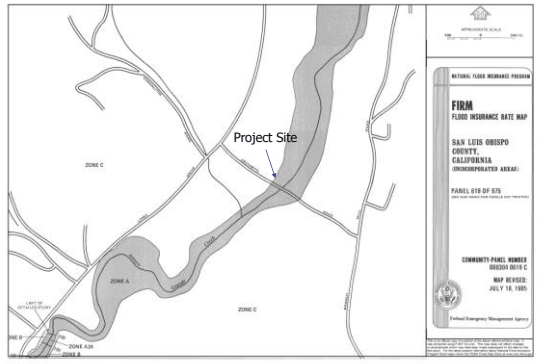
Hydrologic Analysis

- Hydrology Information
  - Gage data
  - Hydrologic models
  - Comparable basin analysis
  - Governmental sources; Caltrans, FEMA, and County Flood Control Agencies



Hydraulic Analysis

- Hydraulic analysis
  - FishXing
  - HEC-RAS
  - Alternative Hydraulic models
- Must have the ability calculate back water impacts



Hydraulic Modeling

- HEC-RAS
  - Good design tool accepted by most if not all agencies for analysis
- Requirements:
  - Accurate topographical survey
  - Surveyed benchmarks
  - Hydraulic structures
    - Bridge soffit/roadway measurements
  - Slope

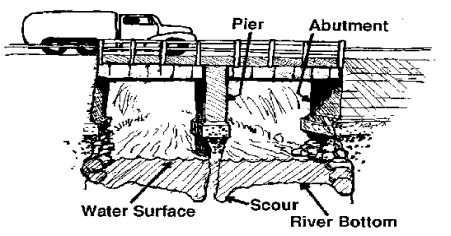
Design Water Surface elevations

- Hydraulic Design Criteria and Freeboard
  - Vary by Jurisdiction
  - 50-year with 2 ft of freeboard
  - 100-year with at least 1 ft freeboard
  - Levees – three of freeboard

Bridge Design and Impacts

- Goal: shortest bridge with the least amount of impact
- Design Criteria
  - Passes design flows with freeborad
    - 50-year with 2 ft of freeboard
    - 100-year with at least 1 ft freeboard
  - No increase in flood threat
  - Minimizes scour and deposition

Bridge Scour Analysis



Bridge Scour

- Event Based scour vs. Long-term scour
  - Hydraulic Engineering Circular (HEC) 18, "Evaluating Scour at Bridges," FHWA-IP-90-017
  - Geomorphic evaluations

Geomorphic Analysis

- Vertical & Lateral Creek Movement
- Sediment Transport
- Bankfull channel
- Low-Flow (scour line) Channel

Determining Vertical and Lateral Creek Movement

- Historic profile analysis
- Existing condition long profile analysis
- Historic air photo examination
- Historic topographic map analysis

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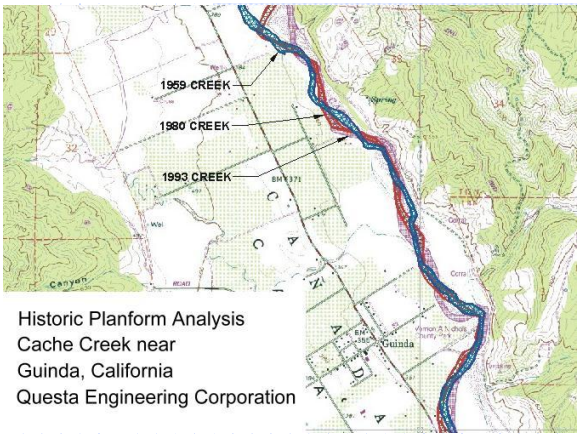
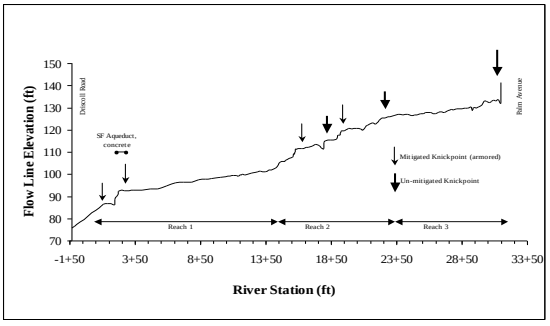


