# Research on Efficiency Improvement Methods for Coordinated Construction of Municipal Roads, Bridges, and Water Supply Pipelines

**Guiqin Li**

Huainan Municipal Gardens and Landscaping Construction Department, Hefei, Anhui, 232000, China

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**Abstract:** This paper analyzes the construction processes and coordination requirements of municipal road, bridge, and water supply pipeline projects, addressing issues such as cross-conflicts, resource waste, and project delays that often arise when these projects are carried out separately. To enhance coordinated construction efficiency, comprehensive methods are proposed from four aspects: construction schedules, resource and site sharing, simultaneous survey and design, and the establishment of a coordinated communication mechanism. Through systematic research, the operational key points of each coordination method are clarified, resolving issues such as poor construction linkage between the two types of projects, low resource utilization, and poor design adaptability. These methods achieve the effects of reducing construction conflicts, lowering costs, and shortening project durations, providing a feasible technical and management framework for the coordinated construction of municipal roads, bridges, and water supply pipelines, and offering reference significance for improving the overall construction efficiency of municipal engineering projects.

## 1. Introduction

Municipal roads, bridges, and water supply pipelines are crucial components of urban infrastructure construction, with their construction areas often overlapping and each having specific construction process requirements. Under the traditional separate construction model, due to a lack of overall coordination, conflicts between the two types of projects in terms of work space and construction pace are prone to occur. This not only increases construction costs but may also affect project quality and progress due to repeated excavations and rework, even causing disruptions to normal urban traffic and residents' lives. With the continuously rising demands for efficiency and quality in urban construction, how to achieve efficient coordinated construction of municipal roads, bridges, and water supply pipelines has become an urgent issue in the field of municipal engineering. Based on this, this paper delves into efficiency improvement methods for coordinated construction by combining the construction process characteristics of these two types of projects, aiming to provide ideas for optimizing municipal engineering construction models and promoting high-quality infrastructure construction.

## 2. Construction Process of Municipal Roads and Bridges

First, conduct site surveys to clarify geological conditions, then clear the construction area by removing obstacles and leveling the site. Perform foundation reinforcement according to design requirements, using methods such as replacement, compaction, or grouting to enhance the foundation's bearing capacity. Pour bridge foundations, including spread foundations and pile foundations, ensuring that the foundation depth and strength meet load requirements. For the construction of bridge substructures, first bind the reinforcement for piers and abutments, set up formwork, and after passing the inspection, pour concrete and cure it to the design strength. If the superstructure is a cast-in-place beam, set up supports, lay bottom formwork, bind reinforcement, install prestressed pipes, then pour beam concrete, tension prestressed tendons, and perform grouting. If it is a prefabricated beam, carry out beam prefabrication, transportation, and lifting for

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precise connection and installation. After the main structure is completed, clean the bridge deck base layer and lay a waterproof layer, pour or lay the bridge deck pavement layer according to the design thickness, and simultaneously install the bridge deck drainage system. Finally, construct ancillary facilities such as guardrails, expansion joints, and lighting, and then conduct quality inspections and acceptance to ensure compliance with traffic standards.

## 3. Construction Process of Municipal Water Supply Pipelines

Conduct on-site measurement and setting-out according to design drawings to determine pipeline routes and elevations and set control stakes. Excavate trenches according to the excavation depth and slope, and take support measures to prevent collapses when the depth is significant[1]. Flatten and compact the trench bottom, and perform replacement treatment if soft soil is encountered to ensure a stable foundation for pipeline laying. Select corresponding connection methods based on the pipe material: PE pipes use hot-melt or electro-fusion connections, steel pipes use welding or flange connections, and ductile iron pipes use spigot-and-socket connections. Lay the pipelines accurately according to elevations and slopes, and conduct sealing and pressure tests after connection to ensure no leakage. After the pipeline passes inspection, backfill the trench in layers, ensuring that the compaction degree of each layer of backfill meets requirements to prevent pipeline deformation under pressure. Install ancillary facilities such as valves, fire hydrants, and water meters, connect branch pipes and user interfaces, and then conduct system flushing and disinfection to ensure that the water supply quality meets standards before final handover and acceptance.

