Transport System Management (TSM)

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A majority of large cities that simultaneously experienced both physical and economic growth in the late 20th century are now experiencing a rapid increase in the use of motor vehicles and, as a result, have faced with the problem of urban traffic congestion. One traditional method of resolving this problem is to increase new traffic facilities, such as roads. This method of continually constructing roads between the 1960s and the 1970s with various extensions was often seen as the answer – particularly in the USA. However, most countries cannot depend on the construction of new roads due to the financial restrictions needed for road construction or the limits of usable land. The so-called 'TSM method' has a also been rather diversely used to increase the efficiency and accommodating skills as a means of resolving traffic congestions in large cities by improving the existing transport system - based on the principle that the extension of roads itself causes more traffic demands. Furthermore, the city of Seoul has also gradually been conducting TSM since 1980. Recently, the approach of TSM has become more systematic and integrated based on ITS through Seoul TOPIS. The main components of Seoul TOPIS, i.e., Advanced Traffic Management System/Traffic Signal Operation System, Freeway Traffic Management System, Bus Information System/Bus Management System, and Unmanned Regulation System/Automatic Penalty Charging System all follow the principles of TSM. That is, there is a clear objective of resolving traffic issues through the optimization of the efficiency of existing facilities, and not the construction of additional traffic facilities.

1. Policy Implementation Period

Seoul city has undertaken the Backside Road Repairs Project and the Transport System Management (TSM) Project from late 1980s onwards, and since then, interest in traffic safety has increased. This has led to the performance of the annual project of the improvement of areas with frequent accidents since the late 1980s. Meanwhile, the Highway Traffic Improvement

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Project, which was selected as a means of improving the traffic congestion problem, was performed as a type of special improvement project, and a series of TSM projects were diversely initiated in different forms, such as the Habitual Traffic Congestion Point Improvement Project in 2004.

2. Background Information

The rapid growth of the Korean economy and the development of the motor vehicle industry of the 1980s resulted in a sudden increase of traffic volume. The total number of motor vehicles surpassed one million vehicles, and in 1990, the number surpassed two million vehicles, wherein approximately half of those (i.e., one million vehicles) were concentrated in Seoul.

Since then, the total number of motor vehicles in Seoul had increased to twice the amount, i.e., two million vehicles, within the last five years. This rapid increase in the number of motor vehicles in Seoul had led to diseconomy - with problems such as increased commute times due to traffic congestion and traffic accidents. Thus, the intensified problem of traffic congestion had been recognized as a serious social problem.

The number of registered motor vehicles in Korea between 1980 and 1990, meanwhile, had increased by eight-fold from 249,000 to 2,075,000, wherein the width of the roads was merely increased by 12.5% from 47,000 km to 56,700 km. The government initiated road construction projects to resolve the imbalance of such demand and supply, while also introducing a policy of using private capital in the extension of information facilities, including roads, by enacting the Private Capital Attraction Promotion Act related to indirect social capital facilities in 1994.

However, in the 1990s, the traffic policy professionals and decision makers shared an awareness that there were restrictions in the method of approach concerning facility supply, such as the extension of traffic systems or road construction, and sought new traffic problem resolution means beyond the more traditional and dated traffic policies.

In Western countries, with a focus on both the USA and England, the recognition of the environment and the effect of budget reduction policies had gradually increased since the 1980s. Attention was therefore gathered on the concept of increasing the accommodating skills of traffic facilities by increasing the efficiency of existing facilities rather than resolving traffic problems by depending on the new construction of traffic facilities, i.e., TSM, which was already regionally being used in the 1970s. From the perspective of a similar goal, another alternative method of approach that was soon noted was the Transport Demand Management (TDM) method, and both the TSM and TDM methods represent a new paradigm in the traffic policy field of the end of the 20th century, which brought on an extensive change in the methods of approach that depended on the construction and supply of existing facilities.

