Recommendations for ODOT Temporary Bridges
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Introduction

Temporary bridges can be used to provide accelerated response to restore collapsed bridge spans following catastrophic events such as earthquakes or floods. Temporary bridges can be constructed using steel, concrete, or timber components.

ODOT currently owns two temporary bridges. One is an "Acrow" bridge and the other is a "Bailey" bridge. Both bridges use steel truss modular units in various configurations depending on the required span and width for the application. For longer span configurations, these bridges may require "double-double" or "triple-triple" configurations where multiple rows and of modular units are stacked both side by side and multiple units high on each side of the bridge to support the required truck loads.

Figure 1 – Bailey bridge

Our Acrow bridge was manufactured by Acrow Bridge [1]. We have sufficient parts for 168 ft of bridge in a two-span and two-lane arrangement [2]. However, the two-span set-up would require an interior bent. ODOT does not own any interior bent parts.

Our Bailey bridge was acquired from a Florida company who had been storing the parts in Minnesota. We have parts to construct up to 240 ft of one-lane structure [2]. 110 ft is the maximum we can construct in a single-span configuration. Some Bailey bridges, such as the one ODOT purchased, are surplus military bridges. Additional parts for these bridges are still available on the market. New parts for Bailey bridges are also available.

ODOT also owns approximately 150 Box Beam units (115 ft long and 4 ft wide) that are stored in West Eugene near the Beltline Highway. These beams were used as part of the temporary bridge prior to the Willamette River Bridge replacement project in Eugene. These beams are not ideal for emergency application since they require special hauling vehicles to transport them. However, should such vehicles be available (most likely from Knife River's precast plant in Harrisburg), then these elements can be used for emergency bridges.

Assembly of ODOT's Steel Modular Bridges

The Bailey bridge was designed to be constructed by a military team. ODOT maintenance staff has installed this bridge at 3 separate bridge sites. It takes approximately 8 hours to construct a 60 ft segment of the Bailey bridge. Use of a forklift or other small lifting equipment significantly reduces erection time.

Configurations for various span arrangements are readily available for the Bailey bridge. These configurations are based on World War II tank loads, but can be adjusted for highway loading.

Bailey bridges are designed to be used as one-lane structures.

The Acrow bridge has heavier pieces and therefore is more likely to require a crane to construct. Most modular bridges, including both ODOT-owned types, have potential to be "launched" into place using a system of rollers and counterweights. Like the Bailey bridge, use of a crane will reduce erection time.

Acrow temporary bridges are constructed from a standard 10 ft long by 7.2 ft high modular steel unit. Multiple panel lines can be combined to create spans as long as 230 ft in a three-lane configuration. For less than 3 lanes, span lengths up to 250 ft are possible [3]. Once a design is ready and a site is prepared, Acrow modular bridges can often be erected in less than 24 hours.

Span charts for Acrow bridges are not as readily available as they are for the Bailey bridges. However, Acrow Bridge is willing to prepare pre-established span configurations as needed.

Acrow bridges can be constructed in either one-lane or multiple-lane configurations.

Other Types of Temporary Bridges

US Bridge [4] has a "Liberty" series low truss which is a steel modular unit similar to the Bailey concept. US Bridge typically manufactures their product to meet a particular need. Use of their product may require additional effort to investigate optional span configurations.

Mabey Bridge Ltd., from the UK, also fabricates modular units similar to the "Bailey" concept. They once had a presence in North America, but no longer appear to be marketing in the US.

Steel Flatbed Bridges – Railroad flatbed cars can be used as temporary bridges. These typically are as long as 89 ft although they may need to be cut back to a 65 ft span length to accommodate highway loads. Truck flatbeds are another alternative and can accommodate a 60 ft span.

Figure 2 – Railroad flatcar bridge

Acrow Bridge also fabricates a modular steel beam bridge. Modular units are approximately 6 ft wide. Modular units are placed side-by-side in 6 ft widths to the desired roadway width. Depending on span length, multiple modular units can be transported using a flatbed truck.

