# Precast Girder Management During the Erection Process: A Review

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***Abstract*—** With a focus on their use in bridge building, the study examines the procedures, methods, and factors that go into erecting precast girders. Large-scale infrastructure projects require precast girders because of their effectiveness and quality, which guarantee less time spent on building sites and less labor. The paper covers several precast girder types, including segmental, box, U, and I girders, and how project needs determine which type is best for a given project. It compares the applicability, benefits, and drawbacks of several erection techniques, such as span-by-span, full-span, and gradual launching. Frameworks such as HIRARC are used to examine the risks related to the erection process, including site logistics, equipment management, and safety precautions. Case studies shed light on difficulties encountered during girder building and give guidance for improving quality and safety. Recommendations for improving construction methods and guaranteeing structural integrity in precast girder constructions are included in the paper's conclusion.

***Keywords*—**Precast, Precast girder, Erection, Launching Techniques, Span by Span

## INTRODUCTION

Precast girders are utilized in building projects where precise, effective, and consistently high-quality structural components must be produced. They are especially prevalent in large-scale infrastructure projects like stadiums and bridge construction. When deadlines are short and project efficiency is a top concern, precast concrete girders that are made offsite and delivered to the construction site are perfect.

For instance, precast girders make it possible to assemble bridges quickly and effectively. They work particularly well on railroad bridges, highway overpasses, and other places where causing the least amount of traffic disturbance is essential. Because precast girders can be manufactured to precise specifications, they are frequently utilized in multi-span bridges, which need to have constant span lengths and load-bearing capabilities. By limiting the need for extended on-site work, its usage in bridge projects reduces the time that roads must be closed and increases safety for both construction workers and the general public.

In the same way, precast girders can support heavy loads in high-rise buildings and other massive structures, allowing for higher and more intricate architectural shapes. For projects requiring structural integrity and performance, they are a dependable option because to their pre-engineered uniformity and quality. In areas with severe weather, including extremely cold or humid temperatures, building timelines might be greatly affected. Even in regions where conventional building techniques would be interrupted by unfavorable weather, precast concrete can be manufactured in controlled surroundings, enabling year-round production.

Precast girders are also utilized in places where there isn't sufficient space for on-site casting or where it's necessary to reduce dust and noise. They are favored for urban or heavily populated regions since they are manufactured off-site, which reduces construction traffic and environmental disruption at the project site.

A crucial stage in the construction of bridges is the erection of precast girders, which signals the change from foundation and substructure work to superstructure assembly. A shorter project timeframe, less onsite labor, and superior quality control are all made possible with precast girders, which are structural beams that are manufactured off-site in a controlled environment. Because of their strength, longevity, and long-distance span, these girders are frequently utilized in the construction of highway and railroad bridges.

Each girder is transported, lifted, and positioned over the bridge piers and abutments by heavy-duty cranes during erection. In order to provide stability until final connections are made, the girder installation is carefully planned, including precise alignment, bearing seat preparation, and the use of interim supports or shoring systems. Girder geometry, camber modifications, and load distribution are important factors that must be taken into account in order to preserve structural continuity and design load-carrying capability.

### *A.* Why Precast Girders are Used in Construction

Precast girders are a common choice in construction because of their many benefits. Better quality control, shorter construction times, superior structural performance, and more sustainable results are their main advantages. Manufacturers may attain a constant degree of quality that is sometimes challenging to maintain on-site by fabricating girders in a controlled environment off-site. Improved structural performance results from precise material and dimension selection, which is crucial for load-bearing elements like girders. Consistent curing is another benefit of the controlled casting process, which lowers the possibility of defects and variances that might damage the girder's strength and longevity.

According to sustainability, precast girders improve environmental efficiency in a number of ways. By using materials more effectively, the off-site production method lowers waste and the carbon impact of the project. To cut emissions, some companies recycle concrete and employ energy-efficient curing techniques. Furthermore, precast concrete can include additional elements like slag or fly ash, which lowers the need for cement and improves the sustainability of the material.

The design flexibility of precast girders is another important factor in their use. Because girders come in a variety of sizes, forms, and load-bearing capacities, manufacturers may create solutions that are customized to each project's needs. Because of their versatility, precast girders are perfect for both commonplace uses like roads and more specialist ones like intricate building structures or unusual bridge spans.

Finally, precast girders are a long-term investment for infrastructure projects due to their endurance. Precast concrete is ideal for bridges and coastal constructions because of its exceptional resistance to environmental stresses such moisture, corrosion, and chemical exposure. Because of this, these girders are more durable and require less maintenance than traditional materials, which eventually reduces the lifecycle costs of the infrastructure they support

### *B.* TYPES OF PRECAST GIRDER

India employs a variety of precast girder types for bridge construction, selecting them based on project specifications, site circumstances, load-bearing needs, and financial considerations. In India, the most popular girder types to construct bridges are as follows:

1. I-Girders

I-girders are frequently utilized in urban infrastructure projects, small to medium-span bridges, and highway overpasses. I-girders are affordable, simple to manufacture, and appropriate for bridges that are normally 30 to 35 meters wide. They are a popular option for India's rail and highway networks due to their simplicity and convenience of installation.

