

# SLIDE-IN BRIDGE CONSTRUCTION WORKSHOP

## Notes Booklet

July 2015



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**Federal Highway Administration**



Photo courtesy of Horrocks Engineers

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## Introduction

### Content

Slide-in bridge construction (SIBC) is a particular method and refinement of construction contained under the broader topic of Accelerated Bridge Construction (ABC), with the specific goal of extremely rapid bridge installation under very short-term road closure.

Several SIBC-related topics will be covered in this document. Collectively, the topics aim to provide a comprehensive overview for owners, designers, and contractors, thereby better equipping each group to pursue SIBC when appropriate.

In this document, slide-in bridge construction is defined and its benefits discussed. Several ABC and SIBC decision-making tools are presented, along with the various delivery methods that can be employed. Planning and designing for SIBC, typical details, and planned contract submittals are also covered.

Relations with the media and public are also addressed. Given that SIBC is a relatively new and innovative method of bridge construction, it is not uncommon for the media and public to have a more involved role, even as spectators.

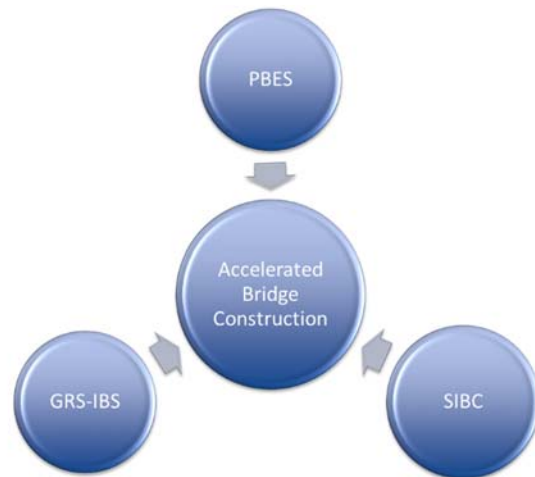
### Background

Nearly 25 percent of the nation's 600,000 bridges are in need of rehabilitation, repair, or total replacement. Given this vast number, the need for bridge reconstruction methods that reduce the impacts to mobility and safety is needed. This need was one reason the Every Day Counts (EDC) initiative was launched by the Federal Highway Administration.

The first EDC effort was established in 2010 as a state-based initiative to identify and deploy implementation-ready innovations—specifically, to shorten project delivery, enhance safety, and protect the environment. The term “get in, get out, and stay out” was popularized under this program.



As a result of these efforts, EDC-2 was launched in 2012 with the specific focus of shortening the time needed to complete highway projects through the use of new technologies and ground-breaking processes. Within that directive, ABC became an area of concentration.



Three particular ABC technologies being promoted under EDC-2 are prefabricated bridge elements and systems, geosynthetic reinforced soil-integrated bridge systems, and slide-in bridge construction.

## SIBC Defined

Slide-in bridge construction, also known as lateral sliding or skidding, is a particular method of ABC along with several variations of the technique. In SIBC, a new bridge is typically constructed adjacent to and parallel to the existing bridge on temporary supports.

When the new bridge is completed, the old structure is demolished and the new substructure is constructed; then the new superstructure is slid onto the new in-place substructure. (In some cases, the old substructure is reused.)

The new bridge is moved laterally, most commonly with hydraulic jacks although other methods, such as a winch, have been employed. Some minor vertical jacking is typically needed.



Slide-in bridge construction, and ABC in general, is primarily used for bridge replacement projects where the impacts to mobility are significant.

In many cases the new substructure is constructed beneath the existing bridge prior to demolition. As one might predict, this expedites the process from demolition to bridge slide.

It should be pointed out, however, that constructing traditional foundation systems might not be feasible. Rather, an innovative foundation system might be required when using this method.

It is possible that prefabricated elements can play a key role in constructing the new substructure.

