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

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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

In urban infrastructure construction, municipal roads, bridges and water supply pipelines are three main components that have overlapping construction areas but their own specific requirements aren e. Under the conventional split construction mode, due to a lack of overall organization, there is an easy occurrence of work space contradiction and construction pace between civil engineering and equipment installation projects. Not only does this inflate the cost of construction, but project quality and construction progress can suffer with repeated excavations and rework. As the need for efficiency and quality in urban construction rises unceasingly, how to achieve high-efficiency coordination construction of municipal roads, bridges and water supply pipelines has become an urgent problem puzzling the municipal engineering field. In view of this, this paper studies methods for improving efficiency of coordinated construction and product feature combination to provide ideas for optimal municipal engineering construction model and high-quality infrastructure construction.

2. Construction Process of Municipal Roads and Bridges

Site surveys are completed to clarify geological conditions at first, followed by site clearing, which involves working in the construction area to remove obstacles and level the site. Of which, carry out the foundation reinforcement according to design requirements, use replacement / compaction / grouting method (or other methods) to improve the bearing capacity of the foundation. In bridge foundation works, including spread foundation and pile foundations, ensuring the design of depth and strength satisfy the loads. To construct the substructures of bridge components i.e Piers and abutments, first you must bind reinforcement, follow up with formwork and after passing the inspection proceed to pour concrete and allow it to cure until reaching designed strength. If the superstructure is a cast-in-situ beam, install supports, place bottom formwork, bind reinforcement, add pre-stressed pipes, cast beam concrete then tension prestressed tendons and perform grouting. For pre-manufactured beam, carry out the activities such as beam prefabrication, transportation and lifting for accurate connection and installation. Phase III (Bridge Deck Pavement Layer)After completing the main body, clean up the bridge deck base layer and lay a waterproofing layer, then pour/lay a concrete bridge deck pavement layer according to design thickness and simultaneously install the bridge deck drainage system. At last the corollary works including guardrails, expansion joints and lighting are made, quality inspection and acceptance activity is performend to guarantee traffic standard.

3. Construction Process of Municipal Water Supply Pipelines

Site measurement and laying-out based on design drawings to find pipeline routes, elevations, set control stakes. Excavation trenches in accordance with the excavation depth and slope, so as to take support measures to prevent collapse when deep [1]. The trench bottom should be compacted and filled up. If soft soil is encountered, replacement treatment shall be carried out to ensure no subsidence occurs due to the laying of the pipeline. According to the pipe material, choose a pipe connection: PE pipes can be hot-melt or electro-fusion;steel pipes welded and flange connection;ductile iron with spigot-and-socket connections. Laying of pipeline as per the elevations and slopes with accurate pipe fittings, pressure testing recorded in case from seals to ensure there shall be no leakages. Backfill the trench through layer by layer after inspection, and requires each backfill soil degree of compaction to meet requirements, so as not to cause deformation of the pipeline under pressure. In the final stage, Install auxiliary facilities (valves, fire hydrants and water meters), connect branch pipes and user interface, then rinse and disinfect the system to determine whether the water supply quality meets standards before handing over.

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

4.1 Unified Planning of Construction Schedules

To systematically tidy up the construction process lists of other two types of projects, define critical processes in road and bridge construction from foundation treatment (main structure pouring, and bridge deck pavement) to pipeline measurement, trench excavation, pipeline laying and backfill in water supply pipeline construction while assigning the duration time and prerequisites for achieving each specific process [2]. Derive the logical relationships between processes, but above all determine the priority for the sequencing of "irreversible" and "widely influencing" processes. For instance, trenching for the water supply line needs digging to depths of 23 meters under ground. If done post-treatment of road and bridge foundations, it can cause damage to the compacted foundation. Thus, it is to generalize that the core sequence of "before highway bridge foundation reinforcement should be completed pipe laying and backfill trench" For topographic area road and bridge deck pavement and pipeline subsidiary facilities for concrete placement, plan "Valve well pouring, bridge deck pavement", in order to prevent secondary excavation and damage the road surface after the cavity before paving. Create a Detailed Schedule Table, marking the beginning and end times of each process in Gantt chart style; reserve 10%-15% of time as a buffer for emergency situations; clarify the responsible units and linking persons for each process. When the backfilling of the pipeline is completed, the constructor of the pipeline shall hand over to the road and bridge constructor in writing, and within 3 working days after receiving the handover notice, the road and bridge constructor shall carry out foundation treatment so as not to affect scheduling [3]. Build a dynamic scheduling control mechanism, hold weekly meetings on scheduling implementation, compare actual progress with schedule progress, and delay in pipeline laying area can quickly adjust the start time of road and bridge foundation construction or reasonable optimization construction process to avoid cumulative project delays.