National highways and state highways often feature bridges with I-girders, especially for projects managed by the National Highways Authority of India (NHAI) and Indian Railways.

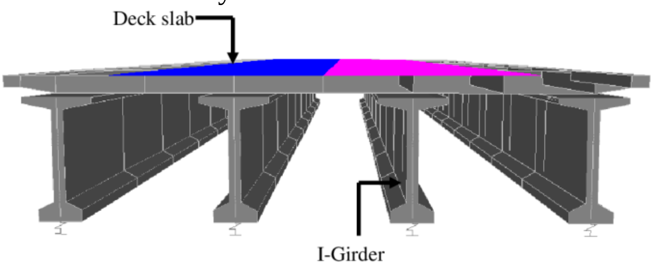

Figure 1 I-Girder

2. Box Girders

In urban areas, box girders are utilized for flyovers, curving bridges, and bridges with greater spans. While box girders have more torsional stiffness, they may be used for elevated structures and curved alignments. Because of their stability and capacity to handle steep curves, they are frequently utilized in metro rail projects. Box girders are used to offer stability and smooth, high-capacity transit paths in flyovers, elevated metro rail lines (such as the Delhi Metro and Mumbai Metro), and long-span river bridges.


Figure 2 Box Girder

3. U-Girders

In Indian cities, U-girders are being used more and more for urban flyover and metro rail projects. Because of its modest height, U-girders make effective use of available space, which is beneficial in crowded metropolitan environments. They can be quickly placed and are pre-stressed, which cuts down the construction time. Metro train systems that need high-strength girders with little vertical clearance, like the Delhi Metro, Bengaluru Metro, and Pune Metro, frequently employ U-girders.

Figure 3 U- girder
https://themetrorailguy.com/2021/05/30/1st-u-girder-launched-for-delhi-metro-magenta-lines-dc-03r/

4. Segmental Girder

Large infrastructure projects including cable-stayed bridges, long-span bridges, and elevated motorways require segmental girders. Long bridges or bridges across water may be assembled more easily and with less on-site casting because to these girders' ability to support modular construction. They are perfect for locations with restricted access and difficult site conditions. Major projects like the Bandra-Worli Sea Link and the Mumbai Trans Harbour Link (MTHL), where lengthy spans and pre-assembled segments are crucial for overcoming site restrictions, have made use of segmental girders.


Figure 4 Segmental Girder

5. T-Girders

For short spans, T-girders are somewhat lightweight, manageable, and reasonably priced. Usually, they are employed in areas with limited resources and in initiatives with modest budgets. T-girders are used for small river bridges, canal crossings, and small country bridges because they are easy to operate and reasonably priced.

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### *C.* TYPES OF ERECTION TECHNIQUES

1. Segmental erection

The span-by-span or balanced cantilever methods are typically used to build precast segments. Before the next span is completed, the span-by-span process entails assembling, post-tensioning, and erecting the whole span so that it can sustain itself. For precast segmental bridges, span-by-span erection is the most popular, straightforward, and economical construction technique. This building technique works well for spans up to 60 meters. It works with continuous spans as well as simply supported spans. In addition to front, middle, and rear support, a conventional launch girder also has a lifting winch or mobile gantry for handling segments.

The lifting frame is constructed above the pier head and secured to the pier head section in the balanced cantilever method, which involves casting the pier head segment onto the pier using the piling cap as support. On either side of the cantilever, it is constructed. The lifting frame's cantilever is fixed according to the segment's length, and there is a 300 mm space between the constructed and erecting segments. After being carried on a trailer, the piece is positioned both vertically and horizontally. The segment's longitudinal and transverse gradients are adjusted using hydraulic jacks. After positioning the section, the stitch concreting between the segment and the pier head is completed. The lifting frame is separated from the built segment when permanent straining is finished.

To keep the system reasonably balanced, the segments are also added to each cantilever either simultaneously or alternately. It is appropriate for maritime activities and larger spans beyond 60 meters (and up to 250 meters) in length and depth. To reduce load imbalance and longitudinal bending in piers and foundations, the deck is built segmentally on either side of the pier in a balanced order. Cranes on the ground or barges, lifting frames or cranes on deck, and self-launching gantries are used to raise the segments alone or in pairs. The benefits of balanced cantilever erection include the ability to handle the segments separately and the lighter and less costly erection equipment compared to span-by-span construction.