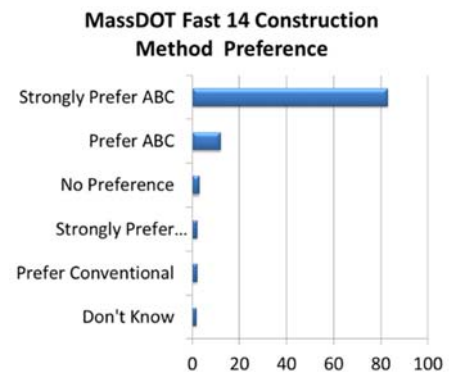
Bridge slides are most commonly used for sliding a new bridge into the position of an old bridge. However, existing structures can be slid to a new alignment to serve as a bypass bridge while a new bridge is constructed using more traditional methods. Keep in mind that in this case, the temporary substructure system will be subjected to live and other transient loads in addition to the bridge itself, typically resulting in a more robust, and hence higher cost, to such an installation.

## Benefits of SIBC

What benefits can be gained by using slide-in bridge construction? Maybe the better question is ‘What needs are driving the use of SIBC, and how does SIBC address those needs?’

Traffic demands are increasing, and congestion is increasing. Both situations create unnecessary nuisances for the traveling public and, thus, the public demand for rapid delivery is increasing.

The chart at right indicates the overwhelming preference for accelerated bridge construction by responders to a poll in Massachusetts prior to the MassDOT Fast 14 project.



Perhaps even more important, the safety of the traveling public and bridge builders is compromised when bridge projects are long in duration. Slide-in bridge construction alleviates some of the safety risks by significantly reducing the time mainline traffic is interrupted.

Societal costs such as motorist time lost due to traffic delays, though often difficult to fully quantify, are also significantly reduced by SIBC, compared to traditional bridge construction methods or even to other rapid structure placement methods such as self-propelled modular transporters, float-in delivery, or a heavy crane pick, for example.

Furthermore, nontraditional site options can be offered, and cross-overs or shoo-flies are eliminated along with staged construction and long-term detours. These things can result in lower construction costs.

Mobility and environmental impacts can also be reduced, and safety is nearly always enhanced for the worker and road user.

Potentially of greatest significance is that SIBC promotes user and worker safety. Safety is nearly always enhanced for the worker and road user; this cannot be understated.

When compared to other ABC methods, SIBC often receives better contractor “buy-in,” presumably because of the reduced risks previously mentioned.

Finally, SIBC removes the bridge construction from the critical path, which may lead to a better quality end product.

### I-84 at Dingle Ridge Road – New York

#### Cost Savings

- Over \$1.2 M in user delay cost savings by using ABC (Source: NYSDOT)
- \$2 M cost savings from elimination of cross-overs, temporary bridge (Source: NYSDOT)
- Savings in work-zone accidents costs



## Challenges of SIBC

Although the benefits of SIBC can be great, some potential challenges exist as well.

While some personnel within the DOTs embrace innovative methods, others are more resistant and tend to rely on traditional construction methods. This resistance can stall a potential SIBC project.

Finding experienced contractors and/or heavy lift engineers can be a challenge, although that challenge is being lessened as more and more SIBC projects are being completed and contractors are becoming more familiar with the process.

Given that many SIBC projects are high profile, public interest is often high, which draws spectators to the job site and creates potential crowd control issues that are not typical for traditional bridge construction.

The SIBC method will require a short-term, full-road closure. The agency and contractor must schedule the closure date well in advance and then meet the target closure dates, leading to schedule pressure on construction.

The common challenges in traditional construction projects—unique bridge geometry, difficult foundations, lack of space, etc.—are only magnified by the nature of SIBC.

A sound traffic management plan with contingency plan is a must.

This method of bridge construction is relatively new, and as a result, there may be some contractor limitations. For example, significant temporary shoring and unconventional schedules are often required.