Historic Planform Analysis
Cache Creek near
Guinda, California
Questa Engineering Corporation

Longitudinal Profile Analysis



Longitudinal Profile Analysis

- Determines average slope through the site
- Assesses offsite bed slope issues
- Places project site in context with upstream downstream areas
- May indicate bed aggradation

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Fall 2003

March 2005

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Design Breakdown

- Foundation design
- Bridge deck design
- Channel Design

Bridge Foundation Considerations

- Required Load Capacity and Anticipated Uses
- Site Conditions & Geotechnical Investigations
- Foundation Types
  - Spread Footings
  - Driven Piles
  - Drilled Cast-In-Place Piers
- Economic Analysis
  - Capacity and Service Life versus Cost
  - Typical Construction Costs

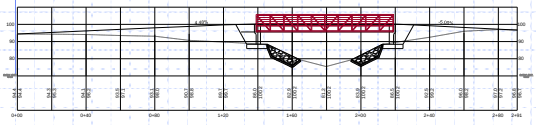
Required Load Capacity and Anticipated Uses

- Public Trails - Pedestrian/Bicycle/Equestrian/Disabled Users
- Light-Duty – Typically Residential Automobiles/Light Trucks
- Highway Traffic – Heavy Trucks HS20-25 loads (AASHTO Load Standards)

AASHTO & Caltrans

- American Association of State Highway and Transportation Officials
  - National Association which establishes and promotes highway construction and safety standards.
- California Department of Transportation
  - Manages State Highway System
  - Issues permits for encroachment into state owned highways and properties

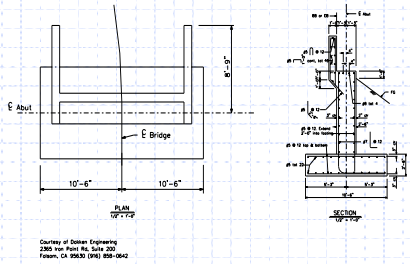
Typical Light-Duty Bridge Crossing Profile



Foundation Types - Spread Footings

- Relatively shallow reinforced concrete mats to distribute bridge loads over wide area of supporting soils.
- Advantages
  - Typically least expensive option
  - Minimal equipment mobilization requirements
- Disadvantages
  - Not suitable over soft or liquefiable soils
  - Minimal resistance to undermining or slope instability
  - Moderate to heavy site disruptions

Typical Spread Footing Bridge Foundation



Courtesy of Dokken Engineering
2365 Iron Point Rd. Suite 200
Folsom, CA 95630 (916) 858-0642

Foundation Types - Driven Piles

- Tubular and Sheet Steel, Reinforced Concrete or Composite Piles driven into soils using a dropped weight or piston hammer, applied typically in marine settings.
- Advantages
  - Minimal site disruption
  - Provides support over soft or variable subgrade conditions
  - Applied in areas prone to flooding or with very soft soils
- Disadvantages
  - Requires mobilization of large equipment and materials
  - Requires minimum embedment depth into soil

Reinforced Concrete Piles Being Installed in a Marine Environment

Foundation Types - Drilled Cast-In-Place Piers

- Drilled holes filled with cast-in-place reinforced concrete piers.
- Advantages
  - Typically provides greatest resistance to vertical and lateral loads
  - Provides excellent resistance to scour
  - Used in steep and/or unstable slope areas
- Disadvantages
  - Typically highest cost
  - Difficult to apply in areas of shallow ground water or loose soils
  - Moderate site disruptions