## 4. Efficiency Improvement Methods for Coordinated Construction of Municipal Roads, Bridges, and Water Supply Pipelines

### 4.1 Unified Planning of Construction Schedules

Comprehensively sort out the construction process lists of the two types of projects, clarifying key processes in road and bridge construction such as foundation treatment, main structure pouring, and bridge deck pavement, as well as core links in water supply pipeline construction such as pipeline measurement, trench excavation, pipeline laying, and backfilling, and mark the construction periods and required preconditions for each process[2]. Analyze the logical relationships between processes, prioritize determining the sequence of "irreversible" and "widely influential" processes. For example, trench excavation for water supply pipelines requires excavation to a depth of 2–3 meters underground. If carried out after road and bridge foundation treatment, it may damage the compacted foundation. Therefore, it is necessary to clarify the core sequence of "completing pipeline laying and trench backfilling before carrying out road and bridge foundation reinforcement." For the construction of road and bridge deck pavements and pipeline ancillary facilities, plan "completing valve well pouring before conducting bridge deck pavement" to avoid secondary excavation and road surface damage after pavement. Develop a detailed schedule table, use Gantt charts to mark the start and end times of each process, reserve a 10%–15% buffer period to cope with unforeseen circumstances, and clarify the responsible units and linkage persons for each process. After pipeline backfilling is completed, the pipeline constructor shall hand over the site to the road and bridge constructor in writing, and the road and bridge constructor shall initiate foundation treatment within 3 working days to ensure uninterrupted scheduling[3]. Establish a dynamic scheduling control mechanism, hold weekly meetings on scheduling implementation, compare actual progress with planned progress, and if pipeline laying is delayed, promptly adjust the start time of road and bridge foundation construction or optimize road and bridge construction processes to avoid cumulative project delays.

### 4.2 Sharing Construction Resources and Sites

In terms of resource sharing, establish a resource coordination team to complete resource demand statistics for the two types of projects 30 days before project commencement, including the models, usage periods, and quantities of large machinery such as excavators, cranes, and rollers, as well as the skill requirements and employment periods of professionals such as surveyors, welders, and concrete workers[4]. Establish a resource-sharing ledger, clarify the ownership units of machinery and personnel, and formulate sharing rules. For example, the excavator used in road and bridge foundation excavation can be deployed to trench excavation for pipeline construction after completion. The requesting party shall submit an application to the ownership party 24 hours in advance, specifying the usage time and work scope, and the ownership party shall respond within 4 hours. In terms of personnel sharing, if there is a shortage of welders for pipeline construction, qualified welders can be transferred from the road and bridge construction side, and the resource coordination team shall coordinate salary settlement and safety training to ensure that personnel skills meet operational requirements. Establish a resource maintenance mechanism. After shared machinery is used, the user shall be responsible for daily maintenance, and the ownership and user parties shall jointly conduct performance inspections monthly to avoid machinery failures due to improper maintenance. Shared personnel shall uniformly participate in safety briefings and technical training to ensure familiarity with the construction specifications of the two types of projects and reduce operational errors. In terms of site sharing, conduct overall planning of the construction area, dividing it into four functional zones: "core operation zone," "material storage zone," "temporary office zone," and "machinery parking zone," among which the material storage zone and temporary office zone are shared. Rebar and cement for road and bridge construction and pipe materials and valves for pipeline construction can be stored separately in the same material storage zone, with clear signs, and equipped with common rain shelters and fire-fighting facilities. Each side shall appoint one manager to jointly be responsible for site management. The temporary office zone shall share facilities such as conference rooms and reference rooms to avoid redundant construction. Optimize site traffic flow design, plan dedicated material transportation and personnel access routes to ensure that concrete transport vehicles for road and bridge construction and pipe material transport vehicles for pipeline construction do not interfere with each other, reducing site congestion[5]. The machinery parking zone shall be divided by machinery type, and share maintenance tools and refueling equipment to improve site utilization.