➢ Merit and demerit of full span precast erection girder

**Merits**:-

- The technique is very simple to design and implement since it constructs one span at a time in a sequential manner.
- Economical for bridges with recurring spans of comparable sizes since equipment and molds may be recycled.
- Perfect for precast segmental bridges, it allows for the regulated off-site manufacturing of high-quality segments.
- For uniform bridge designs, the process's repeated nature enables faster learning curves and expedited construction.
- Because each span is finished separately, alignment and geometry can be precisely controlled throughout construction.
- Ideal for continuous multi-span bridges and lengthy viaducts, particularly in projects like elevated roads and metro lines.

**Demerit:-**

- Not recommended for extremely long spans, which may call for more durable construction techniques like cable-stayed or balanced cantilever.
- Particularly for lengthy bridges, the process may be slower than other approaches like incremental launching since it builds one span at a time.

- Segments must be aligned correctly. Any misalignment may cause delays in later phases of construction or structural problems.
- Incomplete spans during construction may cause transient unequal load distributions; therefore, careful load management is necessary to prevent the structure from being overstressed.

2. Full span precast erection girder

Using a specially made multi-axle tire trolley, the whole bridge span is transported to the bridge site after being cast at the casting yard using the Full Span Method (FSM). The whole span will be lifted and placed in its final position at the bridge site using a specially designed Full Span Method launching device[1]

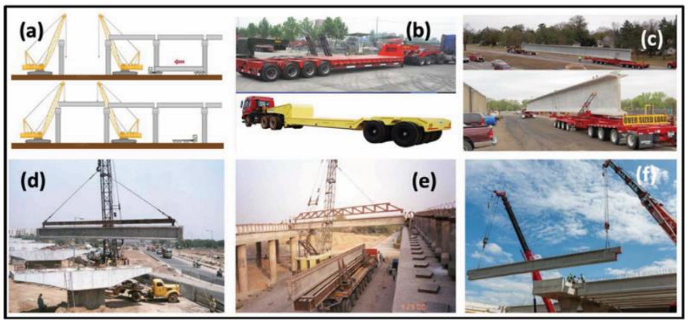

Figure 5 FSMG erection with cranes

Gantries and cranes are the simplest and most often used technique for erecting full span precast multi-girders. Gantry and crane erection is the most cost-effective method, and since the deck may be constructed in many locations simultaneously, there are numerous work fronts available. However, sufficient access is required all the way across the bridge to allow the cranes to be positioned so that the girders can be transported and put into place. The piers cannot be extremely tall in this situation.

Full span precast multi girders are transported using multi axle low bedded trailers (Fig. 5b), which are utilized to negotiate the bends and vertical clearance requirements along the way. The paired multi axle special trucks (Fig. 5c) at the front and back sides with the steerable rear trailer may also be utilized if the girders are longer. To prevent any unplanned forces in the girder, a single crane with the proper spreader beam configuration (Fig. 5d & e) is often utilized for the lighter girders. Tandem lifting (Fig. 5f) with two cranes is also frequently used when the girder's weight and length are greater.

➢ Merit and demerit of full span precast erection girder

**Merits:-**

- In order to minimize on-site labor and significantly cut down the construction time, complete girders are prefabricated and delivered to the site.
- Compared to in-situ construction, girders are produced in a controlled environment, guaranteeing superior quality, uniformity, and longevity.
- On-site construction activities are minimized, resulting in less equipment and manpower at the construction site, which is particularly beneficial in urban or restricted areas.
- Accidents are less likely when there are less construction-related activities taking place on the property. Additionally, the technique reduces work at height.
- For bridges spanning major highways or rivers, the speedy assembly procedure results in less traffic disruptions.
- Perfect for projects in difficult locations where large scaffolding or falsework is unfeasible, such as across rivers, railroads, or steep valleys.

**Demerits:-**

- Requires a large investment in specialized machinery for moving and building the huge girders, such as cranes, launching gantries, and trailers.
- It can be challenging to move full-span girders from the precast yard to the job site, particularly when doing so over long distances, through populated areas, or in places with poor road systems.
- When spans exceed a particular length or weight, the approach is not appropriate because it becomes difficult to transport and move girders that are too heavy.
- Significant delays and cost overruns may result from any breakdown of the specialized equipment utilized for girder erection.
- The precasting yard needs a lot of space, which might not be possible for projects with limited land.

- The process raises labor costs and training requirements since it calls for trained engineers and operators to handle, move, and build the girders.

I beams are the most often utilized full span multi-girders. Girders typically span between 20 and 40 meters, although in very rare cases, they may reach up to 60 meters. In addition to decreasing the thickness of the deck slab, the wider top flanges of the beam improve lateral stability during stacking, construction, and transit by increasing the transverse moment of inertia. Temporary bracings must be used to stabilize these girders while work is underway until the deck slab and diaphragms are cast. Without any interim bracings, the "U" beams are often sturdy throughout construction. Additionally, the "U" beams' breadth may reach 4 meters, making deck slab construction easier and their building generally safer. And faster. The girder's weight can range from 25 to 200 t, and if it must be moved on highways, it may be limited to around 100 t, which often results in a girder length of up to 40 m[2].

