Bridge Engineering 101
Part 2 -Planning and Design

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Introduction

Today's Talk:

- General Design Steps
  - Planning to Construction
- Bridge foundation types
- Environmental Review & Permits
- Construction

Multi-Discipline Approach

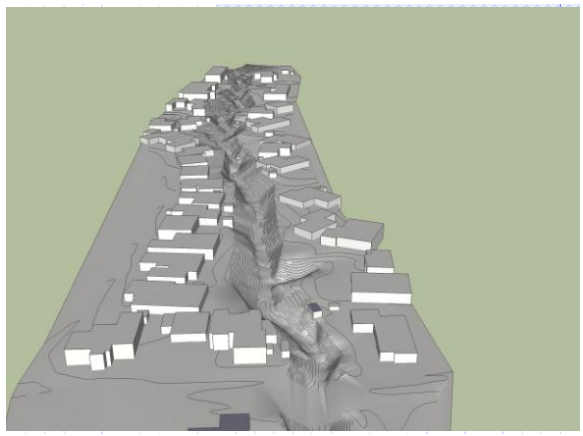
- Structural Engineering
- Geomorphology
- Geotechnical Engineering
- Hydraulic Engineering
- Civil Engineering
- Biologic Evaluations
- Planning and Permitting
- Geologic Evaluations

Basic Design Steps

- Investigate the site
  - Survey, Geotech, Hydrology, Biology
  - Opportunities and constraints
- Determine bridge type and location
- 40% Design
- Permitting
- Final foundation and superstructure design
- Construction drawings
- Construction
- Construction management

Site Survey Data

- Site Survey
  - General topography for 100 feet upstream/downstream min.
  - Channel slopes
    - Long profile at 350 feet upstream and downstream
  - 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:
  - Geotechnical Considerations
  - Hydrologic/Hydraulic Studies
  - Geomorphic Considerations
  - Biologic issues
  - Bridge Layout

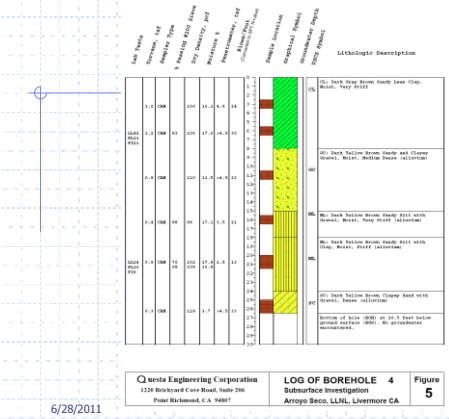
Geotechnical Investigations

- Regional geologic and seismic conditions
- Local Soil conditions
- Local Geologic hazards
- Subsurface exploration
- Design recommendations

Subsurface Investigations

- Exploratory holes; 10 - 100+ feet
- Soil samples are collected for analytical testing
- Perform Standard Penetration Test (SPT) sampling for strength characteristics (I.e. Blow Counts/ft)
- Determines groundwater levels

Types of Drilling

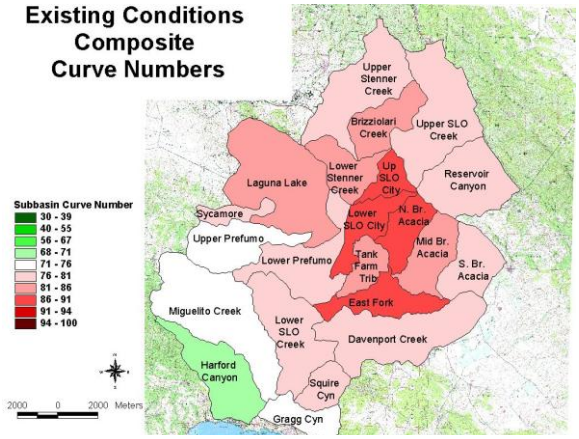


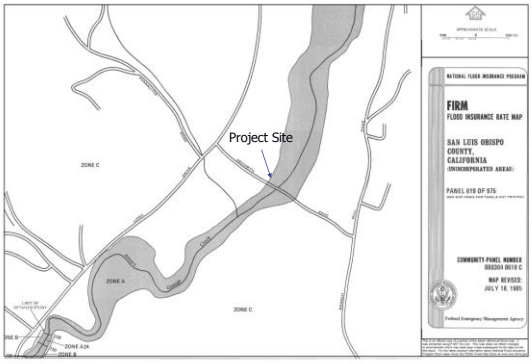
Geotechnical Reports

- Summarize geological hazards
- Local site conditions
- Provide recommendations for foundation design

