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Chapter 21 - Prefabricated/Temporary Bridges

21.1 Commonly Found Prefabricated Bridges

There are several types of prefabricated bridge types that have been used to serve as temporary bridges during construction, as emergency bridges, and (in some cases) permanent structures. In all cases, the prefabricated bridge or bridge components are intended to be quickly and easily assembled on site, minimizing the time required on site to construct or restore the bridge.

21.1.1 Types

21.1.1.1 Panelized Truss Systems

Panelized truss systems, also known as Bailey Bridges, were originally developed for the British Military in the 1930’s to provide the ability to quickly construct a crossing in remote environments with limited equipment. The panelized truss systems are composed of prefabricated truss panels that bolt/pin together, floor beams that span between the trusses, and a steel deck system. The bridge type was developed to be flexible enough to be used in a variety of conditions and be constructed in the field quickly by inexperienced crews with little or no heavy equipment. The concept was refined during WWII and used during the war. Since that time, several suppliers have developed proprietary systems based on this concept.

All of these bridges have standard parts, which can be assembled in a variety of configurations based on the length of span and the loads being carried. The configuration variables include the length of the span, and the number and depth of trusses. Figure 21.1 below shows configurations possible from one of the bridge manufacturers. Bridges of this type are typically shipped to the site in pieces and assembled on site.

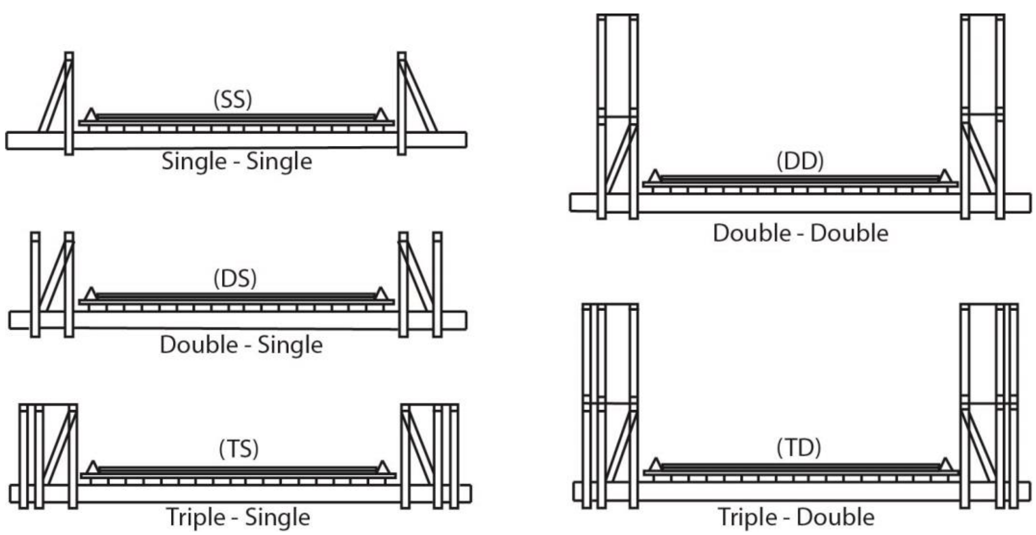

Figure 21.1 Example Configurations for Temporary Bridges

The floor beams are set on the truss, and the deck is set on the stringers, or floor beams if the floor is a structural deck. The decks are typically steel grate, skid-resistant steel plate, or steel plate with a skid-resistant overlay.

The abutments for this type of bridge can be any variety of materials that will adequately support the truss. Some of the materials used have been steel piles, cast-in-place concrete, precast concrete blocks, timbers, cribbing and gabions.

A double-single (two trusses on each side, one panel deep) with a steel grate deck is shown in Figure 21.2. The abutment for the bridge is steel plate resting on timbers.

Figure 21.2 Panelized Truss Temporary Bridge with Two Trusses on Each Side of Roadway

Typically the trusses with the floor beams are assembled on one side of the feature to be crossed, and then rolled/launched to the other side. The launch often uses a "launching nose", which is an angled set of panels at the leading end of the truss. An example of the installation of a panelized truss with a launching nose is shown in Figure 21.3. The launching nose is removed once the truss assembly has been set in place.

