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Exploring Delays of Korea Express Railroad Project using Macro – Microscopic Approach

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Abstract
In April 2004, Korea has become the 5th country to own and operate the high speed railroad. However, there were many difficulties until Koreans enjoy it. The high speed railroad requires elevated quality standards differently from traditional railways. In addition to the technical difficulties, the construction project itself was an unpleasant case with huge delays and cost overruns mainly due to the lack of experience, poor project planning, and environmental concerns. This paper analyzes the reasons for delays on this mega-project. The route of the railway is divided into three sections which have different characteristics. Furthermore, it is very complicated and linear project, whose total length is around 412 km. Subsequently, the analysis is performed in both macro and micro level. First, macroscopic analysis such as S-curve comparison responsibilities of participants on the causes of delay is performed to find any critical sections in the railway route that induce the significant delay in opening day. Then, microscopic analysis is followed to quantify the causes and effects of delays focused on these critical sections in more detailed way. Finally, this paper provides lessons learned from this project to avoid the decisive delays in performing the similar large-scaled projects.

Keywords
Delay analysis, High-speed railway, Causes of delay, Macro-Microscopic analysis

1. Introduction
Korea high speed railway construction project, so called KTX (Korea Train eXpress) project was planned in 1992 as a national blueprint to taking the role of the logistic hub in Northeast Asia. The initial plan was set up to constructs the railway system from Seoul to Busan within 6 years, whose total length is 412 km (see figure 1). However, this large-scaled project has faced with severe obstacles, which resulted in the huge increase of cost and time. The budget was grown up from 5 billion dollars to 16 billion dollars and the duration of construction extended from 6 years to 18 years. In short, project cost increased about three times and the duration increased more than three times the original plan, which led to the burden on the public. To make it worse, due to the huge increases in cost and time, the government changed its initial plan toward stepwise construction. As the first step, KTX were completed and opened in the partial route from Seoul to Daegu in 2004. The second phase from Daegu to Busan will be finished by the time of 2010.

Figure 1. Korea High Speed Railway (Seoul-Busan Line)

As stated, a series of unexpected factors can affect the original plan negatively. Consequently, it is important to manage and prevent these causes in the changeable environments. This case study of KTX project can be a good lesson from a viewpoint of project management. It was faced with huge delays and cost overruns, which are mainly due to the lack of experience, poor project planning, and environmental concerns. This paper analyzes the reasons for delays on this mega-project and then provides lessons learned from this project to avoid the critical delays in performing the large-scaled projects.

2. Delay Analysis Methodologies

The existing methodologies for delay analysis can be categorized into three groups : (1) to measure the delay impact utilizing computerized CPM (Critical Path Method) analysis that performs based on genuine construction schedule (Bubshait and Cunningham, 1998), (2) to determine and evaluate the relative importance of significant factors causing delays in construction projects (Chan and Kumaraswamy, 1997), (3) to compute activity delays and assess their contribution to project delay (Shi et al, 2001). These methodologies are useful for a simple construction analysis, but not enough for this large-scaled complex and linear project. In simple term, if a small part of the railway route might be delayed, it implies that total line cannot be opened to the public. Subsequently, it requires another approach to analyze the project delays with a consideration of both macro and microscopic viewpoints. For this reason, this case study conducted both macroscopic and microscopic analyses, called MMDAM (Macro-Micro Delay Analysis Method). Macroscopic analysis constituted of S-curve scheduling comparison and responsibilities of participants on the causes of delays to find any critical section in deferring opening date of the total route. Then, microscopic analysis is followed to quantify the causes and effects of delays on these critical sections in more detailed way, primarily based on As Planned Method, As Built Method and Time Impact Analysis, which are designed to analyze delay factors and to compute the delayed days. Finally, it presents the impact of delay factors in managing project schedule through the survey from engineering managers working in Korea Railway Network Agency.

3. Macroscopic Level Analysis

3.1 Comparisons of S-curve Scheduling

KTX project is divided into various sections, each of which shows different reasons to the delays. It is difficult to scan of overall project because KTX project has multi-separated and complicated activities and furthermore, all delays do not necessarily affect the final completion date. Delays which influence the final due date may be occurred in a specific section. The approach of scheduling with S-curve can be helpful to identify critical parts of the railway route. KTX project consisted of 3 sections and 21 subsections according to its contractual structures. The overall construction progress can be seen at a glance with S-curve of each subsection. Through the S-curve comparisons, the critical delay subsections were found to be 2-1, 5-1 and 8-2 (See Figure 2).

