

April 2023 Webinar

Design and Construction of Incrementally Launched Segmental Bridges



Outline

Overview – What is launching, when should it be considered, why are we talking about it here?

Construction – How do you do this, exactly?

Design – Constraints and considerations to optimize a design for the construction method.

Applicability - When is this a good idea?

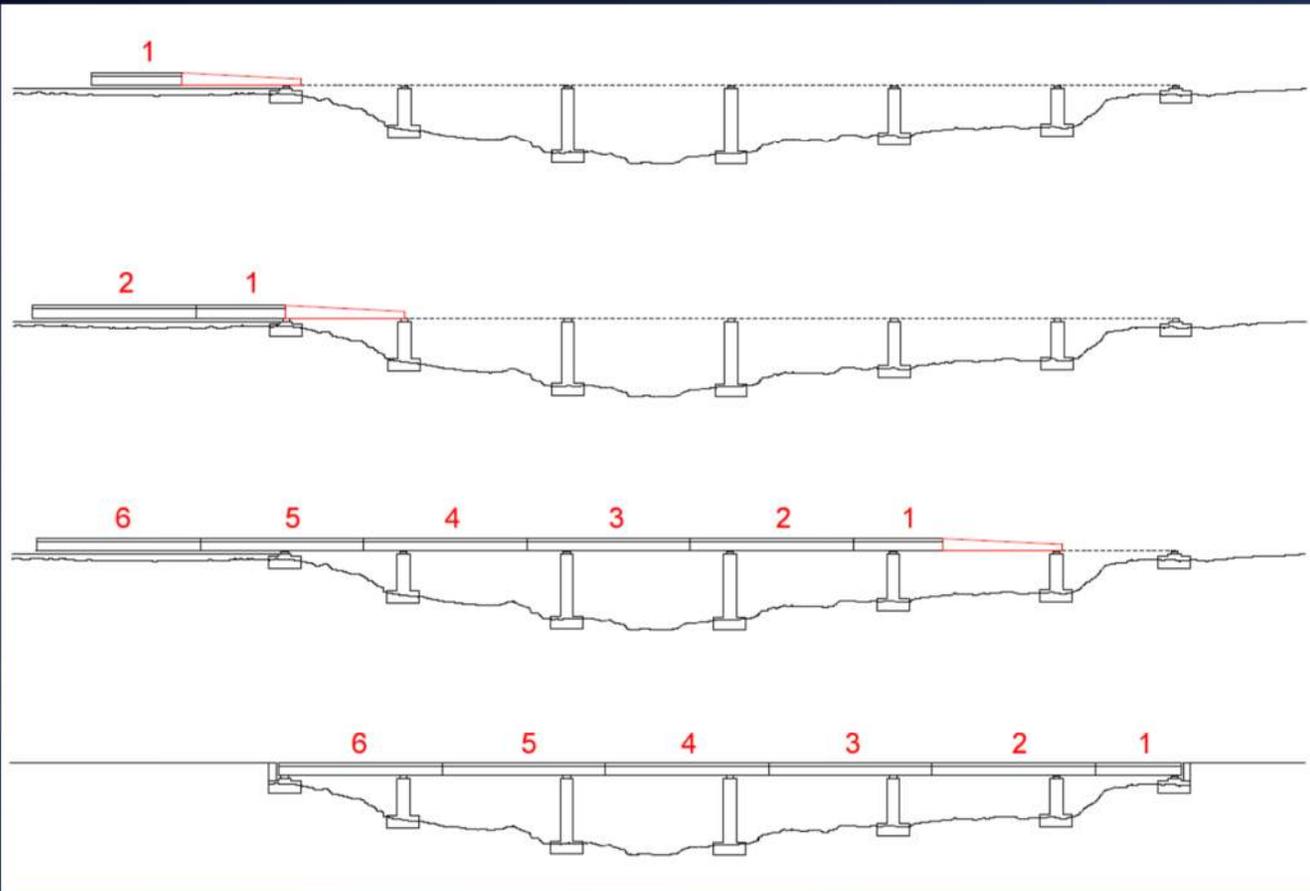
General Overview



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General Overview



Bridge is cast in place in sections at abutment, then gradually pushed forward towards the opposite abutment.

General Overview

That's cool.

But do people actually
do this?

General Overview



Almost 300 entries in Structurae – almost all of them outside the US.