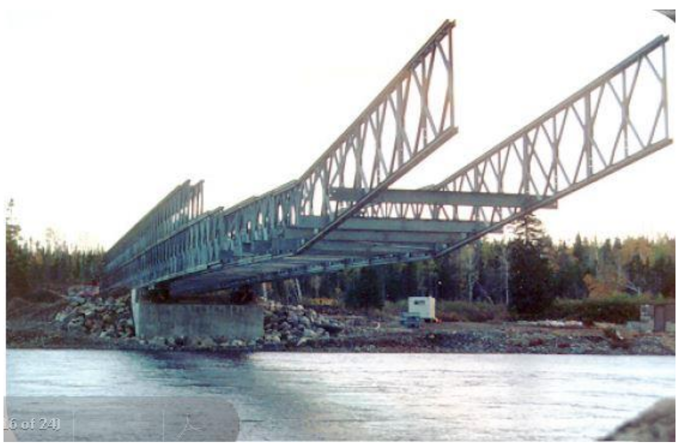

Figure 21.3 Installation of Panelized Truss with Launching Nose

In some cases, where the equipment is available, these bridges may be set with a crane.

Once the truss assembly is in place, the decking is then installed, the back wall placed (which may be steel, concrete, or timber), and the approach graded. A photo sequence for the installation of a panelized truss bridge is presented in Figure 21.4. The figure shows (a) Stored panels, (b) Assembling truss and floor beams, (c) Assembling and attaching second truss, (d) Setting bridge with crane and dozer, (e) Installing steel deck panels, and (f) Placing wearing course on deck.

Because these types of bridges are most frequently used on a temporary basis, the manufacturers often rent them to transportation agencies and contractors.

Figure 21.4 Erection of Panelized Truss Bridge

21.1.1.2 Steel Girder Pre-Fabricated Deck

Another common type of temporary bridge is steel girder bridge with prefabricated deck panels. The deck panels may be steel, wood, or concrete. Contractors will periodically construct this type of bridge using salvaged girders. A temporary bridge erected after the existing bridge was damaged by flooding from Hurricane Irene in 2011 is shown in Figure 21.5. This bridge was built with salvaged girders, stress laminated wood deck panels, and precast concrete barrier, and using the existing approaches as the abutment.

Figure 21.5 Steel Girder Temporary Bridge

A variation of this type of construction uses steel girders, steel deck, and steel rail. In one example of this case, a local government used salvaged material to construct a one lane bridge that could be shipped in two pieces. The abutments for this bridge are precast concrete blocks. This bridge was erected to temporarily replace a bridge that was washed out by a dam failure in 2005. This example is shown in Figure 21.6.

Figure 21.6 Steel Girder Temporary Bridge with Steel Deck and Steel Bridge Rail

21.1.1.3 Railroad Flatcar System

Flat Cars have been used in rural areas for permanent bridging on low volume roads for many years. The concept of using railroad flatcars as temporary bridging was developed by W.H. Wattenbug of the Lawrence Livermore National Laboratory in the 1990's. The modular system consists of a flatcar acting as a foundation and supports the half flatcars that serve as columns, which in turn support a flatcar that acts as a bent cap. The deck system consists of four flatcars, which are interlocked side-by-side. Figure 21.7 and Figure 21.8 display the concept.