During slide operations, a 24-hour commitment from the contractor, designer, and owner is necessary. These and other periods during the overall SIBC process that require extended time for the contractor, owner, and designer can result in worker fatigue if not properly managed. Multiple crews can help alleviate this potential problem.

Even more, difficult foundations, equipment breakdowns, and the speed required to complete approach work can present a challenge. Also, significant critical time can be lost to surveying mistakes.

## Decision Making

### Factors of Interest

When deciding whether or not a bridge project is a good candidate for SIBC, some factors to consider include the following: average daily traffic, the facility or feature being crossed (railroad, roadway, other), detour length (duration and viability), and environmental effects (limits on when and how).

Questions to consider include the following: Is the bridge on the critical path of the entire project? Is right of way available? Should traffic analysts be engaged? Where will the contractor's workspace, entrances, and exits be located?

If comparing only the costs of building a bridge using traditional methods with building a bridge using SIBC, it is possible, and maybe even likely with an agency's first projects, that SIBC costs will be higher.

It has been found, however, that costs become more aligned when including other project-related costs, such as direct versus indirect costs and detour costs, which are often not included in the bid. Therefore, it may not be appropriate to compare conventional construction costs with ABC costs. Project planners should evaluate the total construction cost when making decisions.

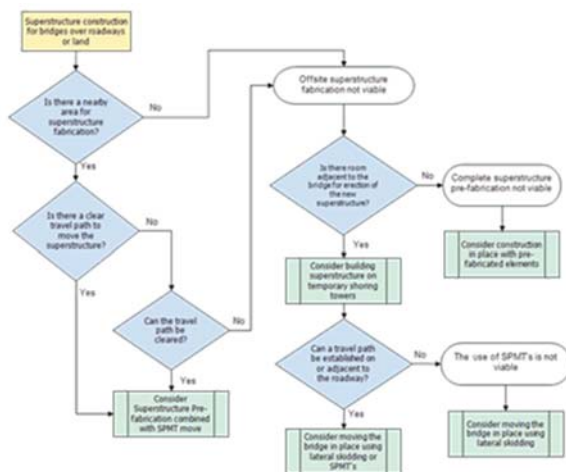
Even more important, due to the decreased construction time, overall inflation costs can be reduced, specifically the risk of price escalation of steel and fuel.

### Decision Making Tools

The decision to use nontraditional construction methods can be difficult. Several tools have been developed that help owners decide when and where to use ABC and SIBC methods.

These tools include the flowchart method, the matrix method, the weighted scoring method, the narrative method, and the analytical hierarchy process. Note that, regardless of the data, ultimately a firm commitment from all concerned to stay the course is needed for a successful and economical project.

The **flowchart method** is composed of a diagram representing a process—in this case, the SIBC process. Boxes of various kinds make up the steps in that process and help visualize the flow. Each box and its respective question prompt an answer from the user that leads to the next box, and the process is repeated until a final box and prescribed answer are achieved.



The **matrix method** is composed of a series of questions to which a user simply responds with yes, no, or maybe. Questions cover multiple aspects of a project including such things as ADT, worker safety, weather, delay-related costs, and more. Totals for each answer are summed and, if the majority of answers are yes, the user is guided towards an ABC method.

The **weighted scoring method** helps assign a value or score to what would otherwise only be a subjective decision. By assigning values to various predetermined categories and then multiplying the value by its overall

importance, a final score can be calculated. A score above or below a threshold previously set within the agency indicates whether ABC methods provide value.

For example, ADT or detour time might be weighted more heavily than economy of scale. A bridge with a high ADT would likely achieve a higher overall score than one with multiple spans.

The **narrative method**, similar to the matrix method, guides an owner to a plausible method of construction using a series of short descriptive narratives.

The **analytical hierarchy process** is designed to select the best option from a set of alternatives. The user can compare ABC versus conventional methods, in addition to specifically comparing ABC alternatives. Paired comparisons are used to rank alternative methods. In this method, the inputs and outputs can be both qualitative and quantitative.