3. Launching of Bridge by Incremental Launching Method[3]

The bridge superstructure is put together on one side of the obstruction to be crossed and then moved longitudinally into its ultimate location using the incremental launch technique of construction. The purpose of the incremental launching is to allow for the installation of portions to the back of the superstructure unit before further launches. Despite being fully constructed before launching, tied-arch has been used with the launching technique. The gradual launching approach will never be the most cost-effective way to build bridges of all kinds. For launching, the Incremental Launching Method necessitates specialized construction equipment as well as a significant amount of analytical and design experience. However, the most practical approach to constructing a bridge across an inaccessible terrain is frequently the Incremental Launching Method. The first bridge was introduced gradually. In 1859, the wrought iron lattice truss railway bridge known as the Waldshut–Koblenz Rhine Bridge was finished.

- Characteristics of the incremental launching technique

Complete construction is done without any false work, making it easy to cross barriers like highways, railroads, rivers, buildings, and conservation zones below. Accurate construction is made feasible by the fabrication yard's fixed location behind one abutment. In addition to lowering site investments and overheads, the concentration of manufacturing facilities in one location also results in very short transportation distances. - The 15–25 m long components that make up the superstructure are finished each week; as each unit is concreted directly against the one before it, there are no seams.-To reduce the tensile stresses brought on by the bending moments, the superstructure is centrally prestressed during the building phase. Small tensile stresses should be allowed even if they are not allowed in the finished construction since they significantly increase the method's economics without compromising the structure's safety. The superstructure's cantilever end is equipped with a lightweight nose to reduce the cantilever moment during launch. There is a launching hydraulic jacking device at the abutment[3].

- Applications

The bridge launching method typically completes 30 meters of work in a week. For project sites that encounter certain difficulties, the bridge launching technique of construction is the ideal option. The difficulties are:

1. Deep valleys or steep slows. This makes material distribution challenging.
2. Bridges across deep sea.
3. Access is restricted or prevented because of environmental constraints. Access to the region underneath the bridge construction is restricted. This can be the result of high traffic on the roads or trains.

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Figure 6 Launching of Bridge by Incremental Launching

### *D.* CAMPARATION OF ERECTION TECHNIQUES

| **Parameter** | **Span-by-Span** | **Full-Span** | **Incremental Launching** |
|---|---|---|---|
| Description | Girders or segments are erected one span at a time and connected on-site. | Preassembled full-span units are lifted and placed in a single operation. | The superstructure is assembled at one end of the bridge and pushed (launched) longitudinally. |
| Speed | Moderate | Fast | Slow to moderate |
| Cost | Moderate | High (due to lifting equipment) | High (due to specialized setup) |
| Equipment Required | Standard cranes or launching gantry | Heavy lifting cranes or launching gantry | Specialized equipment for longitudinal launching |
| Disruption | Moderate to high (depends on site access) | Minimal (fast erection reduces disruptions) | Minimal (operations above ground) |
| Suitability | Ideal for short to medium spans or urban areas. | Best for long spans or projects with repetitive span designs. | Suitable for continuous long bridges with uniform geometry. |
| Construction Complexity | Moderate | High (due to handling of full spans) | High (requires precise alignment and planning) |
| Material Usage | Efficient, but requires joint connections. | Efficient, but needs transportation and lifting of large spans. | Efficient for repetitive designs. |
| Alignment | Works for straight and curved alignments. | Works for straight and curved alignments. | Best suited for straight or slightly curved alignments. |
| Initial Investment | Moderate | High | High |
| Safety | Moderate risk due to more joint work at heights. | High safety with reduced joint work at heights. | High safety as most work is done on the ground. |
| Common Applications | Urban bridges, constrained sites, and variable span lengths. | High-speed rail bridges, long highway spans. | River crossings, long viaducts, and elevated highways. |
| Examples | Multi-span urban viaducts. | High-speed rail bridges. | Continuous viaducts with long spans. |

Table 1 CAMPARATION OF ERECTION TECHNIQUES

### *E.* METHODOLOGY OF ERECTION PROCESS

1. Transporting girder using staddle carrier

A straddle carrier is a very effective and adaptable method that is frequently used in precast bridge construction to move girders. Heavy girders may be precisely lifted, carried, and maneuverer using the straddle carrier, a specialized vehicle with an open frame construction. The first step is to firmly place the girder on the ground or a specified support structure. Using its lifting slings or adjustable spreaders, the straddle carrier engages the load firmly as it glides into place over the girder. The carrier raises the girder off the ground when it is securely fastened, making sure the weight is distributed uniformly to avoid structural stress or damage. After that, the carrier delivers the girder to the intended destination, which might be the construction location itself, a storage yard, or an assembly facility. Flexibility during transportation is ensured by its capacity for tight turns and cramped operations. Operators also employ cameras and sophisticated control systems to keep an eye on and guarantee safe handling throughout the process, lowering the possibility of misalignment or accidents. This approach is especially beneficial for large-scale projects when accuracy and productivity are essential.

