eSPAN140 Design

Short-Span Steel Bridge Workshop – AL LTAP
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Why Short Span Bridges?

- Roughly 600,000 bridges in the United States.
  - Majority of bridges are in the short-span range (40-140 feet)
The Problem

• Bridge engineers are well trained on the use of short span concrete bridges.
  – In fact, about than 70% of the short span bridges in the United States are made of concrete.

• Many County and Department of Transportation (DOT) engineers are simply not educated on the design, construction, and economics of short span steel bridges.
Concrete provides simple, standardized, cost-effective, “tinker toy” solutions to construct short span steel bridges.

Steel bridges are “perceived to be too” complex, “Swiss watch”-like, and too expensive.
Why steel for bridges?

• **First Cost/Economical**
  – 25% less than concrete with cost-efficient design, fabrication, and construction practices
  – Up to 33% less with new innovative designs concepts

• **Modular**
  – Light weight, prefabricated options, easy to construct
  – Standardized plans

• **Durable**
  – Highly resistant to natural disasters (seismic)
  – Long life cycle (weathering steels & galvanized options)

• **Sustainable**
  – 100% recycled
  – Recycled content (steel has over 90% recycled rate)
**Target Audience (Bridge Owners & Designers)**

**United States**
- 3,000 USA County Engineers (Local/Regional Officials)
- 50+ USA State DOT
- Federal Highway Officials
- Consultants, Designers, Universities, etc.

**Canada**
- Ministers of Transportation (MTOs)

**Mexico / Latin America**
- Municipalities
Standard Short Span Steel Bridge Designs

Goals & Design Methods
Standard Designs for Short Span Steel Bridges

• Goals:
  • Economically competitive
  • Expedite & economize the design process
  • Simple repetitive details & member sizes.

• Bridge Design Parameters:
  • Span lengths: 40 feet to 140 feet (5-foot increments)
  • Girder spacing: 6 feet, 7.5 feet, 9 feet and 10.5 feet
  • Homogeneous & Hybrid plate girders with limited plate sizes
  • Limited Depth & Lightest Weight Rolled Beam Sections
  • Selective cross-frame placement/design (AASHTO/NSBA)
Weight Comparisons

The graph shows weight comparisons for different types of steel plates as a function of span length in meters (m) and feet (ft). The weight is represented in kilograms (kg) and tons (ton).

- **Homogeneous Plate**: Represented by blue triangles (△) on the graph.
- **Limited Depth**: Represented by green crosses (×) on the graph.
- **Lightest Weight**: Represented by purple triangles (△) on the graph.
- **Hybrid Plate**: Represented by yellow squares (□) on the graph.
eSPAN140

Free Online Design Tool for Short Span Steel Bridges

Developed by the Short Span Steel Bridge Alliance

http://www.espan140.com/
eSPAN140

- eSPAN140 is an easy-to-use and **free** resource for bridge engineers & owners.

- In 3 easy steps, multiple steel solutions are recommended!

**Step 1.**
Create a User’s Account

**Step 2.**
Input Your Specific Project Details

**Step 3.**
View Your Instant Customized Solutions Books
- Start new project:

**My Projects**

Welcome to eSPAN140. If this is your first time here, please click on “Start New Project” to begin.

If you have already created a project, please use the table below to view past projects, complete pre-existing inputs you provided, please click on “Duplicate”. This will allow you to create a new project if you have multiple bridges to design and have only a few input values to change.

- [Start New Project](#)
- **Range of available solutions:**

<table>
<thead>
<tr>
<th>Solution Type*</th>
<th>Bridge Span Length</th>
<th>Skew Angle</th>
<th>Overhang Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll Beam (40' to 100')**</td>
<td>0'</td>
<td>+/- 20 degrees</td>
<td>3'3&quot; or less</td>
</tr>
<tr>
<td>Homogeneous Plate Girder (60' to 140')**</td>
<td>0'</td>
<td>+/- 20 degrees</td>
<td>3'3&quot; or less</td>
</tr>
<tr>
<td>Hybrid Plate Girder (80' to 140')**</td>
<td>0'</td>
<td>+/- 20 degrees</td>
<td>3'3&quot; or less</td>
</tr>
<tr>
<td>Corrugated Steel Pipe/Structural Shape (0' to 85')</td>
<td>0'</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>Manufacturer's Steel Solutions (all)</td>
<td>0'</td>
<td>All</td>
<td>All</td>
</tr>
</tbody>
</table>
• **Step 1: Project Information**

- **Project Name**
  - Sample Bridge

- **City/County**
  - Morgantown

- **State/Province**
  - West Virginia

- **Roadway Name**
  - Main Street

- **Bridge Span Length**
  - 82 Feet 4 Inches
• **Step 2: Project Details (general dimensions)**