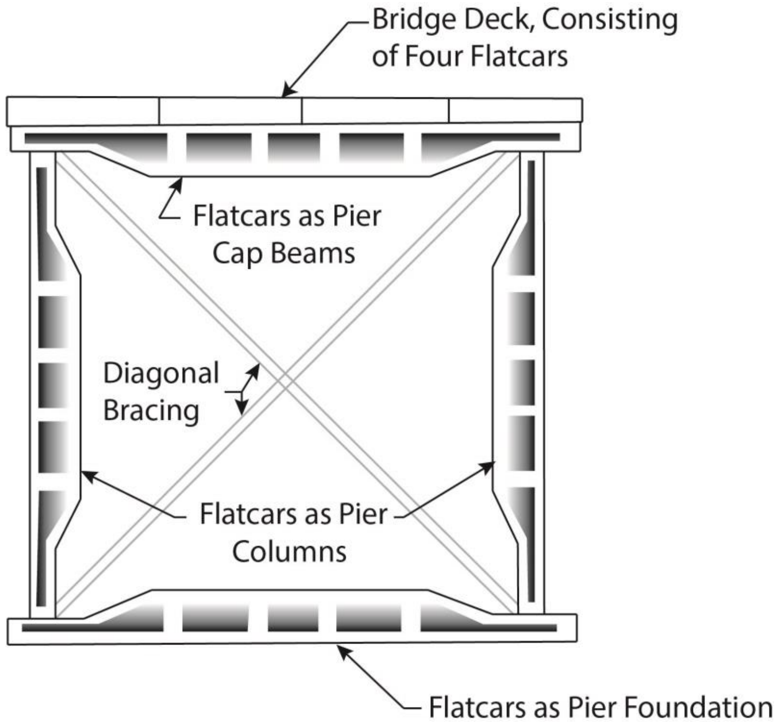

Figure 21.7 Railroad Flatcar Modular System Schematic

Figure 21.8 Single Span Rail Car Bridge

The flatcar system has been in use in California and was used for the emergency replacement of I-5 over Arroyo Pasajero Bridge in 1995. The design requires substantial amounts of cross bracing and the substructure is not practical for use in underwater conditions. However, it has been recognized that the flatcar deck can be an economical solution to bridge decking requirements for use in temporary structures.

21.1.1.4 Composite Concrete and Steel

The composite concrete and steel structure is a twin girder unit tied together with diaphragms that are precast into a concrete deck. This design takes full advantage of the composite action of the steel and concrete allowing for a light steel section. This type of construction was used extensively on the central artery project in Boston for bridges that were to be in use for approximately 10 years before removal.

The units shown in Figure 21.9 were initially installed as temporary spans but were later removed and reinstalled as permanent bridges in another location. The figure shows (a) Composite superstructure component prior to removal from temporary installation location, (b) Composite section after removal, (c) Stockpile of used composite sections awaiting shipping to new location, and (d) Permanent bridge built with used composite sections.

(a)

(b)

(c)

(d)

Figure 21.9 Temporary Span Removal

21.1.1.5 Prefabricated Decks (Concrete, Steel, Composite, Wood, FRP)

Prefabricated decks are used for new bridges, rehabilitation of existing structures, and temporary bridges. All prefabricated decks, regardless of the material used, are installed as units, thereby reducing installation time. The choice of material for the deck is dependent on:

- The allowable dead load on the superstructure
- The design life of the deck
- The design live loads for the bridge
- The economics of a particular material at that particular location.

21.1.2 Best Practices

Many state and local bridge owners maintain an inventory of various kinds of temporary bridges for use as on-site detours during construction projects or for rapid deployment in cases of bridge failures. Depending on the agency, the number of bridges, and space availability, the bridges may be stored at various locations around the jurisdiction or at a central depot when not in use.

Storage

For storing the bridge parts, the important thing is to keep all like parts together. Different sized panels or panels from different manufacturers should be stored in separate stacks. Different sizes or types of transoms or sway braces should not be intermingled. Maintaining a manual on the storage, maintenance, and installation of an agency's temporary bridges and bridge decking is recommended. Temporary bridge parts should be stored in a manner to prevent collecting debris and trapping moisture. An inventory of all bridge parts and their location in storage should be maintained.

Shipping

When shipping parts for temporary or prefabricated bridges to the site for erection, it is important to carefully inventory the parts to be shipped to insure that all the parts necessary for erection are shipped to the site and are in good usable condition. Within the constraints of safe loading and transport, the components should be delivered to the site in the approximate order in which they will be used to erect the bridge. This is particularly important if the site is constrained. If the deliveries are carefully sequenced, components can be unloaded and immediately incorporated into the bridge. If there is ample room on the site, and the components are being delivered in advance of assembly, the parts should be stockpiled in a manner that will allow them to be easily accessed for assembly with a minimum amount of handling.

The following are examples of temporary bridges that state agencies own.

- NY owns several temporary bridges that are stored at various locations around the state for emergency use.
- DC owns a single temporary bridge manufactured by Mabey, which is used primarily for emergencies.
- CA has several temporary bridges stored at various locations around the state for use in emergency situations. The State uses Acrow bridges, which allows part compatibility among the bridges in the inventory.

- MD owns a single 100 foot long bridge manufactured by Mabey, which is deployed for emergency use.
- FL owns approximately 9000 feet of 36 feet wide Acrow bridging and 650 feet of 24 feet wide Acrow bridging. The temporary bridges are stored at a central depot near the middle of the state, and are used for emergencies and construction projects.
- SC owns 4 temporary bridges, 2 of which are 120 feet long manufactured by Mabey, and a 120 feet long Acrow Bridge as well as a 150 feet long Acrow bridge. South Carolina has developed a manual for use and storage of temporary bridges.