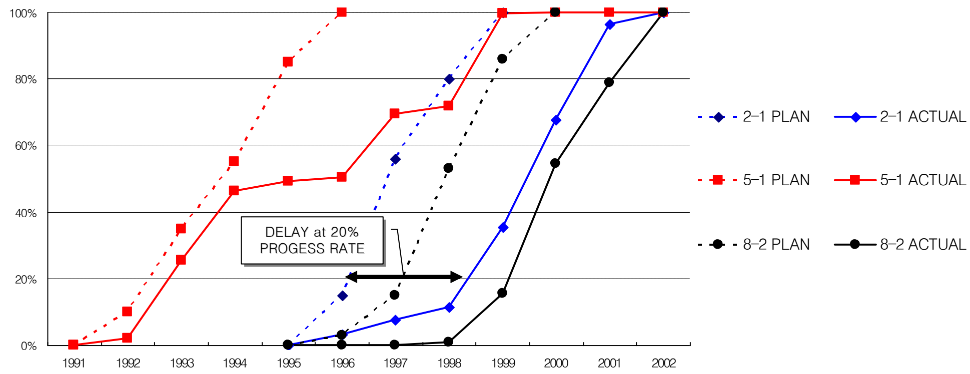

Figure 2. S-curve Comparisons of Critical Delay Subsections

These subsections had critical delay factors which influence the final due opening day, whereas other subsections were completed ahead of a due day. This approach can be useful in figuring out critical sections that affect the total delay of railway opening.

3.2 Responsibilities of Participants to the Delays

Focusing on critical sections is necessary in this case study because KTX project includes multi-separated and complicated activities that make it difficult to examine the overall project. In addition, this paper investigates the responsibilities of participants on the delays of each critical subsection at a macro-level. Responsibility of participants was divided into four parts according to their peculiarities: (1) owner's responsibility, (2) contributory responsibility, (3) contractor's responsibility, and (4) public resistance. Delays due to owner were excusable but not compensable; subsequently it was possible to extend construction duration. Meanwhile, delays due to contractor were inexcusable, so it was impossible to extend the duration and the contractor took responsibilities for overdue. Contributory responsibility is taken into account as a concurrent delay, which implies that both owners and contractors are thought of entailing corporative responsibilities. So, it is possible to extend duration to some extent. Responsibilities due to public resistance were responsible to causal party owing to delay. Table 3 reveals the parties of responsibilities of delays.

Table 1. Responsibility of participants to the Main Delays

Section			Seoul-Cheunan 2-1 Subsection	Cheunan –Daejeon 5-1 Subsection	Daejeon – Daegu 8-2 Subsection	Extension of Duration
Owner's Responsibility	Design Changes	Redesign by Dynamic Behavior	■	■		Possible
		Design Verification	■	■	■	
		Acquisition of Soil	■	■	■	
		Geological Survey	■			
		Change of Cross Section	■	■	■	
		Temporary Road for Work	■			
		Design Supplementation	■			
		Verification of Utility of Open Box	■			
		Design Change of Pier			■	
		Change of Location of Sound-proofed Wall			■	
		Change Order of Cross				
		Change of Location of Tunnel			■	
		Unsettled Urban Plan		■		
		Design Change of Station	■		■	
	Site Acquisition	Spare Area	■	■		
		Main Area	■	■	■	
	Underground Obstacles	Buried Obstacles	■	■	■	
		Electric Pole / Transmission Tower	■	■	■	
		Moving Tombs	■	■		
		Discovery of Cultural Assets	■	■	■	
	Approval	Approval of Use of Roads	■	■	■	
		Approva ofl Use of Rivers	■	■	■	
		Approval of Passage of Railway	■		■	
		Approval of Damage of Forests	■			
		Approval of Use of Farmlands	■			
		Building of Temporary Structures	■			
Corporation Responsibility		Noise / Vibration / Dust	■	■	■	
		Drying of Underground water	■	■	■	
		Government Supplies			■	
Contractor's Responsibility		Bankruptcy of Subcontracts	■			Impossible
		Suspension for Sharing Conflict	■			
		Defect of quality	■	■		
		Safety Inspection of Structures		■		
		Insufficiency of Technician	■	■		
Public Resistance		Contractor's Cause	■	■	■	Impossible
		Owner's Cause		■	■	Possible

4. Microscopic Level Analysis

Macroscopic Analysis draws critically delayed subsections (2-1, 5-1 and 8-2) and traces delay factors in accordance with responsibilities. Based on these results, microscopic analysis provides details of delays in these critical subsections. The details of delays consist of delay activities, estimation of delayed days, and delay factors. For the time control, KTX project used the scheduling chart of Primavera 3 (P3) as a scheduling software. Based on scheduling chart of P3, microscopic analysis for critical subsections employed three techniques of delay analysis: As Planned Method, As Built Method and Time Impact Analysis.

