Construction Factors Affecting Success of Fish Passageways

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Background

- 10,000 culverts in Washington and Oregon
- 5,500 impassable
- $375 Million to restore passability
Problem Statement

ODOT has experienced both successful and unsuccessful waterways.

Discovery of factors that correlate with poor fish passageway performance.

The focus is on the construction process…

All the while recognizing changes may have occurred after completion of construction--therefore, the field investigation will look for compounding effect of potential changes.

This portion of the study presents a summary of the prior results of field investigations and adds information regarding construction practice.
Fish Passage

- Aquatic organism use
- Roughened channels to achieve stream simulation
- Low flow is the issue
- Disturbance to the channel bed creates failures

Upstream

Structure

Downstream
Field Investigation

- Of 22 locations 19 investigated in detail
- 6 bridges, 13 culverts
- Most culverts had weirs or baffles
- Conditions encountered:
  - Scour, jumps
  - Subsurface flow
  - Blockage

- Slopes
- Structure characteristics
- Channel conditions
- Streambed soils
- Flow conditions
- Channel cross-sections
Field Investigation

Conclusions

The number of sites reviewed don’t allow conclusive statistical conclusions, but…

– Slope of the system itself is not a clear determinant of success, yet…
  Downstream slope is a likely important factor in development of a healthy waterway.

– Poor soil gradation is a threat to surface flow, but…
  Channel characteristics are not identified as the causal factor.

– Study continued to explore construction methods.
Construction process research

• Survey collected:
  – Background Information—key players and design or construction entity
  – Design Process—whether design considered hydraulics, and/or fish passage
  – Construction Process—information concerning source of fill material, mixing methods, the specified fill proportions, and methods of placement and consolidation
  – Post-Construction Process—maintenance work and site inspection frequency

• Respondents:
  – Hydrologists—responsible for design and opportunistic site visits
  – Regional ODOT personnel—construction, inspection and maintenance
  – ODOT Biologists—in charge of evaluating the passages for healthy fish passage; they do most of the monitoring
Design, construction, and monitoring practices

• Design:
  – Mostly designed by ODOT, mostly re-hab of existing passages
  – In most cases, design focus was for fish passage, not hydraulics

• Construction
  – Construction was split between ODOT and contractors

• Monitoring
  – occurred most frequently twice a year, but often less frequency occurred.
Specified channel fill mixes

A wide variety of mix designs:

- soils were generally specified at a ratio of 2:1 (cobble and gravel to sand and fines) by volume;
- soils to riprap varied from 25% to 50% by volume
- at five locations, the channel fill mix was not specified, but rather was determined in the field, the detail of which is unavailable.
- in all of the sites, riprap was placed

Specified channel fill mixes were achieved using the in-field, combined judgment of the construction and supervising personnel, without instrumentation.

Actual fills likely varied from those specified.
Sources of channel fill

Channel fill was sourced from local quarries, the existing riverbed, or stockpiled soil material.

The majority of the time the soil material was from a combination of local quarries and existing soil at the site. Soil obtained from quarries was always larger material such as boulders, cobble, and gravel.
Mixing methods

Mixing methods:

- Pre-mixed
- During placement in the channel. The mixing was done using the equipment on site, such as skip loaders, and the material was hosed down with water
- Prior and during placement using a skip loader
Consolidation methods

- Riprap was placed in a layer, then additional soil material, which included cobbles, gravel sand and fines was placed above each layer of riprap and mixed into the riprap by hose-applied water to fill the voids, then the protruding large riprap was shaken with a skip loader in order to facilitate the filling of the voids.

- Layering of materials as described above, without the mechanical shaking; and

- No mixing occurred when only large material was placed

No vibratory or similar compaction
Success Index analyses indicate that success is not clearly related to any specific factor

- when site soils are used, success was found to be higher
- "shaking" of the large boulders to better consolidate the finer soils around them led to higher success
- more frequent visits to the site also led to higher success, likely due to more maintenance before problems worsen
Construction Investigation
Conclusions

- With gained experience, the personnel involved are constructing better projects, but movement of personnel causes loss of experience.
- Success didn’t depend on whether the sites were constructed by ODOT crews or contractors.
- In practice the placed mix was of locally-available materials was determined without instrumentation:
  - where channel materials included site soils, subsurface flow was less likely.
  - site soil is already well graded and is more well-graded compared to mixing soil materials from quarries.
  - failures are more likely to occur when fills are mixed in the channel (so pre-mixing is encouraged), and
  - the practice of shaking the larger rip-rap material to improve consolidation decreases the likelihood of subsurface flow.
- The fish passage sites need to be constantly monitored, even beyond the period that is demanded by the environmental organizations:
  - Frequent site visits can catch any problems that might arise, and corrective action be taken sooner.
- A more rigorous method of capturing key conditions of construction and performance would facilitate the development of future success analyses:
  - actual soil gradations
  - in-place fill mix ratios
  - standardized placement and consolidation methods
  - use of a measuring system, such as the Success Index, to monitor longitudinal performance.
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