### 4.3 Simultaneous Survey and Design

In the survey stage, formulate a joint survey plan, clarify the survey scope, survey point layout principles, and survey content. Conduct on-site survey operations, with the joint survey team adopting a "simultaneous survey, data sharing" model, using the same geological exploration drill to continue operations at adjacent pipeline survey points after completing road and bridge foundation surveys, and recording survey data in real-time into a unified database. Road and bridge survey engineers and pipeline survey engineers shall jointly analyze the data. If a high groundwater level is found in a certain area, they shall jointly assess its impact on the anti-floatability of road and bridge foundations and the anti-corrosion of pipelines, and form a joint survey report to avoid design deviations caused by fragmented survey data[6]. Organize a survey results briefing, invite road and bridge designers and pipeline designers to participate, and the joint survey team shall explain the survey data in detail and answer questions raised by the designers to ensure that the designers fully grasp the site conditions. In the design stage, establish a joint design team, hold design communication meetings twice a week to share design progress and technical difficulties. When the road and bridge designer determines the position of bridge pier foundations, they shall inform the pipeline designer in a timely manner, and the pipeline designer shall adjust the pipeline route accordingly to avoid conflicts between pipelines and bridge pier foundations. When the pipeline designer determines the position of valve wells, they shall consider the flatness of the road and bridge deck pavement to avoid valve well protrusions affecting bridge deck traffic. If unavoidable, they shall jointly design "sunken valve wells" with the road and bridge designer to ensure that the well cover is flush with the bridge deck. Carry out collaborative optimization of design schemes. If a large-span beam is adopted for road and bridge design, calculate the pressure of the beam's self-weight on the foundation, and the pipeline designer shall adjust the pipeline burial depth accordingly. If PE pipes are adopted for pipeline design, inform the road and bridge designer of the anti-impact performance of PE pipes, and the road and bridge designer shall avoid drain outlets directly facing the pipelines when designing the bridge deck drainage system to reduce the impact of water flow on the pipelines. Organize a joint review of design schemes, invite survey units, construction units, and supervision units to participate, and review the design schemes from the perspectives of construction feasibility, cost control, and safety performance[7]. If the review finds that the road and bridge foundation treatment scheme increases the risk of trench collapse for pipeline construction, the road and bridge designer and pipeline designer shall jointly adjust the scheme to ensure that the design schemes meet the respective functional requirements of road and bridges and pipelines while being mutually compatible, reducing post-construction adjustments.

### 4.4 Establishing a Coordinated Communication Mechanism

At the organizational structure level, formulate a regular communication system, with the coordination team holding an offline coordination meeting once a week. Twenty-four hours before the meeting, both construction parties shall submit a "Weekly Construction Progress Report" and a "List of Issues Requiring Coordination." The report shall include completed processes, plans for the next week, and existing problems, and the issue list shall clearly describe the problem, its impact range, and the expected resolution time. During the meeting, the team leader shall preside and discuss solutions to issues one by one. If cracks appear on the pipeline trench slope due to the vibration of the road and bridge roller, the road and bridge constructor shall adjust the roller's operation route, and the pipeline constructor shall reinforce the slope, clarifying the responsible unit and completion time limit. Within 24 hours after the meeting, a "Coordination Meeting Minutes" shall be formed and sent to all participating units to ensure that all parties are aware and implement the decisions. Establish an emergency communication mechanism. In case of unexpected issues, both construction parties shall notify the coordination team leader within 1 hour, and the leader shall organize relevant units to hold an emergency meeting within 2 hours to formulate emergency response plans and avoid issue escalation. At the same time, clarify an emergency contact person system, with each party arranging a full-time person to be on duty 24 hours a day to ensure timely communication in case of emergencies[8]. At the information platform level, improve platform functions and information entry mechanisms. The "Progress Management" module shall be updated daily by both construction parties with construction progress, and on-site construction photos and videos shall be uploaded, allowing the coordination team to view progress in real-time and compare planned and actual progress deviations. The "Quality Inspection" module shall be used by the supervision unit to upload quality inspection data for the two types of projects, which both construction parties can view at any time to ensure transparency of quality information. The "Issue Feedback" module allows both construction parties to submit issues requiring coordination online, mark the urgency of the issues, and the coordination team shall respond within 24 hours and provide solutions online. The "File Sharing" module shall upload design drawings, survey reports, meeting minutes, safety regulations, and other files to ensure that all parties have access to the same version of files and avoid construction errors due to outdated file updates[9]. Establish a platform usage assessment mechanism, requiring both construction parties to complete progress and quality information entry before 18:00 daily, and the supervision unit shall assess the timeliness and accuracy of information entry weekly, with assessment results linked to project progress payments to ensure the effective operation of the platform.

## 5. Conclusion

Through the above analysis, it can be seen that improving the coordinated construction efficiency of municipal roads, bridges, and water supply pipelines relies on multi-dimensional and systematic methods. Unified planning of construction schedules can effectively avoid cross-operation conflicts and ensure orderly construction progress by sorting out process logic, clarifying sequences and linkage responsibilities. Sharing construction resources and sites breaks down resource barriers between the two types of projects, enabling efficient reuse of machinery, personnel, and sites, significantly reducing construction costs and improving resource utilization efficiency.

Simultaneous survey and design reduce post-construction adjustments and enhance the adaptability and feasibility of design schemes by sharing survey data through joint surveys and collaboratively optimizing design schemes. Establishing a coordinated communication mechanism can promptly solve cross-issues during construction, ensure information synchronization, and improve decision-making and execution efficiency through regular meetings and a unified information platform.

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