Precast prestressed concrete slabs are another option. If slabs are kept to 55 ft or less, slabs can be transported on a flatbed truck. Each slab is 4 ft in width. Multiple slabs are placed as needed to match the desired roadway width. Precast slabs can be used without the need for additional roadway topping. This results in fast assembly and fast disassembly and potential redeployment.

Temporary bridges can also be supplied using timber. However, since ODOT's need is long-term, timber is not recommended. The ODOT Bailey bridge has timber decking which has already deteriorated to the point where we have had to replace many panels. We are currently purchasing metal decking panels to replace the deteriorated timber.

Other State Inventories

The following is a list of Acrow bridges owned by other states [5].

Alabama	unknown	(parts only)
Alaska	720 ft	(6 total bridges with 2 each of 200' x 24', 80' x 24' and 80' x 18')
California	~1000 ft	
Colorado	160 ft	(160' x 12')
Connecticut	200-300 ft	
Delaware	150 ft	(150' x 12')
Florida	8,000 ft	(8,000' x 24')
Hawaii	unknown	(parts for 2-3 bridges)
Louisiana	3,200 ft	(3200' x 24')
Massachusetts	~5000-8000 ft	
New Hamphshire	450-700 ft	
New Jersey	130 ft	
New Mexico	100 ft	(100' x 28')
New York	2,000 ft	
Pennsylvania	270 ft	
South Carolina	270 ft	(120' x 30' and 150' x 30')

South Dakota	280 ft	(2 each 140’ x 30’)
Utah	200 ft	(200 ft x 2 lane)
Vermont	800 ft	(6 bridges purchased after Hurricane Irene)
Virginia	60 ft	(60’ x 24’)
Wyoming	400 ft	(2 each 200’ x 24’, goal is for 3 each 140’ x 24’)

Washington state also used an Acrow bridge as a temporary bridge on I-5 following the Skagit River incident. This temporary bridge included two bridges at 160 ft span and 24 ft width for each bridge. It is not clear whether WSDOT purchased the bridge or simply rented it.

Figure 3 – WSDOT’s Skagit River Temporary Bridge (Acrow Bridge) – Triple-Double configuration

Acrow Bridge stores approximately 1000 to 1500 ft of bridge material in their Washugal, WA storage facility. They plan to eventually move this facility to Centralia, WA.

Site Preparation for Storage Areas

ODOT’s two temporary bridges are stored at a maintenance facility on the north side of I-205 near Milepoint 10 in West Linn. It is accessed from the southbound I-205 lanes. ODOT spent approximately $140,000 to prepare this site to serve as the storage location for these bridges. This site is also a security concern. Most smaller bridge parts are stored in locked containers. Larger pieces, including truss modular units are stored in the open. Some smaller pieces and fasteners have been stolen.

Figure 5 – ODOT's Region 1 Storage Area

The storage area for ODOT's current inventory of Bailey and Acrow bridge parts is 200 ft x 500 ft (100,000 sq. ft.). This area allows storage space and enough room to allow a semi-truck and trailer unit to turn around. For sites where a truck can pass through the site without turning around, the storage space needed could be reduced up to 50%.

For any new storage sites, the following items are likely necessary:

- Purchase land, if not already owned by ODOT
- Level area – minor undulations will be acceptable.
- Place gravel
- Purchase lockable storage container (can be obtained for around $1500)
- Install fencing

Construction of a pole barn would also be helpful to limit long-term environmental damage to temporary bridge parts. The cost of a semi-open pole barn approximately 50 ft x 100 ft would be around $30,000.

Recommendations for New Bridges and Storage Sites

ODOT Bridge Engineering Section has investigated highly vulnerable areas of Oregon and identified 6 possible storage locations for temporary bridging material. The six sites are listed below by priority:

OR58	Glenwood Maintenance Station
I-5 South	Grants Pass Maintenance Station
I-5 South	Ashland Maintenance Station
US26	Manning Maintenance Station
US20	Corvallis Maintenance Station
I-205	East Portland Maintenance Station

Although these locations have been identified, ODOT staff at these locations has not been contacted. It is expected that most locations will not have sufficient area to store the needed temporary bridge material. Therefore, additional land may need to be purchased near these locations.