It has been found that these tools are best used when several people independently complete the process and then collaborate for a final decision. Even more, when those people are the same for multiple projects, a more consistent approach and process can be achieved.

So, when should SIBC be considered?

Ideally, the project site will have a wide flat area adjacent to the existing structure. This is rarely the case, however, so other factors—right of way, terrain, geotechnical conditions, alignment restrictions, etc.—need to be considered. If right of way is limited, temporary right of way may be available. Rugged terrain doesn't necessarily prohibit the use of SIBC, but it does introduce another challenge. Since temporary works will be significant and must support the entire superstructure, the adequacy of geotechnical conditions is key.

## Delivery Methods

It should be noted that not all delivery method options are available in all locations, as some methods are prevented by existing state government laws or policies, but numerous delivery and contracting methods exist nationwide.

These include design-bid-build, design-build, construction manager/general contractor, A+B contracting, and value engineering.

### Design-Bid-Build

Design-bid-build has been the traditional method of contracting. Separate contracts are extended from the owner to the designer and builder, and the selection is based on the lowest-bid total construction cost.

For this method, a complete design must be developed prior to the bid process taking place.

It should be noted that the designer is not responsible for the design of the temporary shoring system or the equipment used to move the bridge. The designer needs to show schematic drawings of the systems and allow the contractor to develop the details of the move.

For SIBC, some advantages of design-bid-build are its wide applicability and familiarity, its clearly defined roles for all parties involved, and competitive bidding process. However, it does have its disadvantages for SIBC in other ways.

There is a lack of input from the contractor; delay claims, disputes, and change orders are all common. Additionally, SIBC is new to most designers and blurs the line of means and methods of construction, typically the contractor's stock in trade.

### Design-Build

Unlike the design-bid-build process, the design-build process brings the design and construction under one contract from the owner. In doing so, the owner gives up some control over the design and construction process and therefore must make expectations very clear.

It is not uncommon for the owner to do some preliminary design work prior to the design-build teams' bidding on the project; through this exercise, the owner must define performance expectations.

An inherent advantage to the design-build method is that a project can often be delivered more quickly than would otherwise be possible. The design can be tailored to the contractor's experience, tools, and equipment.

### Mesquite Interchange - Nevada

#### Design-Build

- DB team proposed SIBC
- Saved 6 months and \$10 million



Also, it may promote innovative design thinking.

As with design-bid-build, some disadvantages exist. Outcomes must be clearly communicated by the owner to eliminate the risk of project scope transforming to something unintended.

The owner is relinquishing control, as the designer is working for the contractor not the owner. It is likely that the final design will be influenced heavily by the required means and methods of installation. Prior to bidding, the design teams must complete some design at their expense.

Lastly, cost savings, if any, can vary from project to project.

## CM/GC

Construction manager/general contractor (CM/GC) is not as common as the previous methods of delivery but is gaining popularity with the bridge building industry.

Construction manager/general contractor is similar to design-build in that the contractor and designer work together. It differs, however, in that both the contractor and the designer have their own contract with the owner and the owner remains an integral part of the overall team. The designer and contractor are both independently selected by the owner.

As a construction manager, the contractor has the ability to provide significant input during the design process. In this way, the designer can better accommodate the means and methods a contractor may use to erect the bridge, and changes to the contract documents that could otherwise be necessary are minimized. As a result, risks are better identified and managed. The transition from construction manager to general contractor is generally smoother on account of the aforementioned role of construction manager.

Some advantages to CM/GC include fast project delivery, no significant up-front design needed, the design can be tailored to the contractor's abilities, construction costs may be lower, and change orders are minimized.

Some disadvantages include the challenge to the owner in selecting a contractor without a design and the checks-and-balance system is needed to verify bid costs.

## A+B Bidding

A + B bidding is most commonly a variation of design-bid-build.