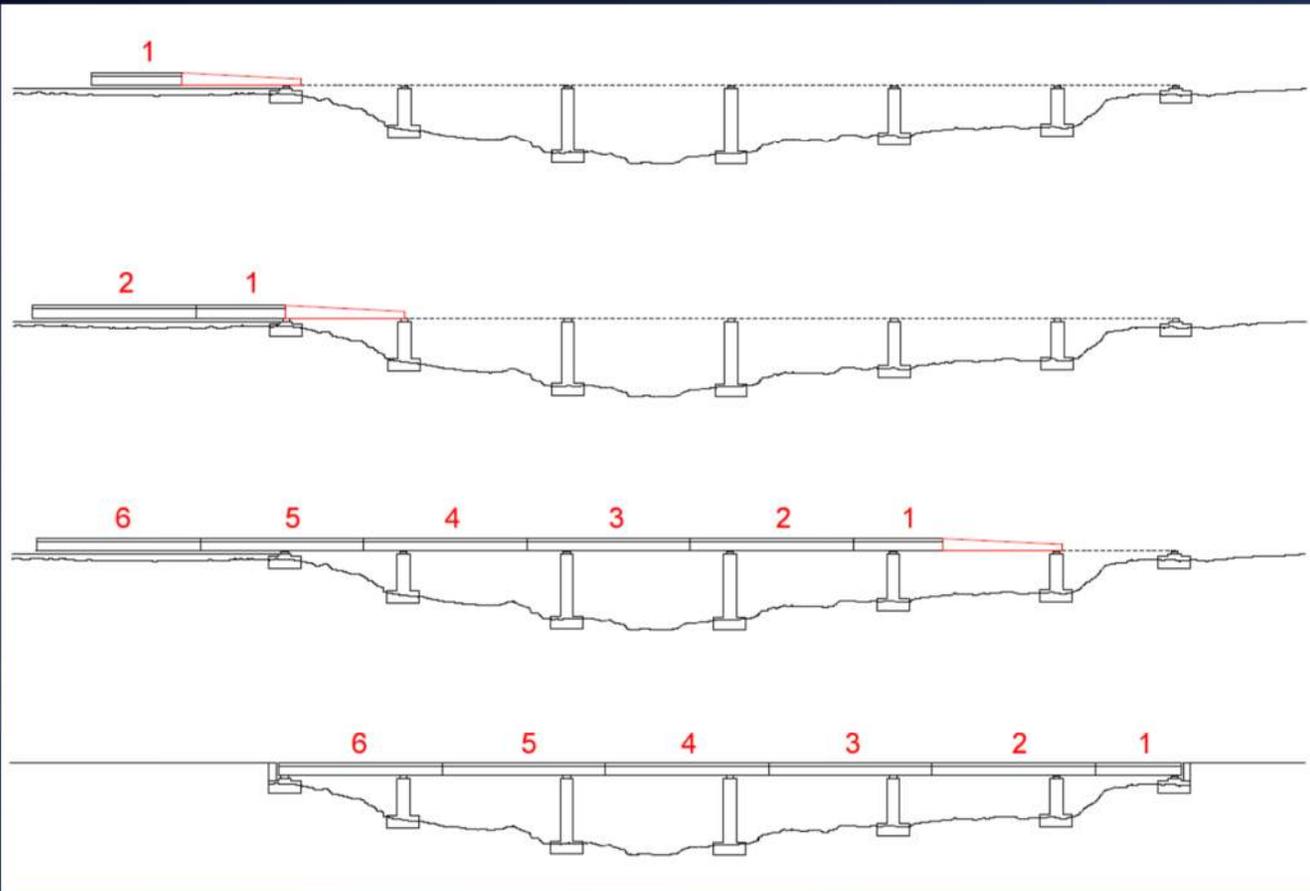
Wabash Bridge (left) built in Indiana in 1977.

General Overview



**Wabash Bridge – Covington IN.
935' in total, ~187' typical spans.
Still in service – rated in 2022**

General Overview

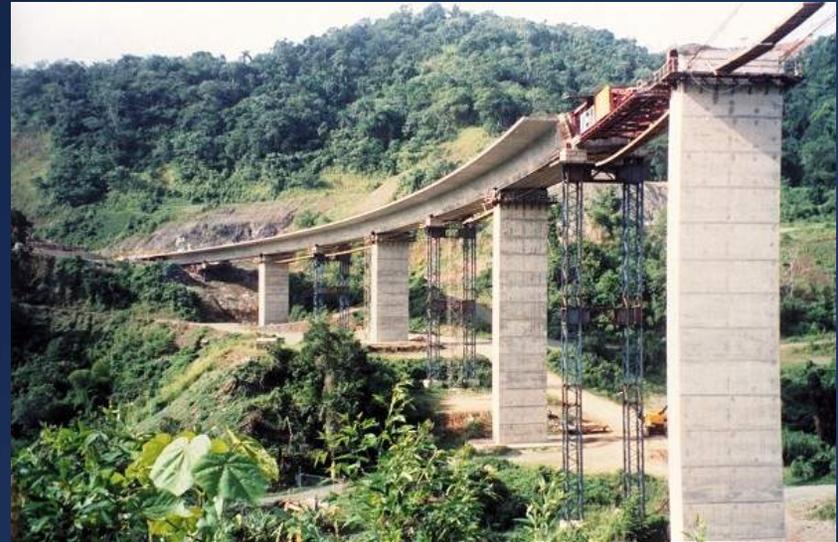


Why am I hearing about this at ASBI?

This is a segmental technique.

It is similar to CIP with form travelers, except the form is stationary and the bridge moves.