OR58 – Glenwood

Bridge number 05286 at MP 2.46 is likely to collapse in a seismic event. This bridge has a total length of 436 ft with a main span length of 184 ft. It is proposed to have a 180 ft x 24 ft modular bridge available to restore the main span of this structure. Should approach spans also fail, local contractors will be contracted to restore those spans. Since OR58 is a lifeline to the main source of recovery supplies from central Oregon, this route is our highest priority.

I-5 South – Grants Pass

Bridge numbers 09440 and 09440A at MP 71.93 near Grants Pass are vulnerable to collapse. These bridges have total lengths of 168 ft ant 175 ft respectively. The maximum span is 68 ft. It is proposed to have a 70 ft x 24 ft modular bridge available to restore the main span of one of these structures. There are also other bridges in this area that are expected to suffer extensive damage. Therefore, it is also recommended to store a suite of prestressed concrete slabs to respond to extensive damage to other structures.

I-5 South – Ashland

There are at least 7 highway bridges near Ashland that are expected to have extensive damage. Most of these bridges have modest spans. Therefore, a suite of prestressed concrete slabs is recommended to respond to likely damage in this area.

US26 – Manning

Three highway bridges are likely to collapse and 10 others are expected to have extensive damage near this location. The longest span likely to collapse is 74 ft. Therefore, it is proposed to purchase a 70 ft x 24 ft modular bridge available to restore the main span of one of these structures. Additional prestressed concrete slabs are also recommended to provide material for shorter spans.

US20 – Corvallis

Seven highway bridges near this location are likely to collapse and three others may suffer extensive damage. The most vulnerable bridges have short spans. Therefore, prestressed concrete slabs are recommended for mitigating this risk.

I-205 – East Portland

Four bridges around MP 24 on I-205 are high risk of collapse. The existing Acrow stored at I-205 can restore one of these failed spans. The maximum span needed is 160 ft. If more than one span fails there will not be adequate bridge material available from the existing storage site. However, the Portland area has many potential contractors with material that can be used to restore spans relatively quickly. Therefore, no additional bridge material is recommended for this area. However, due to the massive damage anticipated from a Cascadia Subduction Zone event, consideration should be given to storing some prestressed concrete slabs or other short-span bridge materials.

Summary of Temporary Bridge Recommendations

OR58 – Glenwood	180’ x 24’ modular bridge ($600,000) Site preparation - $100,000 no prestressed concrete slabs Box beams stored in West Eugene may be available to this area
I-5 South – Grants Pass	70’ x 24’ modular bridge ($190,000) 8 – 21” x 55’ concrete slabs ($75,000) 8 – 15” x 40’ concrete slabs ($48,000) 8 – 12” x 30’ concrete slabs ($34,000) Site preparation - $150,000
I-5 South – Ashland	8 – 21” x 55’ concrete slabs ($75,000) 8 – 15” x 40’ concrete slabs ($48,000) 8 – 12” x 30’ concrete slabs ($34,000) Site preparation - $50,000
US26 – Manning	70’ x 24’ modular bridge ($190,000) 8 – 21” x 55’ concrete slabs ($75,000) 8 – 15” x 40’ concrete slabs ($48,000) 8 – 12” x 30’ concrete slabs ($34,000) Site preparation - $150,000
US20 - Corvallis	8 – 15” x 40’ concrete slabs ($48,000) 8 – 12” x 30’ concrete slabs ($34,000) Site preparation - $40,000
I-205 – East Portland	None recommended at this time

The total estimated cost for all temporary bridges above is approximately $2,000,000.