Rather than selecting a contractor based on low bid construction costs, two components—contract work items and road user costs—are quantified and added together to compose a bid price. The contractor with the low bid of the summed total is awarded the contract.

In the actual contract, the contractor will be reimbursed only for unit items (A), and the time allowed to complete the project is set at the bidder's time component (B).

Emphasis is placed on the project's effect on the public, not just on the lowest construction cost.

An advantage of A + B bidding is that the contractor's schedule must minimize construction time and delays. Two disadvantages are that contract changes are magnified and more resources may be required for contract administration.



## Planning for SIBC

Planning for SIBC generally follows that of traditional construction, with some additional issues.

For example, the owner must ensure that there is sufficient right of way at the site for SIBC equipment and cranes for erection of beams; this might require more space than anticipated.

A comprehensive study of an acceptable duration of closure must be completed to appropriately assign incentives or disincentives. The owner must define expectations related to traffic impact, both on the bridge and below the bridge.

The owner and/or contractor should involve the public very early on to communicate the intent and expectations regarding the use of SIBC. Given that SIBC is an innovative method for bridge construction, it is likely to draw the attention of the public and media. For this reason, naming or branding the project or program should be considered, since it will undoubtedly be named by someone.

Higher overall costs, especially for initial SIBC projects, may be realized and should be addressed when programming.

Additionally, the owner must define any needed submittals and provide project specifications that define the desired design criteria. Creating and reviewing specifications and submittals will require more attention, especially on the first project. Accordingly, the owner should devise a reasonable timeline to accommodate the added attention so that weather and closure times can be best mitigated.

It should be expected that once construction begins, additional owner resources will be required in the form of construction inspectors. Ensuring that inspectors have a clear understanding of what is acceptable will take additional time. Inspectors may have to work longer hours. Given the time-sensitive nature of SIBC during slide operations, a contractor must be willing and able to commit more resources than normal.

An assembly plan is critical so that the contractor can clearly communicate its means and methods. The contractor's overall ability to communicate efficiently both before and during construction will be key to success.

Finally, the contractor must have a contingency plan that addresses questions such as the following: What should happen during an emergency response or equipment failure? What if an extended detour time is required? What if there is an accident on the detour? What happens if severe weather approaches? Project specifications should include the minimum contingency scenarios. The specifications should also encourage the contractor to determine and plan for other contingencies.

## Designing for SIBC

The design and detailing of a bridge slated for SIBC is more similar than different from that of a traditionally constructed bridge. In general, the loads during sliding operations are minimal and likely will not exceed loads typically seen during normal service life.

It is at the jacking locations that additional loads should be addressed. The use of concrete integral diaphragms is quite useful in dealing with this issue; an example is shown along with a slide plate in the detail below. Forces can best be related to those seen in maintenance operations, such as replacing a bearing.

Special attention should be paid to the detailing of slide shoes, bearings, and jacking locations if bearing change-out is required.

In particular, the owner should be willing to entertain a contractor's suggestions for design modifications that would enable a specific construction process to be completed with other equipment or in a different manner.

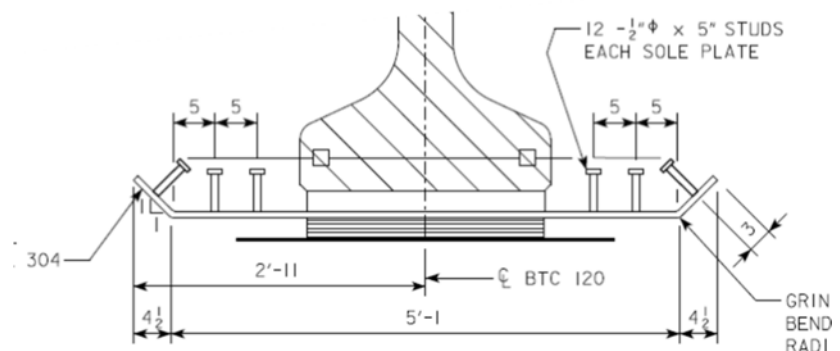
A semi-integral abutment with properly designed substructure can be used to facilitate slide details and modifications. In general, the slide surface should be level. This means that the depth of the semi-integral diaphragm will vary with roadway cross slope.