Using these techniques, this paper presents the details of critical delay subsections. Estimation of delay consists of 3 components: start-delay, net-delay and total-impact. Start-delay is to subtract planned start day from actual start day. Net-delay is to subtract free float from delay in construction progress. Total-impact is estimated by adding start-delay and net-delay. For example, subsection '2-1' with a hugest delay has 6 critical delay activities, where its total planned duration is 1,563 days. In comparison to its original due date, total actual duration is jumped to 2,902 days. Figure 3 indicates that most of delays occurred in start-delay because site acquisition was notably deferred. In addition, most of critical activities were generated from structural defects and as a result, require redesign and change order that led to the significant project delays (See Figure 3).

Sequence	Critical Delay Activity	Delay Causes and Effects	Successive Activity
1	Site Acquisition Start Delay : 112 days	● Public Resistance ● Negotiation of Compensation of Land Net Delay : 529 days	BANWOL Viaduct PALGOK Viaduct EOCHEON Bridge BANWOL Tunnel WANGNIM Tunnel
2-1	BANWOL Viaduct Start Delay : 276 days	● Design Change of Cross Section ● Redesign of Upper Structures ● Safety Inspection ● Redesign of Main Line Net Delay : 1,089 days	Tracklaying IMPACT : 1,365 days
2-2	PALGOK Viaduct Start Delay : 389 days	● Design Change of Cross Section ● Redesign of Upper Structures ● Moving Buried Obstacles ● Approval of Use of Railways / Road Area Net Delay : 965 days	Tracklaying IMPACT : 1,354 days
2-3	EOCHEON Bridge Start Delay : 1,282 days	● Design Change of Cross Section ● Redesign of Upper Structures ● Approval of Passing by Reservoir Area ● Redesign of Main Line Net Delay : 49 days	Tracklaying IMPACT : 1,331 days
2-4	BANWOL Tunnel Start Delay : 1,055 days	● Design Change of Cross Section ● Redesign of Upper Parts ● Acquisition of Approach Road Net Delay : 213 days	Tracklaying IMPACT : 1,268 days
2-5	WANGNIM Tunnel Start Delay : 1,403 days	● Redesign of Main Line ● Negotiation of Mining Right ● Compensation of Buried Obstacle ● Finding Fault Plane ● localized Torrential Downpour Net Delay : 0 days	Tracklaying IMPACT : 1,403 days

Figure 3. Microscopic Delay Analysis in '2-1' Subsection

5. Lessons Learned and Conclusion

KTX project is the representative case that the owners or operators should realize the importance of project management in the early stage of a project. The most critical delay factor in the case of KTX project is the privileged technological level of design for satisfying higher quality standards of railways. Unverified design brought out frequent change orders and reworks, and subsequently caused continuous delays in the construction progress. Therefore, it is necessary to verify the quality of design and constructability sufficiently and to reinforce coordination between design and construction interface by applying proper delivery system like design-build or alternative bidding. Another important factor is an improper/tardy acquisition of work site and right of way, particularly where cultural properties/ historic relics were buried. Accordingly, it is essential to investigate work fields and negotiate to acquire sites with landowners even in the design phase. Clearly, critical delays in KTX project occurred in early stage of project and enormously affected time and cost overrun. Therefore, the delay control in early stage is the key to minimize time and cost overrun in this type of large-scaled project.

Mega construction project like KTX is complicated and complex. So, project managers should consider various changeable factors such as time, cost and quality to progress a project successfully. Among the variables, critical delay factors are normally found in critical sections and paths. Therefore, project managers should take proper measures of delays in the parts by utilizing the methodologies suggested. In short, managing critical delay factors in critical path is a shortcut of successful project management.

6. Reference

Bubshait, A.A. and Cunningham, M.J. (1998), "Comparison of delay analysis Methodologies", *Journal of Construction Engineering and Management*, Vol. 124, No. 4

Chan, D.W.M. and Kumaraswamy, M.M. (1997), "A comparative study of causes of time overruns in Hong Kong construction projects", *International Journal of Project Management* Vol. 15, No. 1

Elinwa, A.U. and Joshua, M. (2001), "Time-overrun factors in Nigerian construction industry", *Journal of Construction Engineering and Managemen*t, Vol. 127, No. 5

Majid, M.Z. and McCaffer, R. (1998), "Factors of non-excusable delays that influence contractors' performance", *Journal of Management in Engineering*, Vol. 14, No. 3

Shi, J.J., Cheung and S.O., Arditi, D. (2001), "Construction delay computation method", *Journal of Construction Engineering and Management*, Vol. 127, No. 1