Temporary Bridge Options

Used railroad flatbed cars are readily available on the market. The cost of flatbed rail cars is relatively inexpensive at around $25 per square foot. The total bridge cost, however, is likely to be more than twice that amount once girder transportation, site preparation, connection details, abutment, and railing costs are included. Temporary rail cars will also require additional care and maintenance when kept in long-term storage.

For this reason, prestressed concrete slab spans are preferred for short-span applications. Precast concrete slabs can be transported on a flatbed truck as long as the slab weight is kept less than 50 kips. The maximum size and span for emergency applications will be limited to 21 inch slabs with a span of 55 ft (42 kip slab weight). Limiting the span to 55 ft also lends to span-by-span construction where piles for subsequent bents can be driven from equipment resting on a previously constructed span.

Concrete slabs for temporary applications will use a different design criteria than those used for permanent applications. Slabs will be connected with double tie rods and traffic will typically drive on the slabs with no wearing surface. Slabs will likely use slightly smaller voids to increase durability of the riding surface. Length of voids at girder ends will also be reduced so that some overhang at each can be accommodated as needed for variable span lengths. Slabs will also require permanent lifting hardware at each end. Steel tie rods and rubber bearing pads will also need to be stockpiled. Slabs may require additional prestressing strand in the top to minimize camber growth.

For longer spans, the ability of modular steel units to accommodate multiple span configurations make them the preferred choice.

The recommended purchase of temporary bridge material will still leave massive holes in Oregon's transportation system. Local contractors will be called on to partially meet this need. Oregon has several large bridge contractors with headquarters in the Willamette Valley. These contractors will be contacted to verify their typical temporary bridge inventory.

Proposed Training Plan

Use of temporary bridges in emergency situations requires maintenance crews with experience in erecting these bridges. With this in mind, ODOT Bridge Section is planning to perform a trial assembly of the Bailey bridge during the Pacific Northwest Maintenance Conference scheduled for October 2016 in Portland at the Jantzen Beach Red Lion. We are also intending to coordinate a trial assembly of the Acrow bridge in September of 2017 during the Western Bridge Engineers Seminar in Portland.

Training will also be required for ODOT bridge design staff. The details of this training will be developed after a decision to purchase additional steel modular bridges.

Use of Temporary Bridges with New Construction

Although the primary use of temporary bridge material is recovery from seismic and flood events, use of modular units with typical construction projects provides additional training opportunities. This use will increase our readiness during an actual event. Of course, this will create risk that a temporary bridge will be in use and not available following an event. There is also risk that the temporary bridge may be damaged by a seismic event. However, if we limit the amount of inventory allowed to be used on construction projects (say, no more than 25%), then the benefits may outweigh the risk.

Conclusion

Oregon is facing major risk to our economy and livelihood from a Cascadia Subduction Zone earthquake. The stockpile and use of temporary bridging material has been proven to be successful in other parts of our country. Even though there may be will and desire from other states to assist Oregon, it is not certain whether our transportation system will be satisfactory to allow recovery materials to get where they will be needed. Establishing a series of temporary bridge storage sites will greatly increase our potential for a quick recovery from this type of devastating event.

REFERENCES:

1. Acrow Corporation of America

   Corporate Contact Information:
   ACROW Bridge
   181 New Road
   Parsippany, NJ 007054-5625
   Phone: 973-244-0080
   Email: sales@acrow.com

   West Coast Contact:
   Jack Arizcuren
   Regional Sales Manager – Pacific States
   Office: 206-489-5624
   Cell: 360-607-1328
   Email: jariz@acrowusa.com

2. Span capacity for ODOT's existing inventory of Acrow and Bailey bridges was provided by Mike Gehring, Region 1 Bridge Crew Supervisor, 9-16-15.

3. Pg 63, NCHRP Synthesis 327

4. US Bridge

   201 Wheeling Avenue
   P.O. Box 757
   Cambridge, OH 43725
   888-872-7434
   info@usbridge.com

5. Stock of DOT-owned Acrow material provided in a 9/24/15 e-mail by Jack Arizcuren, Acrow Bridge.