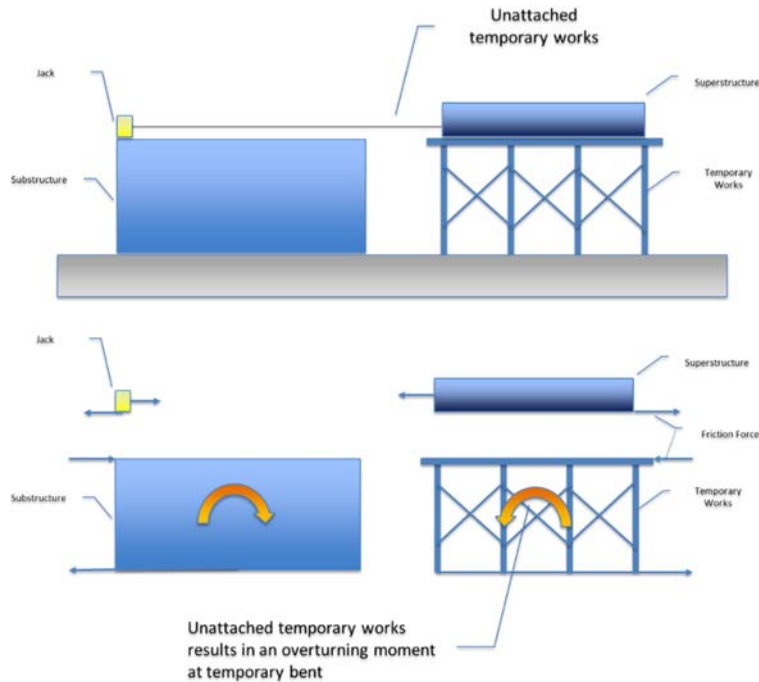
Adjustability should be provided on the bearing to ensure uniform loading on all bearings.

A system for monitoring displacement during the slides should be in place.

Finally, it is greatly beneficial to the overall substructure design, both permanent and temporary, to attach the temporary works to the permanent substructure.

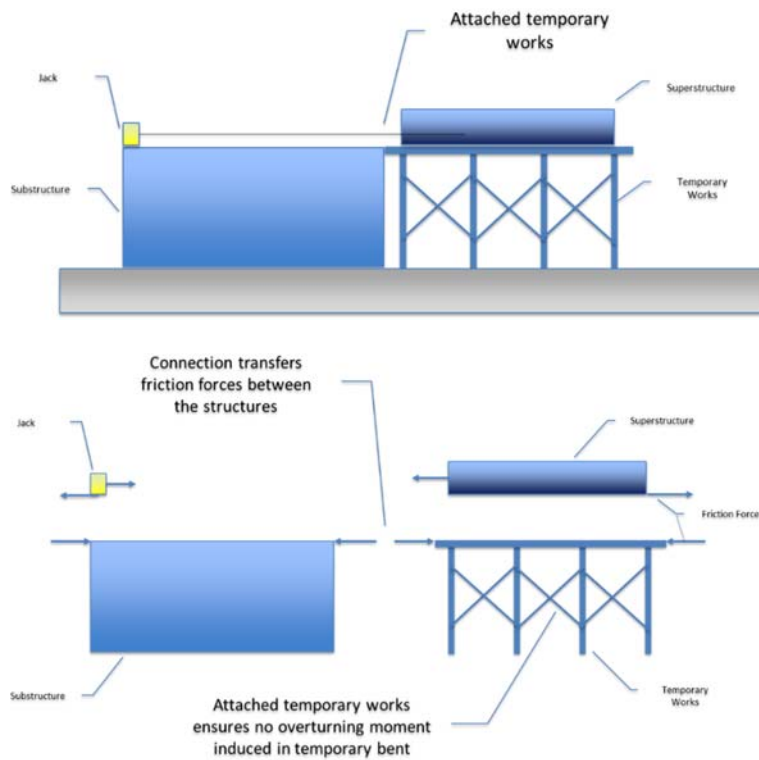
Generally the temptation is to treat the bridge as very fragile when being moved and placed. Although this is appropriate, the tendency should be tempered with the perspective that bridges are, in fact, quite strong and durable structures.