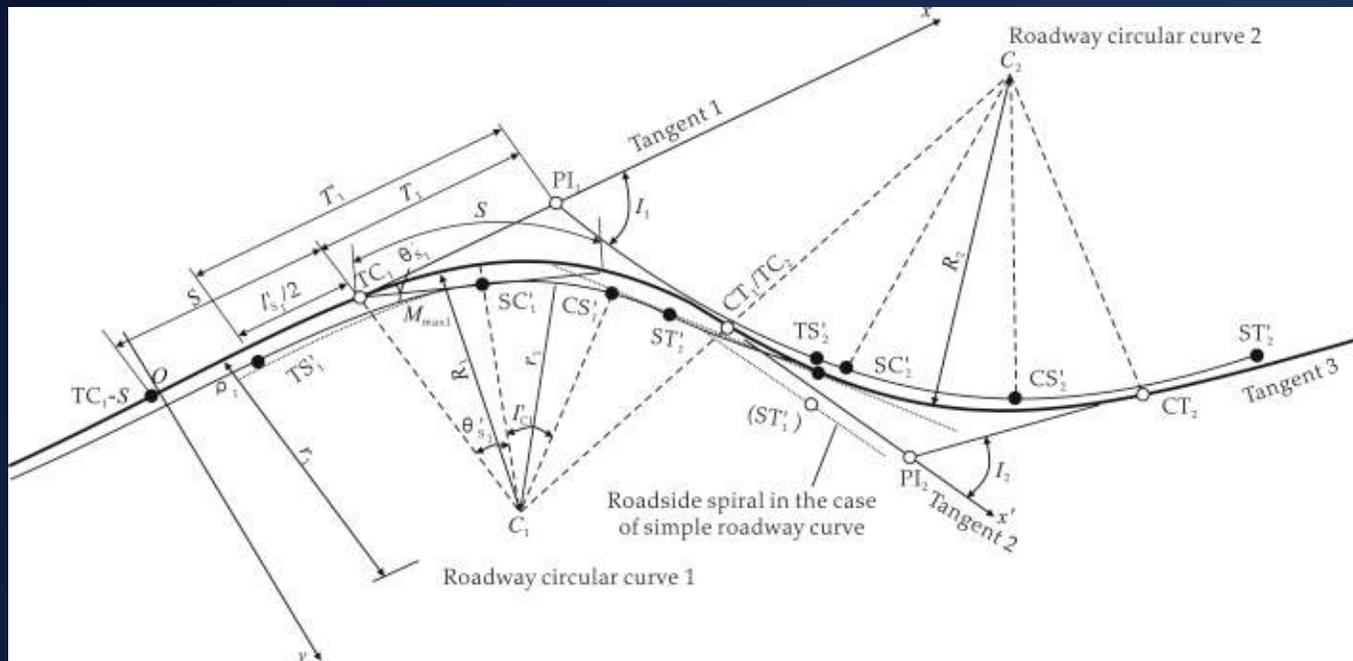
General Overview - Concrete



The technique is used with steel bridges as well. Kicking Horse in Canada is a recent example.

However, a key difference is that with segmental concrete, once the launching is done, the bridge is done.

Geometry



This technique requires a compatible roadway geometry, both in plan and profile.

Geometry



In plan, the bridge needs to be straight, or have a constant radius.

Geometry



Launching from both ends opens the door to combinations of those two elements.

Geometry



In profile, the bridge should be either straight, or have a constant curvature.

Construction

Casting – layout, staging, special considerations.

Pushing – how do you move the bridge.

Reaching – launching noses.

Steering – keeping the bridge on the piers.

Braking – a good idea.

Construction - Casting



Casting takes place immediately behind the alignment, so there must be adequate space available.

Construction - Casting



This sounds obvious, but it is best if the casting beds are on the ground – i.e., behind an abutment.

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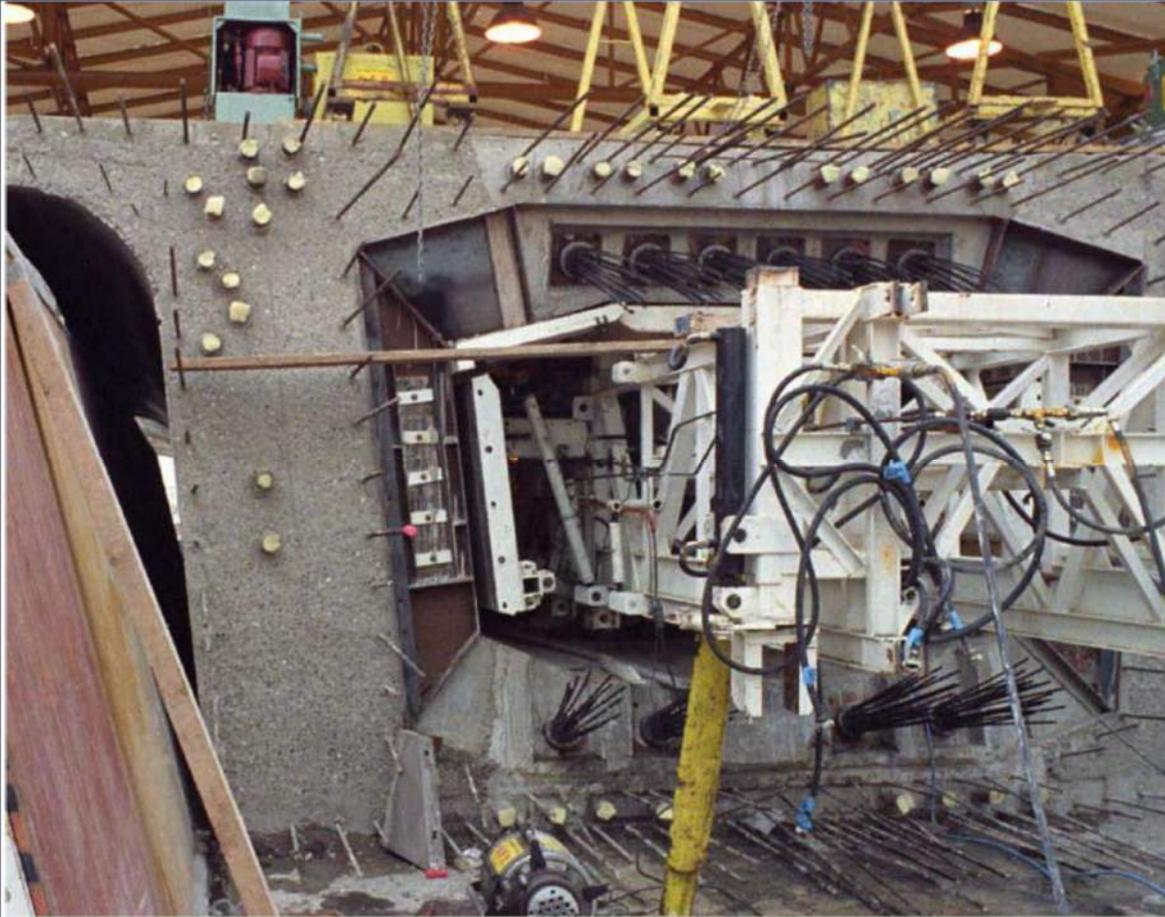


Construction - Casting



Typically, the most economical casting setup is in stages, to simplify the forming inside the box.

Construction - Casting



In some cases, the full section can be cast at once, though this increases the price of the formwork, as the core form requires hydraulics for retraction.

Construction - Casting



With staged casting,
interior forming is
simplified.