Drilled Pier Foundation Design for Timber Framed Bridge

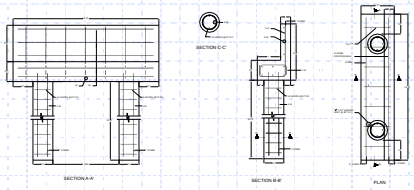
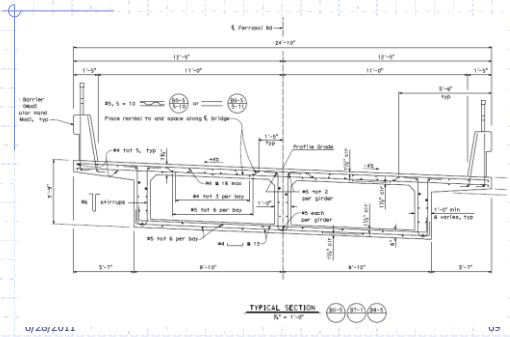


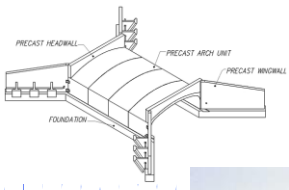
Photo of Drilled Cast-In-Place Pier Installation

Economic Analysis

- Capacity and Service Life versus Cost
- Typical Cost for Light-Duty Bridges
  - $1,000/ft for pre-fabricated steel bridges w/ wood decking
  - $2,000/ft installed including design and foundations

Concrete Box Girder



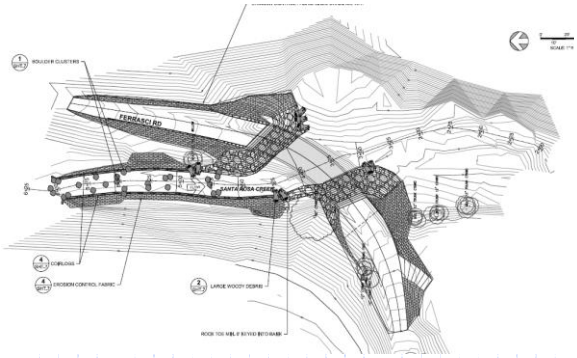


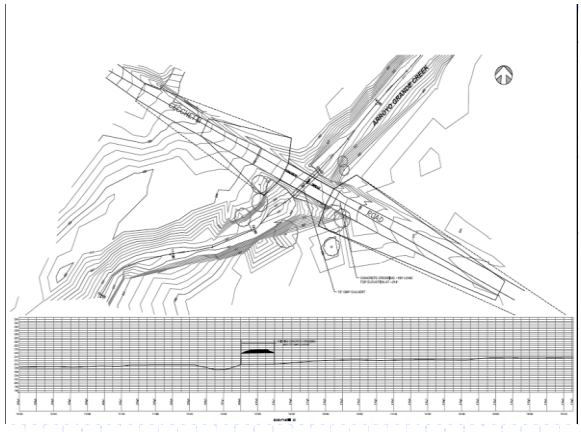
Bridge Widths

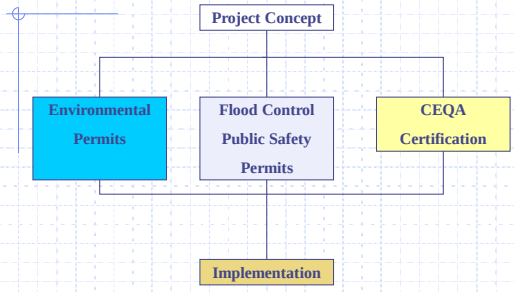
- 12 foot width lanes plus 2 feet of railing/curb
- Single lane = 18 feet, 14 feet between railings/curbs
- Two Lane = 28 feet, 24 feet between railings/curbs

Planning Level Bridge Costs

- Pedestrian Bridge construction costs in northern California
  - $125-$140 per square feet (sf) for cast in place concrete,
  - $115-$150 per sf for prefabricated bridges.
  - $1,500 per lineal foot
- Traffic Rated Bridges
  - Two Lane light to medium traffic
    - **$350-500 sf**
  - Major arterial structures
    - **$600-$750 sf**







Permits and Approvals

- Documents needed for permitting
- Permitting procedures
- Design Review
- Construction implementation
- Construction management and inspection