## Unattached Temporary Works

Shown are the two substructures for the permanent and temporary works in an 'unattached' state. When pulling or pushing the new superstructure from one substructure to the other, significant forces are introduced to the substructures as seen in free-body-diagram. The resulting overturning moments must be accounted for in the design of the substructures, especially that of the temporary works.



## Attached Temporary Works

Conversely, if a point of attachment is provided between the two substructures as seen in this schematic diagram, then the overturning moments are eliminated, thereby greatly simplifying the design of the substructure and the temporary works.

With the significant focus on the constructability and slide of a new superstructure, the approach slabs should not be overlooked. Attention to approach slab design and construction should be a priority rather than an afterthought.

Several methods have been used, including the 'Utah method,' which involves sliding the approach slabs with the bridge; precast approach slabs placed after the slide; cast-in-place approach slabs; or even buried approach slabs, commonly referred to as the 'European method.'



A site-specific evaluation should be completed to assess which method is best. Most DOT's have standards for this item that are not compatible with SIBC; again, perspective is key. Age-old standard details can often be placed on a pedestal, resulting in resistance to otherwise reasonable alternatives.

Specifications for SIBC projects largely resemble those of a traditionally constructed bridge. However, additional specifications or modifications of existing specifications should be provided that cover the unique aspects of a slide-in project.

For example, requirements for an assembly plan should be included. The assembly plan is similar to an erection plan, except it includes more detail on the temporary works and equipment. It also includes a step-by-step plan for the completion of the work, including a schedule.

Prequalification of high early-strength grout and review of field welding procedures should be considered. Reasonable tolerances should be included that accommodate thermal expansion and contraction and the fact that the bridge will be moved.

Special attention should be paid to contractual specifications such as incentives and disincentives or liquidated damages. Requirements for timing of plan submissions and reviews should be included. Possible prequalification of the slide contractor or the project superintendent and slide system should be considered.

Additional specification considerations include the following: the need for a rehearsal slide prior to the final slide, a contingency plan during slide-in, a detailed CPM schedule for slide-in, and the submittal of slide system working drawings.

In most cases, the design of temporary is the contractor's responsibility. If, however, the traveling public will at least minimally travel over the temporary works, the responsibility may lie elsewhere.

The design must be completed by a competent, registered professional engineer. The engineer of record should be responsible for the geotechnical investigation around the site, including the area proposed for temporary works.

Both deep and shallow foundations should be considered, and all design parameters should be included in the contract documents.

If temporary works foundations different from those considered are proposed by the contractor, the contractor must hire a geotechnical engineer. Several codified resources exist to guide the temporary works design.

In the end, acceptance of the temporary works will be up to the engineer of record for the installation.

Further, the engineer of record should have the ability to verify materials certification.

A pre-bid meeting is recommended in which sample temporary works drawings can be viewed for those unfamiliar with slide-in construction.

For SIBC, the actual construction of the new superstructure on the temporary works is very close to that of conventional construction; very few methodical changes are needed.

The expected jacking forces and jacking locations are key to the design of temporary works. It should be noted that possible misalignments or hang-ups during slide operations can considerably increase the jacking forces. Accordingly, connections should be appropriately designed.