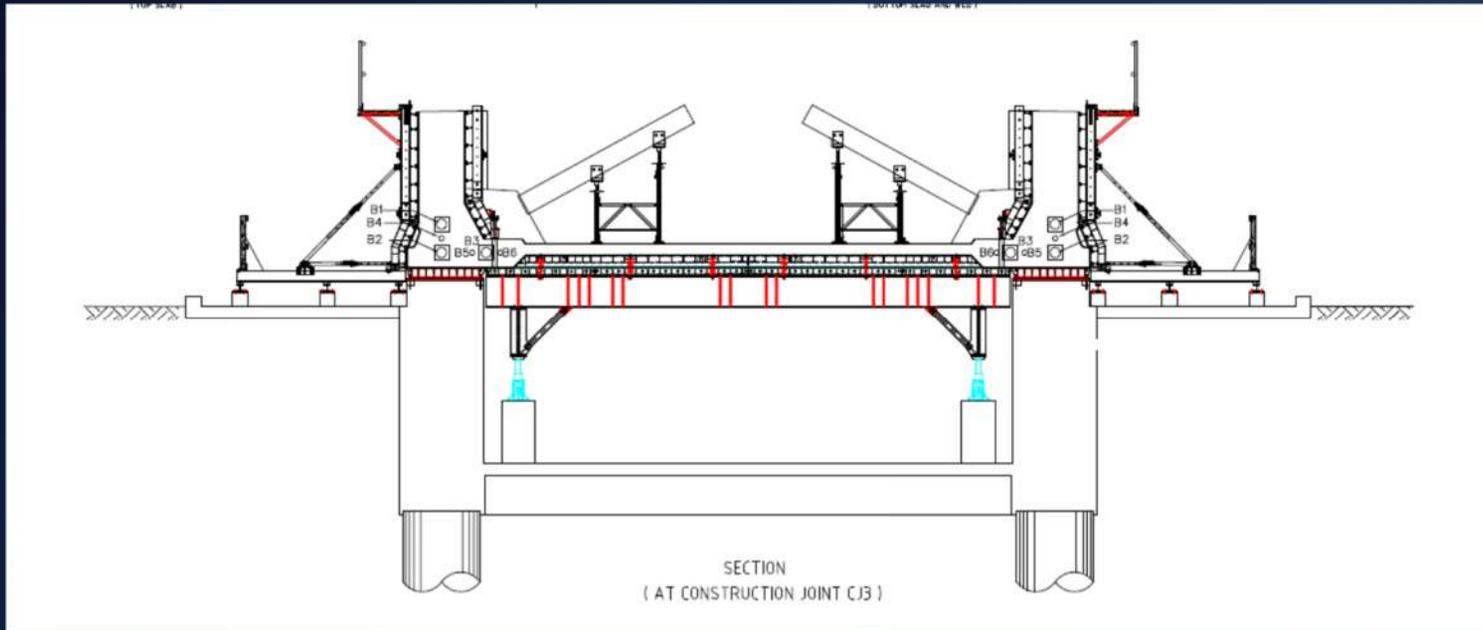
Construction - Casting



Placement of the reinforcement is the first step.

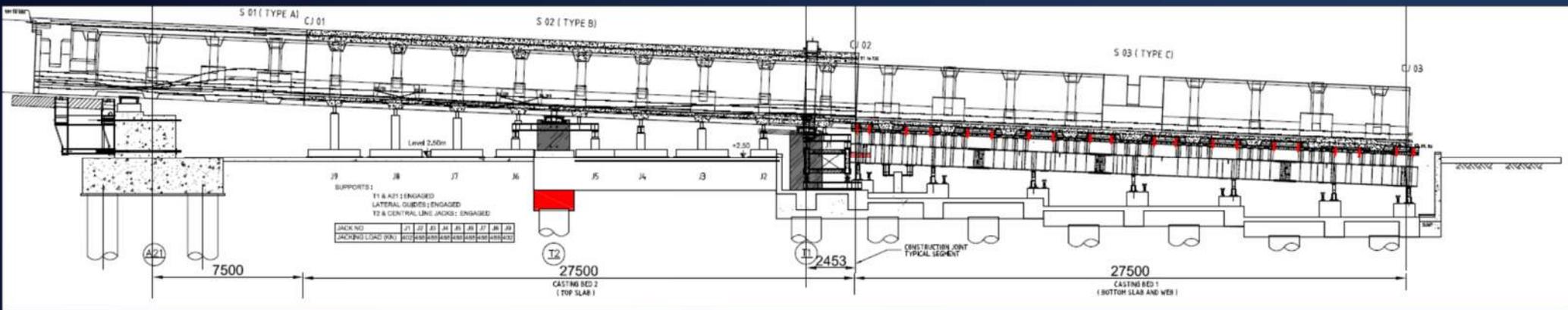
Pre-tying sub-assemblies is common.

Construction - Casting



Casting of concrete – forms should also accommodate launching needs – will see movement.

Construction - Casting



For complex bridges, a phased approach can be incorporated into the form design.

