International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 03 | Mar 2026 www.irjet.net p-ISSN: 2395-0072

Advancement of Construction methodology in Water Sector

Rajesh Paul[1], **Pinaki Chattaraj**[2]

[1]*Joint General Manager, Larsen & Toubro Construction, Tamil Nadu, India*
[2]*Senior Engineering Manager, Larsen & Toubro Construction, Tamil Nadu, India (Chartered Engineer, The Institute of Engineers (India), AM1811795)*

***

Abstract – *Construction practices in the water sector have historically been characterized by limited mechanization and a high dependence on manual labour, resulting in lower productivity, safety concerns, quality variability, and extended project timelines. With the increasing scale, complexity, and performance requirements of modern water and wastewater infrastructure projects, there is a critical need to adopt advanced and mechanized construction methodologies due to reduce project timeline.*

This paper presents an overview of recent advancements in construction practices implemented in the water sector, focusing on the transition from labour-intensive methods to mechanized and technology-driven approaches. The study discusses optimized construction sequencing, prefabrication, and industrialized construction techniques in large-scale water infrastructure projects.

The paper evaluates the impact of these advanced methodologies in terms of improved productivity, enhanced safety standards, superior quality control, and accelerated project execution. The study concludes that the adoption of advanced construction methodologies is essential for achieving sustainable, efficient, and timely delivery of water sector projects, particularly in rapidly urbanizing and infrastructure-driven economies.

***Key Words*: Water Infrastructure, Advanced Construction Methodologies, Mechanized Construction, Productivity Improvement, Sustainable Infrastructure**

1. Introduction

Large-scale water sector projects typically involve the construction of a substantial number of valve chambers distributed over wide geographical areas. Conventional cast in-situ construction of valve chambers is highly labour-intensive, time-consuming, and often constrained by variability in workmanship and quality control. Managing formwork, reinforcement fixing, concreting, and curing at scattered locations further increases execution time and dependency on skilled labour resources. To address these challenges, this paper presents a case study on the adoption of precast valve chambers as an alternative to conventional cast in-situ construction. The precast approach significantly reduces on-site labour engagement, accelerates construction timelines, and ensures consistent quality through controlled factory production.

In addition, underground and above-ground reservoirs constitute critical and frequently recurring components of water infrastructure projects. In conventional practice, the construction of reservoir roof slabs involves extensive formwork, staging, and prolonged construction period, making it one of the most time-consuming activities in project execution. This paper also discusses a second case study highlighting the recent advancement in the use of precast hollow-core roof slabs for reservoir structures. The adoption of hollow-core slabs eliminates the need for conventional formwork, shortens construction cycles, and enhances structural quality and durability.
Together, these case studies demonstrate how industrialized and precast construction methodologies can effectively transform execution efficiency, labour optimization, and quality standards in large-scale water sector projects.

1.1 Case Study1: Precast Valve Chamber

In a recent large-scale water transmission project executed in the Saudi region, a total of thirty-four (34) valve chambers were required to be constructed along an extensive pipeline corridor to accommodate Washout valves, Isolation valves, and Air valves. Valve chamber had a typical plan dimension of approximately 2.6 m × 5.2 m, with depths varying between 4.0 m and 5.0 m depending on pipeline profile and hydraulic requirements.

1.1.1 Challenges

The pipeline alignment passed through a designated royal reserve area, where environmental and access restrictions severely limited conventional site-based construction activities. Cast in-situ construction was not permitted due to restrictions on prolonged site occupation, extensive formwork,concrete pouring activities, and labour deployment.

Although precast construction was identified as the most viable alternative, the site posed additional constraints related to equipment and logistics. Restricted access roads and limited working platforms prevented the deployment of very high-capacity mobile cranes exceeding 300 t, which are typically required for lifting precast valve chambers. These constraints necessitated the development of an alternative precast strategy that balanced constructability, safety, and structural integrity

1.1.2 Mitigation Measures and Engineering Solution

To overcome the above constraints, the valve chamber design was optimized by subdividing the structure into multiple precast rectangular wall segments instead of a single monolithic unit.

Each precast wall element was designed with reduced individual weight, enabling safe lifting and erection using mobile cranes with capacities not exceeding 300 t.

Vertical Pipe sleeve was kept during pre-casting to create hole at 500mm c/c spacing along wall periphery. After Raft segment placed, Vertical rebar placed through hole & aligned. To maintain accurate alignment of vertical rebar passing through hole and to avoid construction tolerances affecting fitment, PVC cover blocks were provided within the sleeves. This ensured correct positioning of vertical reinforcement bars.

The wall panels were erected sequentially by positioning them over the protruding vertical reinforcement bars, ensuring accurate alignment and stability during erection. Structural continuity between the panels was achieved by grouting the vertical joints after completion of erection, with grout placement carried out from the top of the chamber to ensure full encapsulation and bond.