H & H Investigations

- Hydrology data
  - Regional source – Flood Control Agencies
  - Site specific modeling
- Hydraulics analysis
  - Governmental sources; Caltrans, FEMA, and County Flood Control Agencies
  - Complete site specific analysis





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 feet of freeboard

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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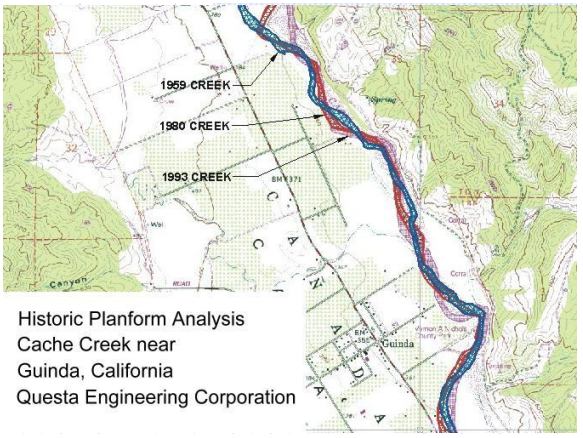
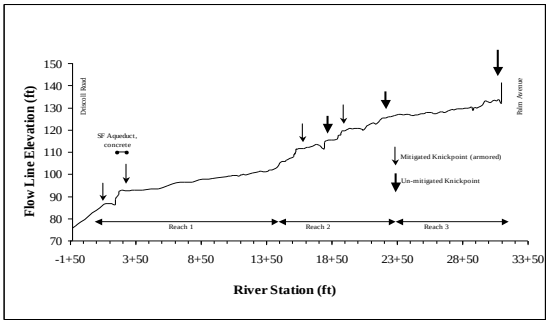


Historic Planform Analysis
Cache Creek near
Guinda, California
Questa Engineering Corporation

Longitudinal Profile Analysis



Fall 2003 March 2005

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Biological Reconnaissance

- Special-Status Species
- Existing Habitat ID and Mapping
- OHW/Wetland Delineation
- CNDDB Search

Bridge Layout – Structure Positioning

- Right of Way
- Alternative alignments
- Approaches
  - ADA Requirements
- Traffic/Roadway design issues
- Utilities

Roadway Design Issues

- Alignments
- Approach elevations
- Vertical curves- approach slopes
- Will you need embankments or other retaining structures?

Bridge Widths

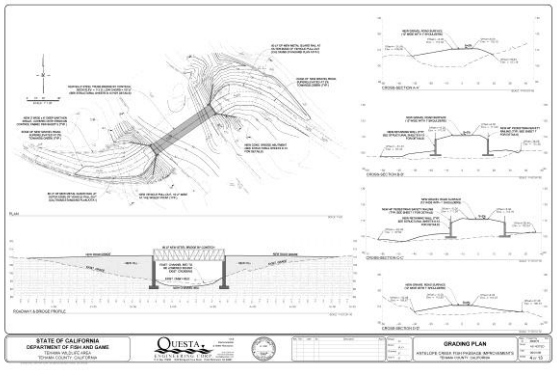
- Typical trail - 10 feet width
- Major trail - 12 foot width lanes plus 2 feet of railing/curb
- Single lane = 18 feet, 14 feet between railings/curbs
- Two Lane = 28 feet, 24 feet between railings/curbs