Construction - Casting



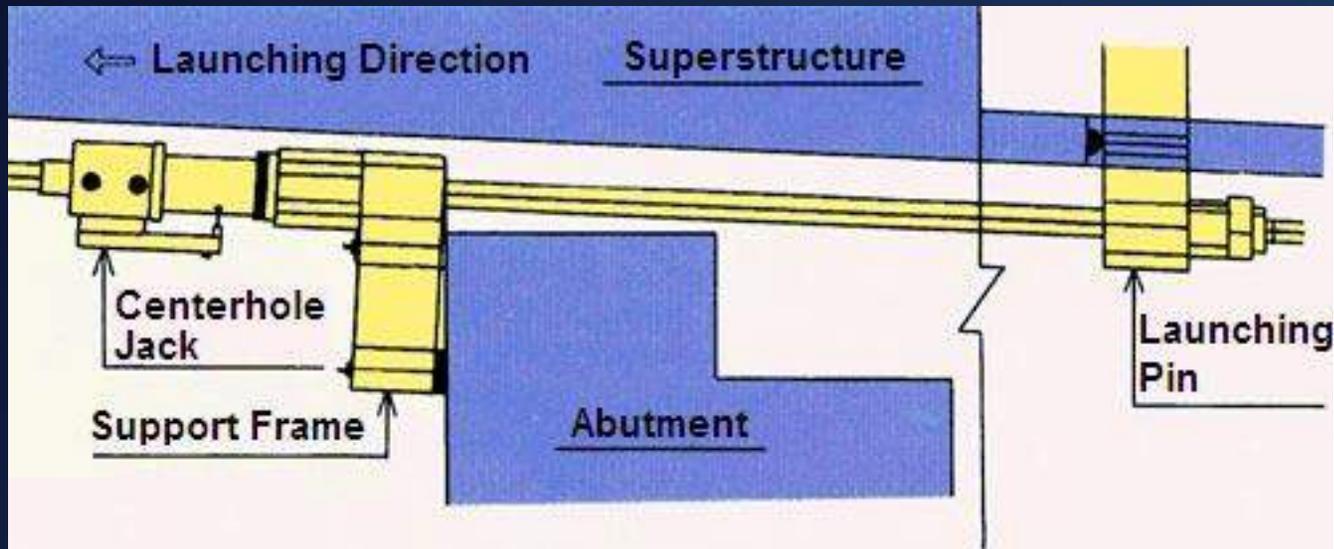
Construction - Pushing



You also need a method to move the entire structure – choices are limited to pushing and pulling.

In either case, the jacking system must be capable of resisting the weight of the full bridge times 4-6% friction, plus the effects of grade.

Construction - Pushing



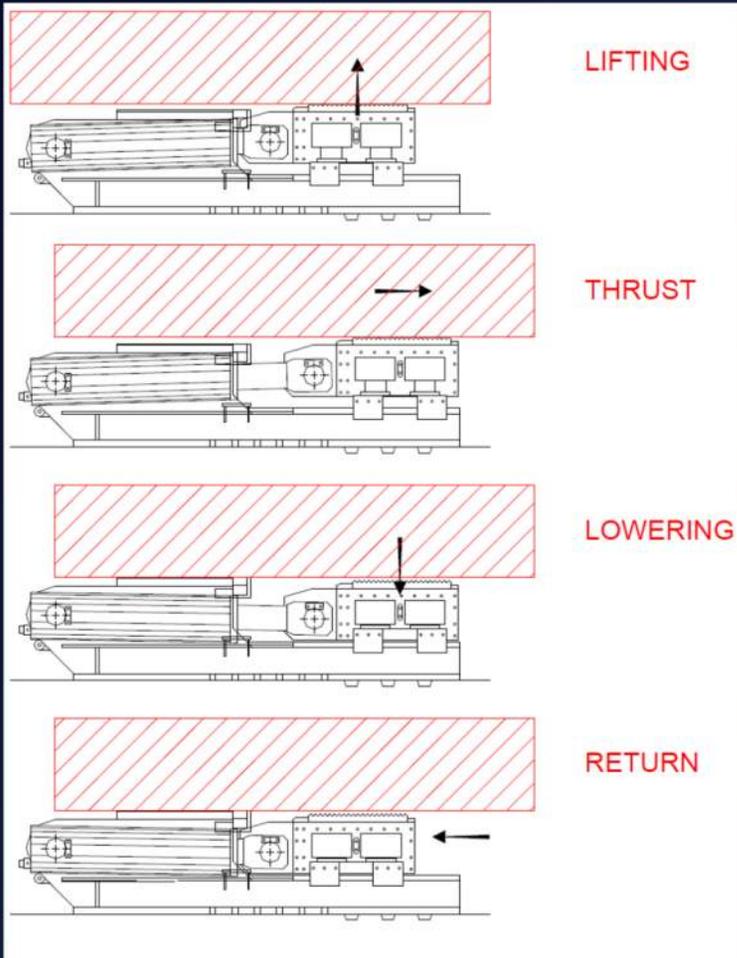
Pulling methods use jacks attached to strands that extend from the back face of the bridge to a fixed point. These use relatively common hollow-core jacks and custom frames.

Construction - Pushing



Simple frames are needed to transfer the force at each end of the strands.

Construction - Pushing



Pushing can use a friction system for smaller applications, in which the pistons stay in a fixed position and cycle the bridge forward with each stroke.

Construction - Pushing

Larger bridges have movable jacks along a fixed track – the jack moves forward with each cycle.

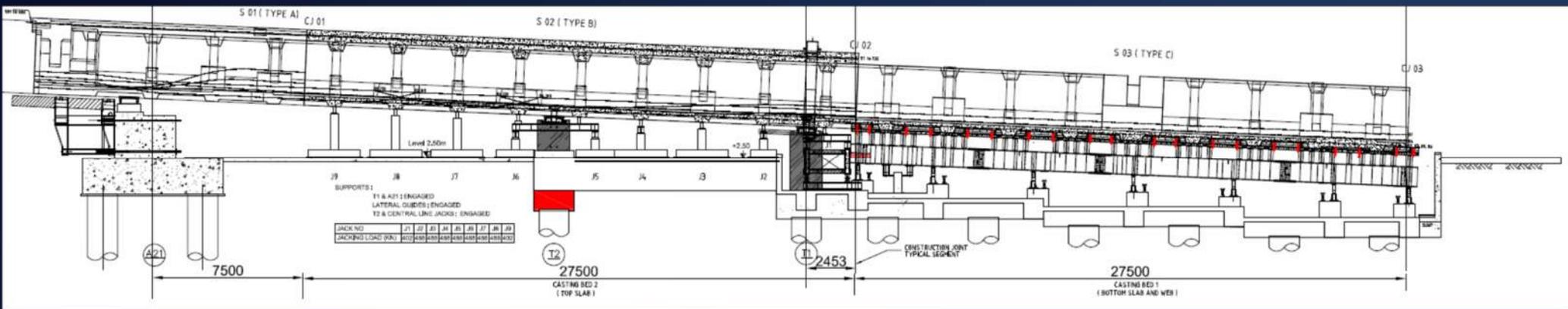


Construction - Pushing

The tracks are as long as the launch cycle. After launching a secondary brake is engaged and the jacks crawl back for the next cycle.



Construction - Pushing



You need something to push against. Again, this seems obvious, but it can be overlooked. There is a large longitudinal force that needs to be transferred to the ground.