4.2 Sharing Construction Resources and Sites

Regarding resource sharing, set up a resource coordination team to finish the statistics of resource demand in advance for both types of projects 30 days prior to project start with information on large machinery such as excavators and cranes (based on models, usage periods, and daily units), rollers (daily units) within non-matrix fields regarding foreign integration; implementation professionals (in regard to skills and employment period) where cluster/matrix field methods are applied which include surveyors, welders, concrete workers [4]. Create a ledger used for resource sharing, specify the property unit of tool and personnel share and make the rules for sharing. Take the excavator used in road and bridge foundation excavation as an example after completion, it can switch to trench excavation for pipeline construction. The applicant shall apply to the owner at least 24 hours before use, indicating the time and scope of work, and the owner has 4 hours to respond. From the aspect of personnel sharing, when pipeline construction needs a large number of welders and there are no corresponding numbers, qualified welders can come from the road and bridge construction side.In this case, project implementation should rely on resource coordination team to coordinate salary settlement and safety training with departments, ensure arrival or account displacement wage payments meet work needs, staff skills meet construction operational requirements. Establish a resource maintenance mechanism. The user will be responsible for the daily maintenance when using shared machinery, and both ownership and user parties shall jointly perform monthly performance inspections due to failure of machinery caused by improper maintenance. Common personnel must participate in the same safety briefings and technical trainings so that all workers are familiar with the construction specifications for both types of project and thus help to reduce operational mistakes. Site Sharing: Carry out the overall planning of the construction area, dividing into four functional areas : "core operation zone", material storage zone ", temporary office zone" and "mezzanine parking area" among which material storage area and temporary office zone share. Rebars and cements in concrete, road construction, and bridge construction can be stored together separately in the same type of storage area as long as easy safety signs are used including plastic-lined lining covers along with rain covering devices and fire-fighting facilities. A single manager appointed by each side shall be responsible for management of the site. To eliminate unnecessary construction, facilities including conference rooms and reference rooms will also be shared within the temporary office zone. Design the flow of people and vehicles entering and exiting the site rationally, formulate dedicated transportation channels for materials (including concrete used BHP in road construction) in special areas to prevent other vehicles from interfering with each other, so as to reduce congestion on the site source [5]. Site Machinery parking area will be divided according to machinery type and sharing-maintenance tools & refueling equipment to increase site utilization.

4.3 Simultaneous Survey and Design

At the survey stage: Jointly formulate a survey plan, clarify the survey scope and principles of layout of survey points and content. On-site survey operations, the joint survey team implements a model of "simultaneous survey, data sharing", uses geological exploration drill gas with drilled road and bridge foundation test points work place pipeline measured active position sequencer site continue to adapt measures real time recording records post in unified database. The survey engineers of roads and bridges and pipeline shall conduct a synergistic analysis of the data. That is, if no high groundwater level exists in the design area, they shall jointly evaluate the effect of anti-floatability on road and bridge foundations and anticorrosion pipelines, form a joint survey report to prevent design deviation caused by fragmented survey data [6]. Hold a briefing on survey results and invite road and bridge designers and pipeline designers to participate; the joint survey team gave a detailed introduction to the survey data, at the same time answered questions raised by designers so that designers will have an in-depth understanding of site conditions. During the design phase, form a joint design team with biweekly design communication meetings to exchange design status and technical challenges. The road and bridge designer must notify the pipeline designer in a timely manner of the location of bridge pier foundations, so that the pipeline designer can adjust the pipeline route to avoid conflicts between pipelines and bridge pier foundations. When the position of valve wells is determined by the pipeline designer, flatness of road and bridge deck pavement should be considered to avoid affecting traffic in the area along bridges due to protrusion of valve wells. If not avoidable, they will co-design "sunken valve wells" with the road and bridge designer so that the well cover sits flush to the bridge deck. Implement the collaborative optimization of design schemes. If the large-span beam applied to road and bridge design, the pressure of the self-weight on foundation should be calculated, and then adjust burial depth of pipeline by designer judgment. If PE pipes are chosen for the pipeline design, notify road and bridge designer on the anti-impact performance of PE pipes, then avoid drain outlet directly facing when designing bridge deck drainage system improving water flow collision to pipelines. Arrange for same-day review of design scheme, closely convene the survey unit, construction unit and supervision unit to participate in reviewing the design scheme from construction feasibility, cost control and safety performance quality [7]. If the review determines that the road and bridge foundation treatment scheme increases the risk of trench collapse when building pipelines, then both parties should work together to adjust the scheme jointly to ensure that the design schemes are compatible and can meet each other functional requirements (for roads or bridges as well as pipelines), this helps in reducing post-construction adjustments.