For reasons previously discussed, the temporary works should be attached to the permanent substructure. Lastly, jacking locations for vertical adjustment of the superstructure should be incorporated into the design.

Attempts to minimize the differential settlements between permanent and temporary works should be made. Note that all loads are transient and changing; therefore, an analysis should be completed for stages throughout the process. Special attention should be paid to differential displacements, p-delta forces, and jacking loads.

To ensure the proper jacks will be supplied to the project, the engineer must make a good estimation of the friction forces during the slide. These forces should be verified during the rehearsal slide.

Two commonly used slide mechanisms include PTFE coated neoprene bearing pads and heavy duty rollers. The estimated lateral force required is 10 percent and 5 percent of the vertical load, respectively. Note that, in addition to the higher forces required during possible binding, a slightly higher force may be required when pushing the superstructure from a static to kinetic state.

Since the engineer of record does not know the make-up of the actual slide system, a recommended value of 10 percent should be used for preliminary engineering. The plans should show the recommended



jacking location on the bridge, and the engineer of record should verify that the structure can accommodate this force.

It is key that the transition from temporary supports to the permanent structure be designed to accommodate the transient load and possible differential deflection. The superstructure should experience little effect due to the changing support condition.



One slide mechanism is PTFE coated bearing pads with stainless steel slide shoes. Each pad is coated with dishwashing soap to further decrease the frictional forces; it is available, cheap, and effective.

Incorporating jacking pockets into the semi-integral abutment can be used for vertical adjustment and bearing pad change-out.

Additionally, a guide channel can be used with heavy duty rollers and threaded rods connected to the jack. The slide shoe option works in conjunction with a semi-integral backwall diaphragm. The slide shoe can be used for the move only, or it can also be used for

the permanent bearing support. By using this method of detailing, the number of permanent bearings can be reduced by more than half. The Utah DOT has designed bridges with only two or three bearings at each support line.

Hardware commonly used in slide-in applications includes rollers, skids, PTFE pads, hydraulic rams, threaded bars, and vertical jacking hardware.

Several power systems can be employed to move the bridge superstructure. These include hydraulic jacks, push/pull jacks, winches, cranes, and even other equipment.

It is recommended that hydraulic equipment be proof-tested prior to being put into service. Even new jacks can blow out seals and fail.

Submittals were briefly mentioned previously. To further elaborate, some of the submittals that should be required include slide system plans; slide plans, including an hour-by-hour schedule, communication plan, and contingency plan; the contractor's ingress and egress plan; and temporary works, which should be separated from the actual slide due to the timeline in which each is required during the project.



## Relations with the Media and Public

Media and public relations are important on any project. Bridge design and construction professionals should be cognizant that the traveling public are customers and should be informed.

Due to the unconventional nature of the bridge construction when using slide-in methods and its potential impacts on the traveling public, SIBC projects are likely to garner more attention through the media.

Accordingly, a media and public relations plan should be developed early in the project that communicates the advantages of reducing inconvenience for the trade of possible increased costs.

Sufficient time should be allowed for the public to make alternative plans during the most inconvenient times. Further, communication with the community prior to setting the schedule will help identify local events that draw additional traffic. Identify periods of least traffic through traffic counts if necessary. Several methods to convey information to the public should be used including the local news, websites, mailings, social media, and others.

Special attention should be paid to businesses and others directly adjacent to the site, as it is likely they will be most affected. Variable message signs are a good way to convey important project information.

Since the construction method is unique, the public should be encouraged to attend the slide but only if attendance can be safely accomplished. The availability of engineers and communications specialists to quickly answer questions during construction can be very beneficial. After the project is completed, surveys of the public to provide feedback can be conducted.

### Jamaica Ave – New York

- Substantial public outreach campaign began 3-4 weeks in advance of construction
- Communicated project details via letters, meetings, radio
- Posted construction details on State and City websites
- Broadcast of press release/travel advisory to media outlets and coordination of area-wide VMS signs