Figure 7 Transporting girder using staddle carrier

2. Girder feeding by bridge gantry to girder transporter

To guarantee the safe and effective transfer of precast girders for additional transportation, girder feeding from a bridge gantry to a girder transporter entails synchronized procedures. The girder, which usually rests on supports or staging areas, is situated above the bridge gantry, which is outfitted with lifting devices like winches and hoists. To provide proper weight distribution and guard against damage, the gantry fastens the girder at specified lifting places using specialized lifting attachments. The gantry raises the girder vertically to a safe clearance height after it is firmly fastened. The load is meticulously oriented to be received by the girder transporter, which is situated beneath the gantry. The girder then aligns with the loading platform of the transporter as the gantry slides horizontally along its rails. The girder is finally lowered into the carrier by the gantry, guaranteeing stability and correct positioning. To reduce hazards and guarantee efficiency throughout the transfer process, operators coordinate motions using precision controls and communication systems. This technique is frequently employed in bridge building projects since it can precisely manage massive and huge girders.


Figure 8 Girder feeding by bridge gantry to girder transporter

3. Girder feeding to launching gantry

A crucial stage in the construction of precast girder bridges is girder feeding to a launching gantry, which guarantees a smooth and effective erection procedure. Using trailers or other heavy transport vehicles, girders—which are usually prefabricated off-site or in a nearby casting yard—are delivered to the building site. When the girders arrive at the feeding area, they are either immediately raised by cranes or set up on makeshift supports. The girder is then positioned to be received by the launching gantry, which is situated above the bridge piers. Specialized lifting devices that firmly grasp the girder and raise it to the necessary height include strand jacks, hydraulic winches, and trolleys fixed to the gantry. The girder is precisely positioned across the specified span after being transported along the rails or tracks of the gantry.

To guarantee both the girder's structural integrity and worker safety, this procedure requires exact synchronization. Planning must take into factors including site access problems, girder weight, and transportation restrictions. Multiple girders are pre-prepared to fit the erection sequence, and feeding procedures are optimized for continuous the structure. A smooth operation is ensured and delays are reduced when the launching gantry operators and the girder feeding crew are properly coordinated.

Figure 9 Girder feeding to launching gantry

4. Girder erection using launching gantry

A sophisticated and effective construction method that is frequently employed in bridge construction, particularly for precast segmental and girder bridges, is girder erection employing a launching gantry. The launching gantry is a large steel construction with cranes, hoists, and winches that is intended to precisely lift and place girders. This technique is perfect to construct bridges over barriers like rivers, highways, or railroads since it does not require a lot of ground-level scaffolding. The gantry moves forward span by span across the existing piers. It aligns precast girders with the piers, fixes them with temporary supports or bearings, and lifts them from transport vehicles or on-site storage. To attain structural integrity, joint grouting and post-tensioning are subsequently carried out.

The launching gantry may accommodate different girder lengths and bridge alignments, both straight and curved. By focusing erection efforts on the superstructure level, it improves safety and guarantees that the region beneath the bridge is not severely disrupted. For lengthy bridges and viaducts, where the repeating girder erection procedure speeds up construction, this approach is very beneficial. To guarantee accuracy and safety during erection, launching gantry deployment calls for careful planning, specialized tools, and knowledgeable operators.


Figure 10 Girder erection using launching gantry

### *F.* Factors Influencing the Erection Plan

The creation of an erection strategy or technique is influenced by several important factors

1. **Site Logistics**

Important factors to take into account are the site's accessibility for moving girders and the amount of space needed for crane assembly and transportation. The erection method and sequence might be greatly impacted by difficult terrain, restricted access, or limited staging spaces.

2. **Crane Access and Lifting**

Crane selection, capacity, and placement are crucial components of the erection plan. The crane size is determined by the site layout, crane reach, girder weight and length, if lifting a crane is a practical technique (or launching is preferred), and whether temporary work is required. It also determines how and when girders will be hoisted and installed.

3. **Temporary Works**

The quantity and price of temporary construction needed. Pre-assembled spans may be more beneficial to launch or move if traditional crane assembly requires costly intermediary piers, bents, or trestles.

4. **Erector's Experience and Preferences**

Erectors frequently contribute special knowledge and favoured techniques derived from prior work. Their hands-on experience with steel erection might affect the choice of crane, lifting methods, and order of operations.