- **# of Striped Traffic Lanes**
  - 2

- **Roadway Width**
  - Feet: 30
  - Inches: 0

- **Individual Parapet Width**
  - Feet: 1
  - Inches: 3

- **Individual Deck Overhang Width**
  - Feet: 3
  - Inches: 0
- Step 2: Project Details (pedestrian access option)
• **Step 2: Project Details (remaining details)**

- **Skew Angle**: 15 Degrees
- **Average Daily Traffic**: Over 2,000
- **Design Speed**: Not applicable

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Diaphragm Spacing (Equal)
Span Length

STA & PGL

Q Bearing

STA __+__

Int. Stiffener
• Step 3: Customized Solutions Book is Provided (pdf)

Standard Design and Details of Short Span Steel Bridges Solutions
  • Rolled Beam Recommendations
  • Plate Girder Recommendations

Standard Design and Details of Corrugated Steel Pipe and Structural Plate Solutions

Manufacturer’s Steel Solutions (SSSBA Partners)
  • Customized Solutions from Members of the SSSBA

Durability Solutions (SSSBA Partners)
  • Galvanized & Paint
  • Weathering Steels

Additional Contact Information
Design Example

- Sample plate girder (homogeneous) elevation:
Design Example

- Sample plate girder (homogeneous) data:

<table>
<thead>
<tr>
<th>SPAN (L) - ft</th>
<th>TOP FLANGE - in</th>
<th>BOTTOM FLANGE (F)</th>
<th>DIAPHRAGM</th>
<th>SHEAR STIFFENERS</th>
<th>SHEAR CONNECTOR MAX. SPACING</th>
<th>INDIVIDUAL GIRDER WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SPACING (C) - ft</td>
<td>X (NO. REQ'D)</td>
<td>Y - ft (SPACING)</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>14 x 3/4&quot;</td>
<td>14 x 1&quot;</td>
<td>17&quot;</td>
<td>14 x 2&quot;</td>
<td>51&quot;</td>
<td>21.25&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEEL D.L. CAMBER - in</th>
<th>TOTAL D.L. CAMBER - in</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0.251&quot;</td>
<td>0.469&quot;</td>
</tr>
</tbody>
</table>
Design Example

• Typical girder elevation:
Design Example

• Typical stiffener details:

BEARING STIFFENER
(N.T.S.)

SHEAR STIFFENER
(N.T.S.)

SEE STANDARD CLIPS & WELD TERMINATION DETAIL

FIT TO BEAR. NOTE 2

CLIP NOT REQUIRED

NOTE 3

$\frac{3}{4}'' \times 5''$ FOR FLANGE WIDTHS $\leq 14''$

$\frac{3}{4}'' \times 7''$ FOR FLANGE WIDTHS $> 14''$

SEE STANDARD CLIPS & WELD TERMINATION DETAIL

OPTION 1

OPTION 2

TIGHT FIT

$\frac{1}{2}'' \times 5''$

CONNECTION STIFFENER
(N.T.S.)

BEARING STIFFENER TO FLANGE WELDING IS REQUIRED IF A DIAPHRAGM OR CROSS FRAME IS ATTACHED TO THE STIFFENER
Design Example

- Typical diaphragm details:
Design Example

- Typical bearing details:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>INTERNAL ELASTOMER LAYERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>16&quot;</td>
<td>18&quot;</td>
<td>4.375&quot;</td>
<td>12&quot;</td>
<td>5</td>
</tr>
</tbody>
</table>

BEARING ELEVATION
OPTION "A"
(N.T.S.)
CSP & Structural Plate Standards
Manufacturer’s Solutions
Durability Solutions

- Painted steel, weathering steel, and galvanized.
Demonstration Example
http://www.espan140.com/
The Bridge Technology Center

- Free resource available to bridge owners and designers with questions related to:
  - Standard design and details of short span bridges (plate & rolled beam)
  - Standard design and details of corrugated steel pipe and structural plate.
eSPAN140 Bridges
Designed Bridges
1st Direct Application of eSPAN140 – start to finish

Jesp South Bridge, Buchanan County, Iowa

- Buchanan County Iowa
- Replacement using W36x135 rolled beams
- 65 feet length, 40 width
- Over $100,000 donations from members
- Better Roads (February 2014)
County Crew
Accomplishments:

- Longest Bridge Built
- First Steel Bridge Built
- First Concrete Deck
- First Integral Abutment
- Galvanized Steel
- Galvanized Rebar
- County Equipment
The New Jesup South Bridge
New Substructure Options
**eSpan140 Substructure Solutions**

**Traditional Abutment**

**Description**

Traditional abutments are a substructure designed to support the lateral earth pressure of the bridge backfill material. Traditional abutments distribute the loads from the bridge ends to the ground while withstanding any loads that are directly imposed on them. They are rigid abutments with a joint between the bridge deck and the backwall. They are built back away from the stream and up on the back slope. They are generally built on piling and resist horizontal earth pressure with its own dead weight.

**Site Selection**

If the following criteria are met, then traditional abutments may be suitable for the project:

- Span length less than 450 feet.
- Skew limited to a maximum of 45 degrees.