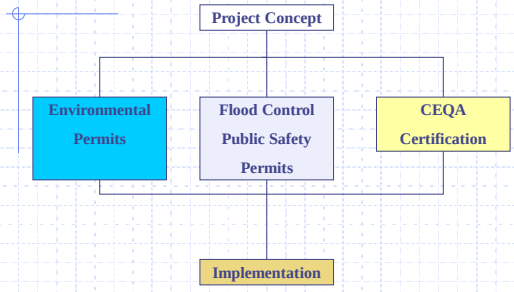
Bridge Design and Impacts

- 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

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**





Project Permit Documents

- Site Map
- Water of the USCOE Jurisdictional Area
- Project Description
  - Detailed
  - Alternatives examined/project justification
  - 40% 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, Mobilization
- Area of impact
  - USCOE, riparian area, vegetated area
- Determination of cut and fill quantities

CEQA Review

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

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 staff review
- Must have CEQA completed to issue
- Includes impacts to riparian areas

Coastal Development Permit

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

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 – 6 months+

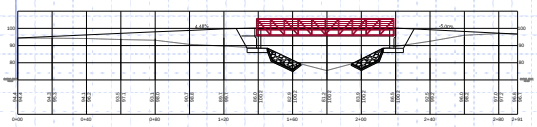
Design Breakdown

- Foundation design
- Bridge deck design
- Channel Design if needed

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



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)

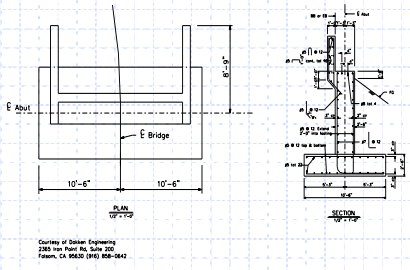
Bridge Foundation Considerations

- Required Load Capacity and Anticipated Uses
- Site Conditions & Geotechnical Investigations
- Foundation Types
  - Spread Footings
  - Driven Piles
  - Drilled Cast-In-Place Piers

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

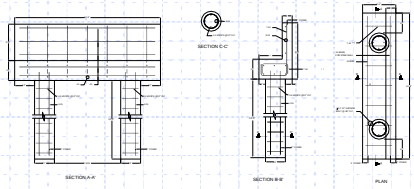


Photo of Drilled Cast-In-Place Pier Installation

Public Safety Permits

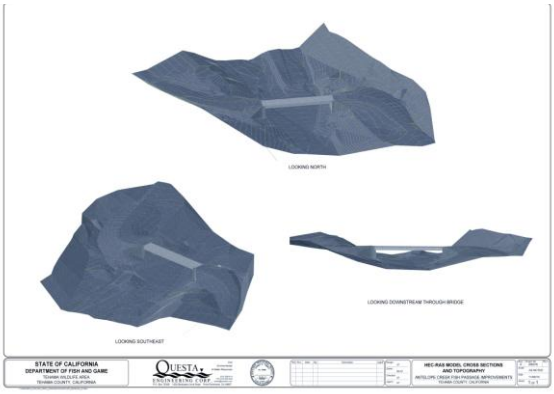
- County/ City Building Permits
  - Structural & Roadway Design Review
  - Floodplain Management
- Caltrans
  - Primarily concerned with impacts to their facilities and safety
  - Maintenance responsibility

County/City Review

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

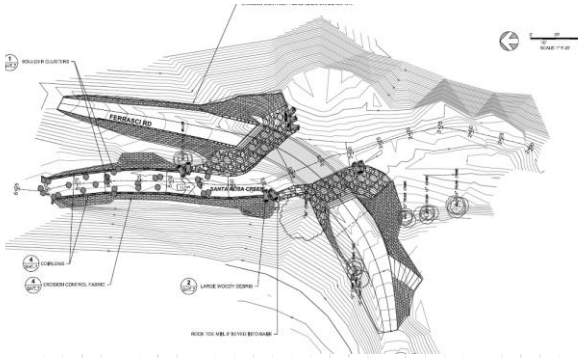
Construction Drawings

- Plan set
  - Site Plan and layout
  - Foundation plans
  - Superstructure plans
  - Road or trail plans
  - Erosion Control
  - Ancillary structures



Construction Specifications

- Bidding instructions
- Work hours
- Contracting requirements
- Construction and material specifications



Construction Factors

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

Construction Sequence

- Water control
- Foundation construction
  - Drilling
  - Concrete forming
- Grading
- Installation or construction
- Approach construction
- Erosion control

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Contact Info

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