**5. Traffic Closures and Restrictions**

Access limitations may be necessary for work over or close to existing highways, railroads, or rivers; thus, collaboration with local authorities is required for temporary closures or restricted environments for crane operations.

**6. Cost, Risk, and Schedule**

Schedule adherence, risk reduction, and cost-effectiveness must all be balanced. To guarantee that the project stays under budget and is finished on schedule, the erection plan has to maximize these elements.

### *G.* Risk identification in erection process

Precast bridge spans must be assembled using a number of complex procedures, each of which has a risk that might affect schedule, cost, and safety. Determining these risks is essential to preventing possible setbacks and guaranteeing the project's successful completion. Site conditions, equipment use, material handling, and personnel management are major sources of risk. Cranes and other lifting equipment may become unstable due to poor site preparation or poor ground conditions, which increases the risk of tipping or structural breakdowns. Furthermore, unfavorable weather conditions, including strong winds, can increase the danger of lifting operations by compromising load stability. Another major area of concern is equipment malfunctions, such as crane failures, incorrect load rigging, or sling and shackle failures, which can result in falling loads, damage to precast portions, or even fatalities.

The erection process is significantly influenced by human variables. The improper handling massive precast pieces can result in accidents or structural misalignment due to poor communication, noncompliance with safety procedures, or insufficient training of staff. Error risk is further increased by the difficulty of managing big crews during high-risk operations like multi-crane lifts or the sequential installation of spans. Additionally, workers' complacency or weariness may be a factor in harmful activities. Precast elements must be transported and stored on-site, which presents additional hazards. Improper storage can cause tipping, and transportation difficulties might cause cracking or other damage to the segments, jeopardizing structural integrity.

The transportation of supplies and equipment may be hampered by external concerns such as interruptions from third-party operations, such as traffic control or illegal site access. Legal and financial consequences may arise from regulatory non-compliance, such as insufficient permissions or failing to satisfy safety requirements. Environmental hazards, such as being close to ecosystems or bodies of water, might impose limitations and necessitate specific methods that increase operational complexity.

A thorough risk identification framework must incorporate equipment inspections, safety audits, and in-depth site assessments in order to adequately handle these hazards. Making use of cutting-edge technologies, such sensor-based monitoring and Building Information Modeling (BIM), can improve the precision of risk assessments. Additionally, reducing human error requires establishing a safety culture via consistent training, emergency readiness, and transparent communication procedures. In the end, proactive risk identification guarantees the structural integrity of the precast bridge spans, improves project deadlines, and prevents accidents. Elimination, substitution, engineering control, administrative control, warning systems, and personal protective equipment use are examples of risk controls that are implemented[4].

### *H.* CASE STUDY

1. Girder Collapse During Erection Process – **Chunabhatti Flyover, Mumbai, India (2019)**

On November 6, 2019, a pre-stressed concrete girder being constructed for the Chunabhatti-BKC flyover in Mumbai, India, fell during the construction process. Fortunately, there were no injuries since the location had been blocked off before the occurrence. The girder, which was about 70 feet long and weighted several tons, collapsed onto the road below, creating substantial inconvenience.

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- Reason behide incident:

1. Improper Lifting and Placement

According to investigations, the collapse was brought on by incorrect alignment during the lifting and positioning procedure. An imbalance may have resulted from the lifting apparatus, such as cranes, being improperly positioned or constructed for the job.

2. Inadequate Temporary Support Systems

The bracing or temporary supports used to keep the girder in place were not made to survive the forces involved in construction. The repercussions of a breakdown were exacerbated by the support system's lack of redundancy.

3. Communication Gaps

There was proof that the crane operators and on-site managers were not communicating well, which resulted in mistakes being made when setting the girders.

4. Neglect of Safety Protocols

There was a lack of adherence to standard operating procedures for girder installation, which include safety inspections and structural integrity verification. Important elements were missed due to hurried timelines and inadequate monitoring.

- Impact of the Collapse

1. Infrastructure Damage

The girder collapsed onto the main road below, seriously damaging the road and nearby buildings. Authorities conducted investigations and put remedial measures in place, which caused delays in the project.

2. Economic and Social Costs

Despite the fact that no one was hurt, the tragedy made many questions the security and dependability of local infrastructure projects. Temporary traffic delays and higher construction expenses for fixing the damage and strengthening additional girders were caused by the collapse.

- Lessons Learned

1. Proper Pre-Erection Preparation

Pre-checks of lifting apparatus and temporary supports, as well as thorough engineering calculations, are crucial. To handle particular difficulties, such as environmental concerns, a site-specific risk assessment has to be carried out.

2. Improved Safety Measures

Similar disasters can be avoided by putting in place rigorous safety procedures and supervision throughout crucial girder building periods. Early danger signs can be obtained by real-time monitoring devices that track structural stability during construction.