21.2 Parameters for Prefabricated Bridge Placement

21.2.1 Length

Prior to erecting a temporary bridge, the necessary span of the bridge must be determined. One factor driving the length of span is the hydraulic opening (in the cases of bridges spanning waterways) or required clear span for bridges spanning other features such as roads. Another factor determining length of span is the terrain and the approaches to the bridge. An example of this would be a relatively wide and deep ravine with a small creek at the bottom.

21.2.2 Waterway Opening

If a temporary bridge is replacing a bridge with no history of flooding, overtopping, or other hydraulic issues, a temporary bridge of equal or greater waterway opening is often the preferred choice. If the agency is trying to optimize the size of the temporary bridge, a more detailed analysis accounting for acceptable risk would be necessary. Determining the required waterway opening for a temporary bridge not only requires an analysis of the watershed and the hydraulics of the waterway opening, but also requires an estimate of how long the temporary bridge will be in place, the importance of the road, and the agency’s acceptable risk for overtopping. The hydraulic design requirements for a permanent bridge may require a minimum freeboard above the 50 year flood elevation (2 percent chance of reaching that in a given year) for a bridge that will be in service for 50 to 75 years. If the temporary bridge is only going to be in service for a limited time, for example 6 months to a year, an increased risk may be acceptable, (e.g., 1 in 25 or 1 in 10 of exceeding the hydraulic capacity in a given year).

When to Call the Engineer

Call the Engineer to determine the appropriate length and waterway opening of the temporary bridge.

21.2.3 Expected Loading

As with permanent bridges, temporary bridges must be designed to handle the traffic that is expected to use the bridge while it is in service. Depending on the traffic volumes, the percentage of trucks, and the availability of reasonable alternate routes, a temporary bridge may not need to be designed and built to carry full legal loads. If a temporary bridge is designed for less than full legal loads, a careful analysis should be done to justify it. If justified and built to handle only lighter traffic, the bridge must be posted for the allowable load and the owner should plan to take steps to enforce the load posting.

If the bridge is designed for full legal loads, it may be posted at a lower level if recommended by the engineer or manufacturer. It may need to be posted at the legal load limit to prevent use by trucks traveling with an overweight permit.

21.3 General Usage and Maintenance

21.3.1 Installation Considerations

Because each type of bridge has its own unique characteristics, the installation considerations given here are general. See the manufacturer, designer, or engineer of the particular temporary bridge for detailed installation instructions.

Before any deployment, experienced bridge personnel (who have previously been trained to deploy the same bridge type) should supervise the deployment.

During the initial deployment of any temporary bridge, the manufacturer (if a manufactured type) or the Engineer (if a custom designed bridge) should provide on-site training and appropriate erection plans.

Whether the bridge is deployed, moved, or disassembled, any component that is damaged or missing should be immediately reported to the Engineer or manufacturer. Damaged components, including the loss of the protective system, should be inspected by the Engineer or manufacturer and repaired or replaced before any further use of the bridge is permitted. The manufacturer or engineer should be consulted as needed. Any missing component must be replaced as per the manufacturer or engineer requirements.

Bridge Deployment and Site Security

All components of the bridge should be on site, inspected for damage, and inventoried before assembly and erection can begin.

Unless approved by the Engineer, there should be no deviation from the manufacturer recommended deployment procedures. In unusual cases where deviation is warranted, the manufacturer should be consulted.

Since these bridges represent a significant investment, each bridge site should be secured. The degree of security necessary will depend on site conditions, the risk of loss or damage, and the amount of acceptable risk the agency is willing to take.

Ideally, bridge components should not be delivered to the site until the foundations are completed and all materials and equipment necessary to erect the bridge are on site.

Typically, assembly and erection should be scheduled in such a manner that as much continuous work as possible is completed, and the time that the bridge components are on site in the un-erected position is limited.

21.3.2 Periodic Inspections of Pins and Connections

Due to the nature of temporary bridges and depending the Average Daily Traffic (ADT) regular inspections should be performed above that required by the manufacturer and the NBIS. The bridge owner should determine the frequency of inspections. Cursory visual inspections should be conducted frequently in addition to scheduled full inspections. Any issues should be immediately reported to the bridge owner for follow up using the standard DOT in-service bridge inspection reporting procedures.

21.4 Chapter 21 Reference List

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4. South Carolina Department of Transportation, Bridge Maintenance Office. *Temporary Bridge Operations Guidelines for Use and Storage.* 2014.