Construction – Launching Nose



The launching nose is the most iconic piece of equipment associated with launching.

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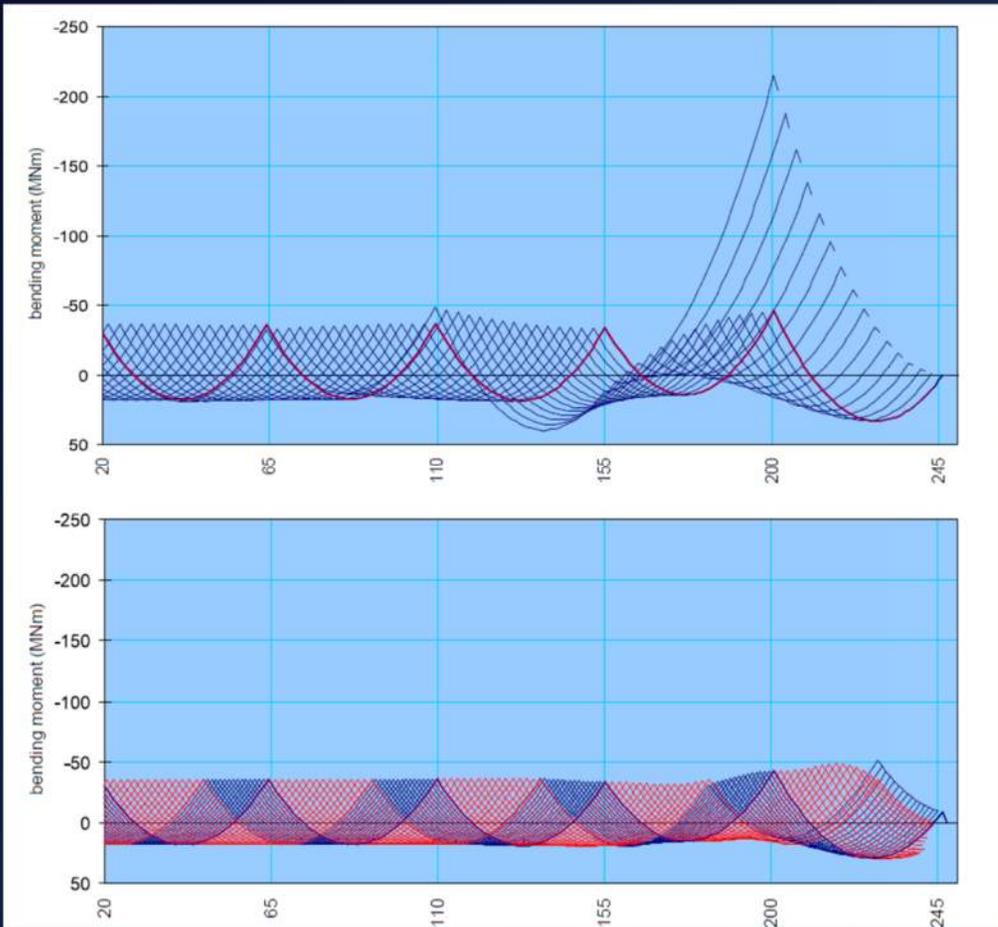


Construction – Launching Nose

Launching noses are on the order of $\frac{1}{2}$ of the span, and are a substantial piece of steel. They are also simple steel, with few moving parts.

With some planning, they can be retained and re-used for similar applications.

Construction – Launching Nose



The launching nose is lightweight and helps to reduce the negative bending moments in the leading girder.

Construction – Launching Nose



More ambitious applications require the use of a cable-stayed launching nose acting as a king post. This is an active system, with the stays being adjusted at different stages.

Construction – Launching Nose



The nose is typically angled upwards to counter the large deflections often encountered in cantilever.

Construction – Launching Nose



Alternatively the tip can be adjusted with hydraulics. This is good when span lengths vary and the deflection is less consistent.

Construction – Launching Nose



Nose attachment is very important, and can be a major design and detailing challenge.

Construction – Steering

The bridge will be moving over the piers as it progresses to the opposite side.

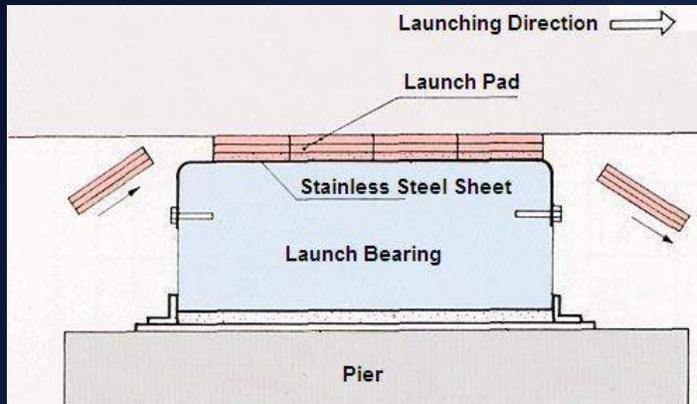
Specialized hardware is needed to accommodate this movement, and to ensure that the bridge stays on the proper alignment.

Construction – Steering



Bearings are placed at supports
They must accommodate the
movement of the
superstructure as it goes by.

Construction – Steering



Teflon pads can be used and cycled through the interface as the bridge advances.

Construction – Steering



Teflon pads under the launching nose tip

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Construction – Steering



Alternatively, fixed rollers can be used.

Construction – Steering

Lateral guides are also needed to keep the bridge on course – particularly in curved applications.



Construction – Braking

From a safety perspective, it is hard to overestimate the importance of braking.

Often two systems, one that is engaged during launching and an auxiliary system engaged at the end of a launching stage.

Construction – Braking



No matter what method is used, an auxiliary braking system is needed.

Construction – Braking



Methods that use positive attachment – keys or bearing – tend to be the most reliable.