3. Quality Assurance

For structural integrity, it is essential to make sure that premium materials are used and that design criteria are followed. Risks can be found and reduced before they cause problems by routine audits of construction procedures.

2. Girder Erection for Delhi Metro – Magenta Line

Figure 11 Erection of U-Girder

- **Project**: Delhi Metro Magenta Line (Janakpuri West to Botanical Garden)
- **Objective**: Rapid construction of elevated viaducts to connect densely populated urban areas with minimal traffic disruption.
- **Key Element**: Use of precast U-girders for constructing viaducts.

- Challenges
  1. Fast-paced development was required to avoid disruptions due to urban congestion.
  2. There is not much space for on-site casting.
  3. short timelines brought on by the needs of urban transit.
- Solution:

Precast U-girders were used on the Delhi Metro Magenta Line to speed up construction and overcome issues including space constraints and urban congestion. High quality and longevity were guaranteed using U-girders, which were cast off-site using pre-stressed concrete in controlled conditions. In order to minimize traffic interruption, these girders, which were each around 27 meters long and weighed up to 160 tons, were delivered to the location on multi-axle trucks during off-peak hours. Each span was finished in three to four hours using heavy-duty cranes and gantries on the job site to lift and install the girders onto pier tops that had already been built. Concurrently, the building of the foundation and piers advanced, utilizing parallel processes to minimize downtime. When compared to traditional approaches, this integrated strategy resulted in considerable time savings, reduced traffic effect, and expedited operations, finishing spans in days rather than weeks.

- Result

Precast U-girders shortened construction times by 30 to 40%, decreased traffic, and improved quality and safety by facilitating on-site erection and off-site production.

**LITERATURE REVIEW**

### A. Factor Affecting Precast Girder

According to Mhatre et al. (2024), There were numerous applications for box girders. To create a more stable structure design, numerous studies have been conducted. The purpose of that work is to investigate the effects of different box girder shapes, concrete material uncertainties on the dynamic response of segmental box girders, and torsion on segmental pre-stressed box girders. The stability of a segmental box girder is significantly impacted by the box girder's shape, material uncertainty, and torsion. Compared to regular concrete, pre-stressing allows for the use of greater concrete strength and effectively controls serviceability. By doing the concreting work farther from the building site, which is often located in the core of the city, the segments system lessens environmental disruption in comparison to the traditional approach[5].

Arditi et al. (2000), By the collection of opinions from a range of stakeholders, including contractors, design companies, precast concrete manufacturers, and labor unions, the study aimed to investigate potential barriers to the adoption of industrialized building systems, namely precast concrete. 100 design companies and 100 contractors were the goal of the study; they were chosen from lists of the best design firms and contractors published by Engineering News Record (ENR). Calculating contractor workloads and design firm billings was part of the selection procedure to guarantee a representative sample. The research emphasized the necessity of better precast concrete system education and training for engineers and architects. It was proposed that expanding exposure to these systems through ongoing education initiatives and academic curriculum may promote their uptake[6].

### B. Hazard Identification and Safety Control

According to Hanum et al. (2023), It is noted that erection girder construction is a high-risk activity, particularly when it crosses existing toll roads. His paper's introduction lists the several types of work that go into constructing a toll road and highlights the serious risks associated with superstructure work, such as girder erection. HIRARC (Hazard Identification, Risk Assessment, and Risk Control) and HAZOP (Hazard and Operability research) were the two main techniques used in the research to identify hazards. The use of these techniques depends on a grasp of the occupational safety and health hazards related to erection girder work, which is mostly dependent on the literature research. In addition to field observations and data gathering via questionnaires and interviews, the research process included a literature review to compile the body of knowledge on hazards. This thorough methodology guarantees that both primary and secondary data provide strong support for the risks that have been identified. That aims to recognize and classify possible risks in erection girder construction, which will improve risk assessment and enable the use of suitable safety precautions[4].

Aninditya et al. (2023), A crucial component in guaranteeing safety during building projects is the building Safety Management System (SMKK), according to the study. It points out that Indonesia's poor SMKK implementation has resulted in a high number of workplace accidents, underscoring the need for better safety protocols. According to the Ministry of Public Works and Public Housing data cited in the publication, there have been a lot of construction accidents in recent years, especially in road infrastructure projects. The necessity for strict safety procedures and risk management techniques is established by this historical background. In order to manage risks in the girder construction process, the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) technique is the main topic of this study. It is anticipated that this approach will assist construction professionals in efficiently identifying and managing risks, which will lower the number of accidents that occur at work. A follow-up questionnaire was created for additional investigation after 57 factors pertaining to risks and hazards were validated by expert views. The survey lays the groundwork for the study done in the article by offering a thorough summary of the important concerns related to risk management and construction safety in the context of the Japek Selatan II Package 3 Toll Road Project[7].