4.4 Establishing a Coordinated Communication Mechanism

Define an entire communicating system in terms of the organization structure, with the team holding offline coordination meeting once a week. This report shall identify in writing both construction parties at least twenty-four (24) hours prior to the meeting and shall include a "Weekly Construction Progress Report" and a "List of Issues Requiring Coordination." The report will include finished processes, upcoming agenda for the next week and existing issues (the issue list shall describe clearly the problem, its scope of impact and the resolution time). In the meeting one person will lead the team to talk about solutions to problems individually. If it found that there are cracks on the bank slope of pipeline trench caused by the vibration of road and bridge roller, the road and bridge engineer shall adjust the operation route or trajectory of road and bridge roller, The slope shall be reinforced by Pipeline construction unit. It is clear who is responsible for handling and when to complete it. Not later than 24 hours after the meeting, a "Coordination Meeting Minutes" shall be prepared and circulated to all units that participated in order to inform everyone in order for some decisions taken by the group members can be implemented. Establish an emergency communication mechanism. If there are any unforeseen issues, both sides of the construction should notify the coordination team leader within 1 hour, and the group leader should organize relevant units to hold an emergency meeting within 2 hours to study emergency response plans and prevent problems from expanding. Simultaneously, clear a person system of contacting emergencies; with each side needing to organize one full-time individual on duty throughout the day, consistently staying accessible to discuss wellbeing crises [8]. At the Info platform level, upgrade platform functionalities and info input methods. The module called "Progress Management" will be updated daily by both the construction parties with the actual construction progress, on-site photos and videos of the construction shall also be posted where finally, this makes it possible for the coordination team to access real-time progress view that allows to make a deviation between planned and actual progress comparison. The supervision unit logs onto the "Quality Inspection" module to upload relevant quality inspection data of two types of projects, and both sides of construction parties can check it anytime and anywhere so that the transparency of quality information is realized. Issue Feedback: construction parties submit issues that need to be coordinated through the Internet, trigger a coordination online within 24 hours and communicate solutions online; mark urgency of issues. This would be achieved by the "File Sharing" Module, which WILL UPLOAD Design Drawings, Survey Reports Meeting Minutes or Safety Regulations and other files in such a way that every party has access to the same version of files so as to prevent any construction error due to file updates not being made [9]. Establish appraisal mechanism for platform convenience usage, write down the progress and quality data by both parties involved in construction respectively before 18:00 every day, the supervision unit can review on a weekly basis the timeliness and accuracy of information writing action and assess results so as to link these with project fund payment. Collaborate from the perspective of jointly ensuring that this element is working as well.

5. Conclusion

The above analysis shows that, aiming at stimulating the construction of municipal roads, bridges and water supply pipelines across multiple dimensions, compared with reforming traditional methods to improve overall efficiency. Unified planning of construction schedules can avoid cross-operation conflicts, It ensures the orderly progress of construction through sorting out process logic and clarifying sequences and linkage responsibilities. Construction resource and site sharing separates resource barriers between projects of both types, conducts efficient reuse of machinery, personnel and construction sites, greatly reduces the cost risk in construction, and raises efficiency for usage of resources. Simultaneous survey and design mitigate the need for post-construction adjustments, increase the adaptivity and applicability of design plans by jointanting society data production using similarly execute surveys, collaboratively optimizing design plans. A coordinated communication mechanism established in advance can quickly solve cross-issues during the construction process, achieve information synchronization and unity of understanding and will help to improve efficiency in decision-making and execution through regular meeting updates and a shared source of information.

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