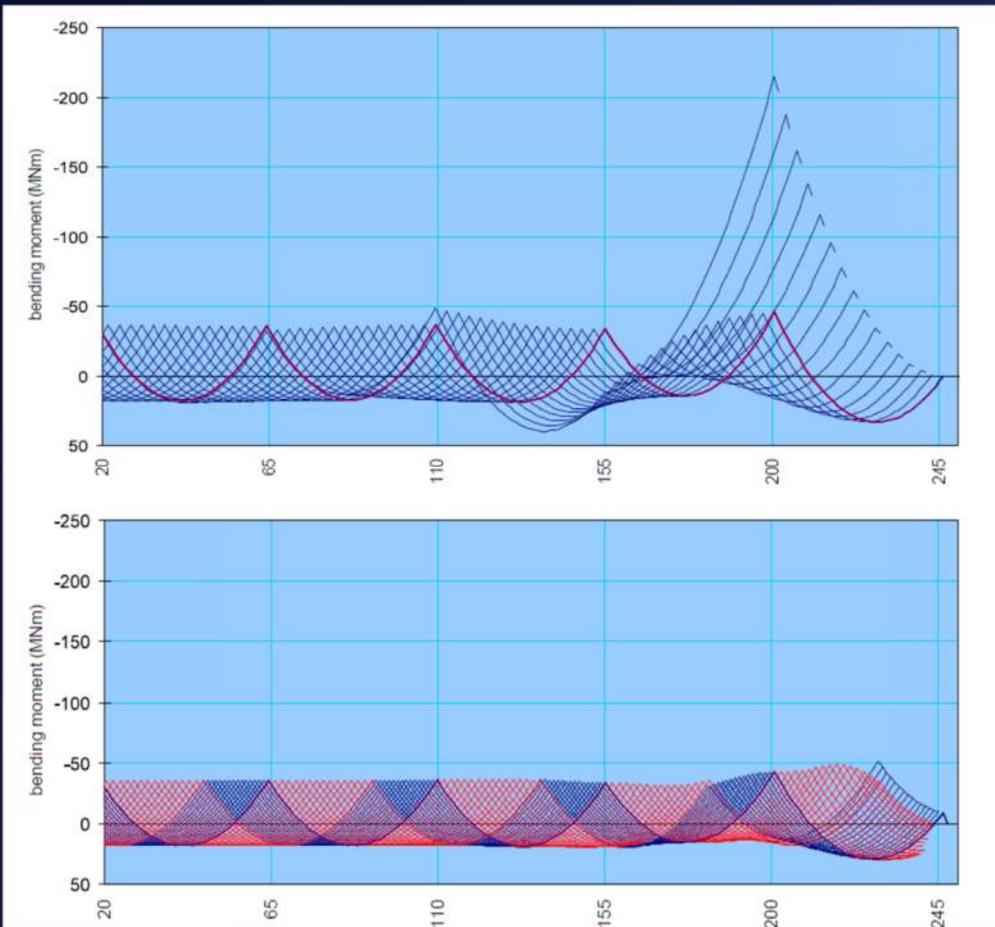
Design

There are a number of design aspects that are affected by this construction method.

There are a few basic things to remember:

1. Variable depth is not an option, so span lengths and layouts will be dictated by the depth.
2. Intermediate joints are not impossible, but not ideal. Superstructure will be continuous.
3. Force effects will reverse during construction.
4. Every point along the web is a bearing.

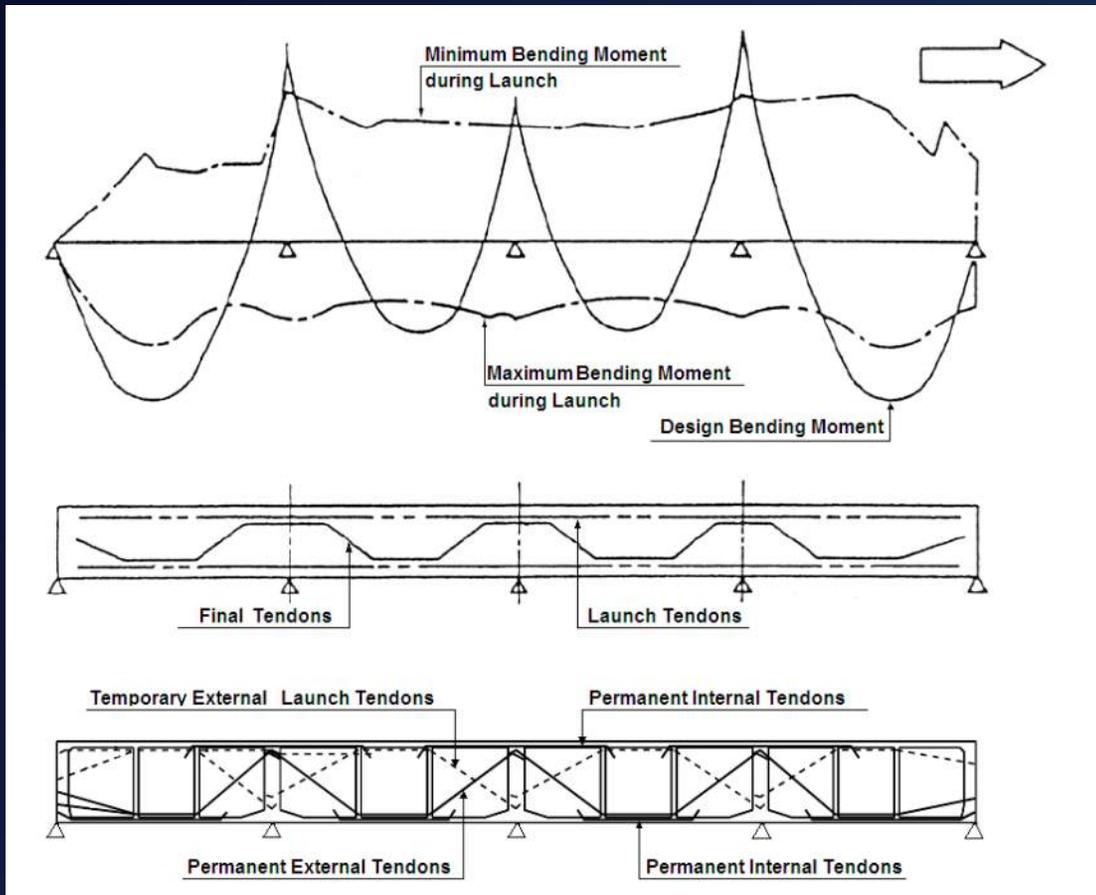
Design



The biggest impact is to longitudinal design, where the moving bridge creates unusual demands

Even when a nose is used to minimize the bending at the leading edge, the entire bridge will see both positive and negative bending.