Note that exceptions to the above criteria are possible, depending on the site and loading conditions.

**Advantages**

- Traditional bridges are built with common, everyday materials.
- Traditional bridges are well known by the common work force.
- Traditional abutments are less vulnerable to flood damage.
eSpan140 Substructure Solutions

Integral Abutment

Description
Integral abutments are a substructure type that are made continuous with the bridge superstructure through a combined shear and moment connection. The superstructure and substructure deform together to accommodate required translations and rotations by encasing the beam ends within the abutment. They are often constructed with a single row of piles that allow for thermal movement and girder rotation. They have no bearings or bridge expansion joints creating a joint-less deck, while soil forces behind the abutments are resisted through the strut action of the superstructure.

Site Selection
If the following criteria are met, then integral abutments may be suitable for the project:

- Span length less than 300 feet.
- Skew limited to a maximum of 45 degrees.
- Maximum grade of bridge limited to 5 percent.

Note that exceptions to the above criteria are possible, depending on the site and loading conditions.

Advantages
- Simple Design—Integral bridges may be considered a continuous frame with a single horizontal member and two or more vertical members for analytical and design purposes.
- Rapid Construction—Integral abutments only use one row of vertical piles and normal delays associated with bearings and joints installation are eliminated.
- Joint-Less Construction—Integral abutments eliminate expansion joints and bearing preventing corrosion due to leaky expansion joints.
- Increased Earthquake Resistance—Integral abutments eliminate the potential of loss of girdle support.
- More Economical to Own Over its Life Span—Integral bridges have lower construction and future maintenance costs.
Sheet Pile Abutment

**Description**

When building bridges, it is beneficial to put the abutments close to each other to reduce the span as much as possible and steel sheet piles help make this easy to do. Another benefit of using sheet piling in bridge abutments and wing walls is speed. Steel sheet piles are also very good at preventing scour from becoming a problem.

Bridge abutments have two primary functions in bridge construction. One is to support the vertical loads of the bridge and the other is to act as a retaining wall for the soil that supports the roadway. Wing walls support the soil adjacent to the abutments.

Most bridge spans are dictated by the terrain or the road or stream they are crossing. When crossing streams and other water ways, it is usually easier to build the abutment away from the water so the contractor does not have to build temporary cofferdams. Building the abutments away from water increases the bridge span which drives up the price. As spans increase, the moments increase as a function of the length squared and the deflections increase as a function of the length to the fourth power. If a bridge span is increased by 10%, the moments increase by 21% and the required stiffness increases by 46%. Using sheet piles to carry the vertical loads from the bridge and the lateral loads from the soil keeps the span short and keeps the construction quick and easy.

Steel sheet piles can carry significant vertical loads just like any other steel pile. Individual sheet piles have been load tested to well over 100 tons (~50 tons/ft of wall). This is more than enough capacity for most bridges. Since most bridges are quite short, the steel sheet piles have plenty of strength left over to handle the bending loads from the soil, and the bridge moments in the case of integral abutments.

**Advantages**

- Sheet piles carry vertical loads from bridge and lateral soil loads.
- Speed of construction.
- Deep scour protection.
- Sheet piles allow for waterfront construction without the need for temporary cofferdams.

**Limitations**

- Shallow rock or very deep bearing strata.
- Short walls and tightly loaded bridges.
- Dry crossing.
eSpan140 Substructure Solutions

GRS–IBS

Description
The Geosynthetic Reinforced Soil Integrated Bridge System (GRS–IBS) is an innovative accelerated bridge construction technology that uses alternating layers of compacted granular fill and geosynthetic reinforcement, or GRS, for the reinforced soil foundation, the abutment, and the approach. GRS–IBS is a solution that allows the designer to place the bridge directly on the substructure to create a seamless and smooth transition between the bridge and roadway without using joints, deep foundations, approach slabs or cast-in-place concrete. The closely spaced reinforcement and granular soil create an efficient composite material that is internally stable and capable of carrying bridge loads with predictable performance. The smooth transition from the roadway to the bridge helps alleviate the bump—at—the bridge problem caused by uneven settlement between the bridge and approaching roadway.

Site Selection
If the following criteria are met, then GRS–IBS abutments may be suitable for the project:

- Span length less than 140 feet.
- Abutment heights less than 30 feet.
- Grade separations.
- Water crossings with low scour potential.

Note that exceptions to the above criteria are possible, depending on the site and loading conditions.

Advantages
- Reduced Construction Time—GRS bridges are less dependent on weather conditions, and can be built with non-specialized labor and equipment.
- Reduced Construction Cost—GRS bridges are built with common materials and use fewer components with potential savings 25–60% less than conventional methods.
- Flexible Design—GRS abutments are easy to modify in the field for unseen site conditions.
- Improved Performance—GRS abutments alleviate the bump at the end of the bridge creating a smooth transition, which can lead to improved long-term bridge performance.
Questions or Comments?