Air vent was provided to facilitate proper grout flow & to prevent air entrapment, the vents were sealed once grout egress was observed.

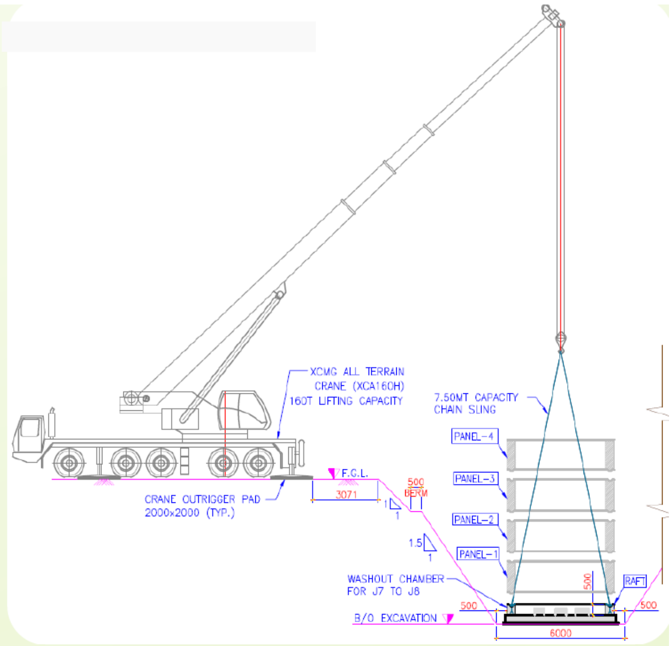

Fig. 1: Typical sketch of precast erection

Fig.2: Precast segments erected & aligned

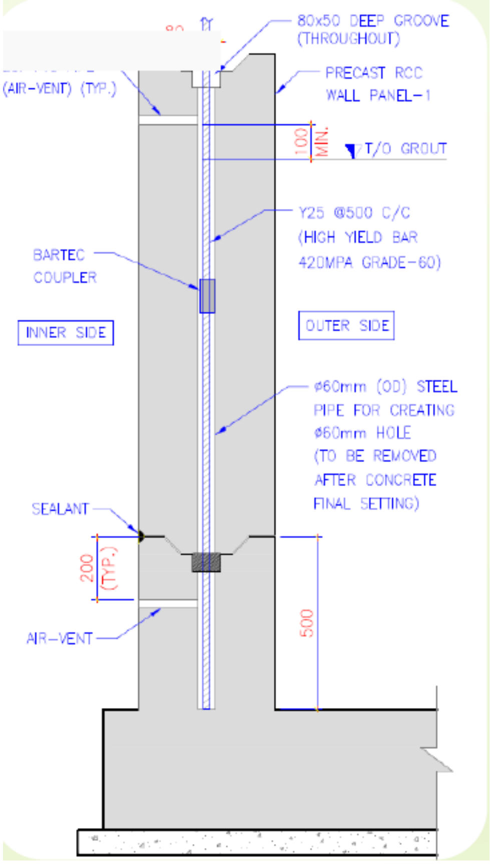

Fig. 3: Typical segmental joints

Fig.4: Raft Precast segment erection

Fig.5: Wall Precast segment erection

Fig.6: Raft & Wall segment aligned

1.1.3 Advantage & Outcomes

The adopted precast segmented construction methodology enabled safe and timely execution of valve chambers despite severe access and environmental constraints. The reduction in individual precast element weight allowed erection using available crane capacities.

The approach significantly reduced on-site labour requirements, formwork activities, and construction duration while ensuring superior quality through controlled precast production. Overall productivity was enhanced, safety risks associated with deep excavation and cast in-situ works were minimized, and consistent dimensional accuracy and finish quality were achieved across all valve chambers.

1.2 Case Study 2: Adoption of Hollow-Core Roof Slabs in Reservoir Structures

In the same project, couple of partly underground service reservoirs with a typical plan dimension of approximately 52 m × 22 m were constructed as part of the water storage and distribution system. Conventionally, reservoir roof slabs in such structures are executed using cast in-situ reinforced concrete systems, either as flat slabs supported on columns or as beam–slab arrangements. While structurally effective, these conventional systems are highly dependent on extensive formwork, staging, and sequential concreting operations, making them time-consuming and labour intensive, particularly in large-area reservoir structures.

1.2.1 Challenges

The conventional cast in-situ roof slab construction involved significant challenges, including large quantities of formwork and falsework, prolonged construction period due to staged shuttering and de-shuttering operations, and high manpower deployment for reinforcement fixing, shuttering, and concreting activities. Additionally, maintaining consistent quality and dimensional accuracy over large roof areas posed difficulties, especially under tight project schedules and labor availability constraints.