Design



This leads to a post-tensioning design that is essentially P/A during launching – the entire section must be well compressed.

Tendons may be added or removed after launching to match permanent demand

Design

There are different strategies for using permanent and replaceable tendons to optimize the PT layout over construction and service. There will be an increase in quantities over traditional erection.



Design



As a CIP construction method, continuous mild reinforcement is possible, reducing the post-tensioning demand somewhat.

Design



Also as a CIP construction method there will be appreciable shortening from PT, creep and shrinkage.

This needs to be calculated and added with every cycle.

Design

Shear is another significant consideration – shear reverses with moments.

Removal of launching tendons can benefit in-service shear.

However, it is not uncommon for the webs to be thicker than other construction methods.



Design



Bearing must also be watched closely. It is important that the supports are aligned with the webs as the bridge is moving – and consistent with the guide tolerance.

Design



Piers will see longitudinal loads during the launch – again around 5%. This can govern the design of the piers.

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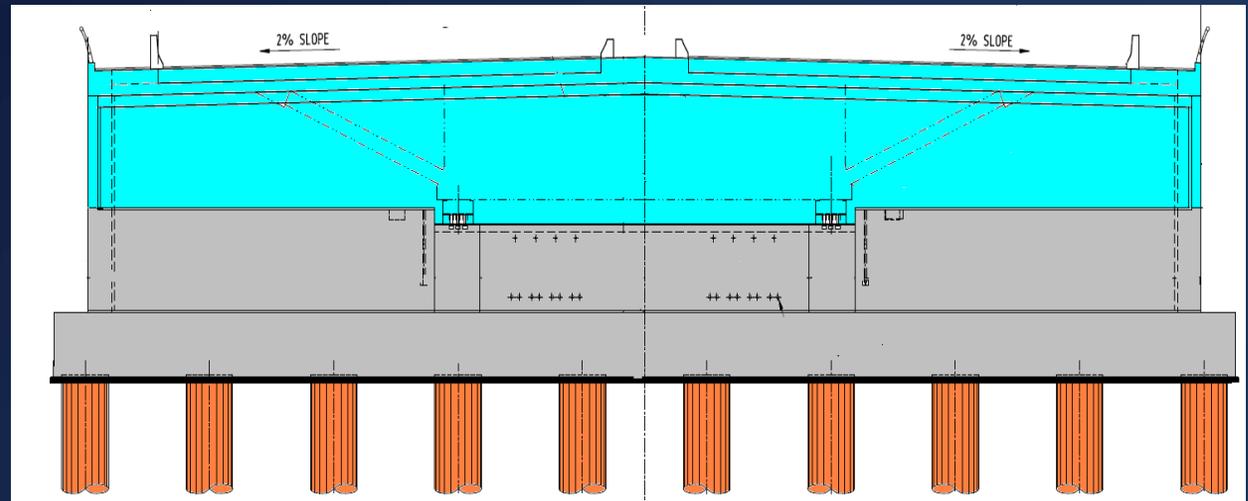
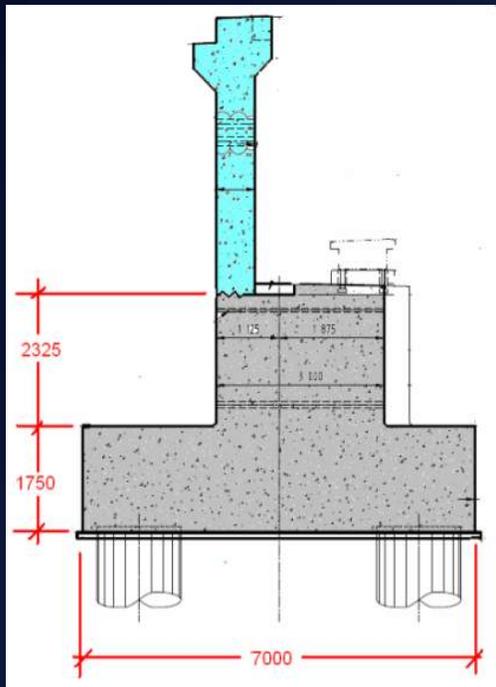


Design



Care should be taken in placing permanent bearings – there may be residual lateral load in the temporary sliding bearings, and the pier can “bounce back.”

Design Impact



When the abutment is used as a reaction block, the forces can govern the design of the piles. The demand is often opposite of the permanent demand.

Why Bother?



Other than an
engineer's love for
complexity?

Applicability

Generally speaking, precast segmental shines on large projects with lots of repetition.

CIP segmental shines on smaller projects with challenging conditions.

Launching fills a niche where access is poor, but spans can be shorter.

Applicability

Permanent material costs will be higher on a square foot basis compared to other construction techniques.

However, the erection equipment is relatively simple, with the moving parts using off the shelf jacks and hydraulics.

Transport costs are low, and most labor is at a convenient location.

Applicability



Water crossing – particularly shallow water.

Applicability



Rail Yards

Applicability



Highways

Applicability



Deep Valleys

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Applicability



Low clearance – above
and / or below.

Applicability



**Arches, cable-stayed
deck installation or
other constant-depth
applications.**

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Applicability



High speed rail can be a good match, with gentle alignments and deep girders



Special Thanks:

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Erwan Allanic – SYSTRA IBT



Questions?



Benjamin Soule, P.E., S.E.