According Saputra et al. (2020), The theoretical underpinnings for the study of safety plans in precast concrete bridge building are established in large part by this publication. The significance of Occupational Safety and Health Management Systems (OSHMS) in construction activities is emphasized in the study. It points out that a lack of safety management procedures is seen in the high number of incidents that happen in Indonesian precast bridge construction. The use of descriptive analysis to understand the information gathered from the surveys is mentioned in the study. The study, which offers a foundation for comprehending how to successfully examine safety risks and costs, supports this analytical approach[8].

### C. Method for Productivity

Purwanti et al. (2021), The government's dedication to improving railway infrastructure is highlighted in the document, especially with regard to Jakarta's Mass Rapid Transit (MRT) project, which started in 2013 and ended in 2019. A number of new railway projects, including LRT and high-speed rail initiatives, were started as a result of this project, which was a major turning point. That study points up a research need concerning the particular tasks required for box girder constructing employing the launching gantry method. Prior research has addressed the WBS and PCI girder building of precast concrete highway bridges, but it has not concentrated on the particular difficulties associated with elevated railway structures. A high degree of agreement (over 90%) on the specified activities was found during the validation process, which was covered in the article and involved expert opinions and practitioner surveys. This agreement highlights the suggested WBS's dependability for next projects. By filling up current gaps and suggesting a uniform framework for box girder erection operations in elevated railway projects, the research makes a significant addition to the area[9].

Hadiyatmoko et al. (2023), They had been focused on a number of investigations and findings about erection girder techniques, including the launcher and crane approaches. The research showed that when it came to girder establishing, the crane approach was more effective than the launcher method. In particular, the crane approach had a higher productivity efficiency of 61.48% as opposed to 29.82% for the launcher method. Additionally, the crane method was less expensive and took less time for construction work. In order to collect information on the erection process, they made field observations, concentrating on the distance and time required to erect girders of different lengths (16, 30, 40, and 60 meters). This empirical information was crucial for confirming the theoretical conclusions and improving comprehension of real-world difficulties in the erection procedure. Despite its greater costs and poorer productivity, the launcher technique was a viable option to the crane method, which was more efficient but may not always have been practical in limited areas[10].

### D. Guideline For Construction and Selection of Equipment

As per IRC:87-2022, That offers a thorough analysis of the crucial elements of launching girders in bridge building, with an emphasis on their design, methods of operation, safety precautions, and financial implications. The span-by-span technique and the balanced-cantilever approach are the two main approaches to bridge segment placement that are covered in the book. Every technique has unique safety concerns and operational dynamics, highlighting the significance of careful preparation and implementation. The need of strict safety procedures and quality control methods, such as visual inspections and non-destructive testing (NDT) of welds, is emphasized in the study. These precautions guarantee the girders' structural soundness and the general safety of the construction process[1].

Mochtar et al. (2016), focused on the crucial elements of infrastructure development, especially as they related to Indonesia's elevated road construction initiatives. According to the research, traffic congestion was a major issue in Indonesian cities that required practical solutions. In order to alleviate traffic problems, especially at high-density junctions, the authors suggested elevated road improvements, notably flyovers. The paper listed essential elements to take into account when choosing installation tools for projects using precast concrete box girders. Environmental circumstances, human resources, project design, timetables, building techniques, precast materials, project expenses, and equipment ownership were some of these variables. Common challenges faced by contractors, such as errors in the design capacity of lifting equipment, which could lead to inadequate lifting capabilities for certain box girder segments. This underscored the need for careful planning and analysis in equipment selection to avoid additional costs and delays[11].

### E. Project Time

Kumar et al. (2023), The precast segmental construction technology, emphasized its importance, methods, and benefits in contemporary building, especially in urban environments. Traditional internal post-tensioning tendons with epoxy-bonded connections were used in the precast segmental method. This technique enabled a span-by-span construction procedure by threading tendons through prepared ducts before tensioning them on-site. Segments could be supported by an erecting truss prior to post-tensioning using the span-by-span technique. After the segments were post-tensioned and resting on their bearings, the truss was transferred to the next span. It could be placed above or below the segments. The shorter construction time was a major benefit of employing precast parts. In comparison to conventional cast-in-situ techniques, around 60% of the total concrete was precast concurrently with foundation work, resulting in a 50% reduction in construction time[12].

## Conclusion

- Certain project requirements, such as those of long-span bridges, metro systems, and urban viaducts, are addressed by various precast girder types, such as I-, box-, and U-girders.
- While methods like as span-by-span, full-span, and incremental launching offer flexibility and efficiency, they must be carefully chosen in accordance with project objectives.
- Precast girders provide long-lasting, high-quality solutions for bridges and major infrastructure projects, making them essential for modern construction.
- Successful project outcomes depend on implementing thorough safety regulations, enhancing construction worker training, and making investments in top-notch equipment.

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