Project Permit Documents

- Site Map
- Water of the USCOE Jurisdictional Area
- Project Description
  - Detailed
  - Alternatives examined/project justification
  - 30% design drawings
- Project Analysis
  - Technical analysis or separate back up design memorandum (H&H, Geotech, etc.)
- Biologic Reconnaissance

Project Description

- Project Justification Site plan
- Project channel bed profiles
- Project cross section views
- Habitat enhancement features
- Limits of work
- Area of impact
  - USCOE, riparian area, vegetated area
- Determination of cut and fill quantities

Environmental Permits

- U.S. Army Corps of Engineers 404 Permit
  - Endangered Species Act Consultation
- California Department of Fish & Game Streambed Alteration Agreement
- Regional Water Quality Control Board
  - Water Quality Certification & General Stormwater Construction Permit
- Coastal Development Permit

USCOE Permits

- Reviews application and notifies National Marine Fisheries Service (NMFS) and/or US Fish and Wildlife Service (USFWS)
  - May ask for formal or informal consultation
  - May require preparation of a Biologic Opinion (BO) and/authorization for take
  - NMFS will review Fish passage analysis

Streambed Alteration Agreements

- CDFG engineering staff will review project fish passage analysis
- Must have CEQA completed to issue
- Includes impacts to riparian areas

Biological Reconnaissance

- Special-Status Species
- Existing Habitat ID and Mapping
- Proposed Habitat Mitigation
- OHWM/Wetland Delineation
- CNDDB Search

Coastal Development Permit

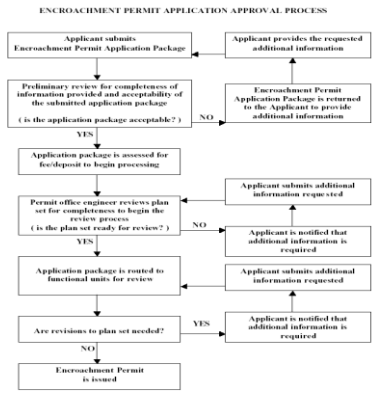
- Usually processed through the County
- May require architectural review
- May require separate monitoring protocols

Public Safety Permits

- County/ City Building Permits
  - Structural & Roadway Design Review
- Caltrans
  - Encroachment permits

Caltrans Encroachment Permit

- Primarily concerned with impacts to their facilities and safety
  - Reviews design storm hydrology and hydraulics
  - Erosion and bank stabilization in and around their facilities
  - Maintenance responsibility



County/City Review

- Reviews detail plans and calculations
  - Roadway design
  - Structural design
  - Geotechnical design
  - Flood control

CEQA Review

- Categorical Exemption
- Initial Study Preparation
- Mitigated Negative Declaration
- EIR/EIS
- Lead Agency
  - City or County
  - CDFG for some grant funded projects

Permit Timeline

- 6 month is likely minimum
- 1 year is not out of the question
- NMFS and USFWS have 135 days
- CDFG - 30 days
- Coastal Development Permit

Construction Factors

- Site and Channel Access
- Work Conditions
- Restricted Seasons
- Mobilization and Staging Areas
- Materials Storage Areas
- Dewatering
- Limits of Work

Construction Issues
Access & Staging

- How are you going to get to the site?
- Dewatering issues
- Do access roads need to built?
- How will machinery move around the site?
- Where will work be staged?
  - Material and spoils storage
  - Maintenance and fueling areas
- Delivery truck access and traffic issues?

Construction Sequence

- Water control
- Foundation construction
  - Drilling
  - Concrete forming
- Channel demo and grading
- False work/deck forming
- Pre-stressing/curing
- Installation
- Approaches
- Erosion control

Construction Inspections

- Inspections are very important - use construction inspection forms
- Extensively photograph work progressing
- Inspection Milestones:
  - Staking and job layout
  - After clearing and grubbing, new topo may be taken to estimate quantities
  - After rough grading
  - During rock placement/willow staking
  - During LWD/in-stream structures placement
  - Check step pool elevation and depths as you go!!
  - After erosion control installation; during and after planting and irrigation installation