1.1.2 Mitigation Measures and Engineering Solution

To address these challenges, a precast pretensioned hollow-core roof slab system was adopted and structurally designed to cater to the applicable dead loads, live loads, and serviceability requirements of the reservoir roof. The hollow-core slab panels were standardized with a typical width of 1.2 m, while the spans were 7.0m to 8.5m based on structural layout and loading conditions.

The hollow-core panels were erected directly over the supporting structural elements, eliminating the need for conventional formwork and staging. A structural screed layer was poured in-situ above the hollow-core slabs to ensure water tightness and provide a monolithic finished surface. All slab panels were installed using a single 90t mobile crane, demonstrating the constructability and efficiency of the adopted system even with moderate lifting equipment.

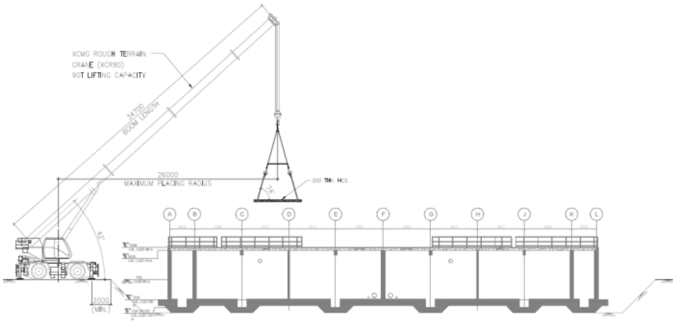

Fig 7: Typical erection scheme section

Fig 8: Typical erection of Hollow Core slab panel

Fig 9: Webbing Sling fixing in Hollow Core Slab

1.1.3 Advantage & Outcomes

The adoption of hollow-core roof slabs resulted in a substantial reduction in formwork and falsework requirements, leading to faster construction cycles and reduced site congestion. On-site labour demand was significantly lowered, and overall construction safety was enhanced by minimizing work at height and temporary staging. The precast system ensured superior surface finish, dimensional accuracy, and consistent quality. Overall, the methodology contributed to improved productivity, reduced construction time, and reliable performance of reservoir roof structures, highlighting the effectiveness of precast solutions in large-scale water infrastructure projects.

Table-1: Comparison between Conventional & advanced construction method

Parameter	Conventional	Advanced method
Construction methodology	Cast In-situ	Precast
Formwork	Extensive	Minimal to nil
Labour	High labour dependency	reduced on-site labour
cycle time	Long cycle	Shortened cycle
Quality	Site-dependent	Factory-controlled
Site access	Requires prolonged site access	Suitable for restricted and environmentally sensitive areas
Equipment	Conventional concreting equipment	Moderate capacity mobile crane
Safety	Higher risk	Improved safety
Environmental impact	Higher site disturbance	Reduced site footprint
Productivity	Moderate	High

2. Conclusions

The case studies presented in this paper demonstrate that advanced and mechanized construction methodologies significantly improve efficiency, quality, and safety in large-scale water sector projects. Conventional cast in-situ construction, though widely practiced, often leads to high labor dependency, longer construction cycles, and variability in workmanship, particularly for dispersed structures and large spans.

The adoption of segmented precast valve chambers enabled safe and timely execution under severe environmental and access constraints, while substantially reducing on-site labor, formwork, and reliance on heavy lifting equipment. Similarly, the use of precast hollow-core roof slabs in reservoir structures eliminated extensive formwork and staging, shortened construction cycles, and ensured superior dimensional accuracy and surface finish.

These case studies clearly establish the effectiveness of industrialized precast construction in overcoming site constraints, optimizing resource utilization, and achieving consistent quality standards. The study concludes that wider adoption of advanced construction methodologies is essential for enhancing productivity, sustainability, and reliability in water infrastructure projects, and should be promoted as a standard practice in future large-scale developments.

References

The precast valve chamber and hollow-core slab systems were designed and executed in accordance with below mentioned standards

I. Building Code Requirements for Structural Concrete, American Concrete Institute, (ACI 318-19)

II. Code Requirements for Environmental Engineering Concrete Structures (ACI 350-20)

III. III ASCE 7-22 Minimum Design loads for Building and Other structures

IV. International Building Code (IBC)

V. PCI-MNL 126-“ Manual for the design of hollow core slab”

VI. PCI Design handbook for precast & prestressed concrete

VII. Saudi building code SBC

BIOGRAPHIES

Mr. Rajesh Paul, Head of Construction Method & Planning Cell, Water & Effluent Treatment Group, L&T Construction

Mr. Pinaki Chattaraj, Sr. Engineering Manager in Construction method & Planning Cell, Water & Effluent Treatment Group, L&T Construction