In Korea, the TSM method had been mainly used under the name, ‘Traffic (System) Improvement Project’ from the late 1980s, and in the 1990s, projects that were not necessarily called ‘Improvement Projects’ diversely accommodated these approach methods with the goal of expanding the accommodation through the increased efficiency of the operation of existing facilities, i.e., following the concept of TSM. Such projects began with the government's introduction of the transport system management method (TSM) in the process of pursuing a new means of resolving the serious traffic congestion that had become gradually metropolized in the 1980s.

3. The Importance of the Policy

The Transport System Management (TSM) Project was initiated to reduce chaos by additionally obtaining roads and applying the method of efficient operation by improving existing road facilities, such as the top of the roads and central islands for improved functions of the more turbulent traffic regions.

4. Relevance with Other Policies

The Intelligent Transportation System (ITS) fuses advanced technologies to traffic facilities-the bus exclusive road system granting priority to efficient traffic means rather than increasing the number of lanes, the traffic signal management system, the automatic illegal parking control system, and the freeway traffic management system (FTMS) applying ITS to urban freeways are all examples of the TSM method. Accordingly, Seoul TOPIS, which supports and comprises these various components, is directly related to traditionally and locally performed TSM.

ITS itself is an innovative means that strongly appeals to policy makers as merely a small cost is required compared to much larger physical infrastructure facility supplies needed for basic road construction, while allowing smoother traffic flows and enabling the efficient operation of existing traffic facilities. Even in Korea, various research and development projects and demonstrative projects were initiated in relation to ITS in the 1990s. In Seoul, overseas ITS advanced technologies were introduced, and the Freeway Traffic Management System (FTMS) was initiated as a part of this project. Accordingly, FTMS is a representative ITS project that has enhanced the efficiency of the urban freeways, and is an important part of the TSM project.

Seoul city established the government's 1997 'National ITS Master Plan' in addition to the 'Comprehensive Plan for ITS in Seoul' in 2000, and overseas countries are also now classifying ITS as a pioneering project in the traffic field and are expanding its areas of activity to live traffic information and safety fields in terms of traffic management, such as the flows between vehicles and roads.

Currently, almost all cities are experiencing extreme traffic congestion due to the rapidly increasing volume of traffic and are, therefore, concerned with various traffic problems. Particularly, since the Seoul metropolitan area includes 46.6% of the entire population of Korea, and the central economic, social, cultural, and educational functions are excessively concentrated therein. Thus, it is experiencing more serious traffic chaos than any other city in the world. Furthermore, the significant economic, social, and environmental loss and national health problems are surfacing, which is leading to efforts for the resolution of such problems. Focusing on the national industrial complex regions concentrated with small and medium businesses that urgently require traffic improvements, means of resolution are proposed centered on TSM, optimizing the efficient operation of existing traffic facilities, such as traffic demand management, improved operation of traffic signals, and improved parking management, which can display a rapid effect with a low budget and immediate enforcement, in comparison to the expansion of facilities, which require a much higher budget and take a far longer time .

This is similar in other countries, where various forms of TSM are performed through diverse policies and systems in each country. Among which, let’s take a look at the case of the US as below.

- Surface Transport Program (STP) - USA

The Surface Transport Program includes the improvement project of roads such as Rural Major Collectors among main or district roads, and is largely categorized into four different types as seen below.

Table 1. Types of Surface Transport Program

Category	Program	Features
Type I	STP-Urban	* Regulated to use more than 50% of the STP fund * Distributed to the main government and local governments based on the regional population * Can be used for the improvement of the transfer skill of the relevant road, such as road expansion, public transportation and reconstruction, joint pass, intersection/bottleneck improvements, signal optimization, and most TSM projects * Ratio of financial support: Federal government (80%), main or local government (20%)
Type II	STP-Rural	* Can be used for the improvement of roads ranked above distribution roads in district regions * Financial distribution based on the driving distance * Ratio of financial support: Federal government (80%), main or local government (20%)
Type III	STP Anywhere	* Can be used irrespective of region (urban, rural) * Can be operated under the determination of the main government * Ratio of financial support: Federal government (80%), main or local government (20%)
Type IV	STP Enhancement	* Can be used for the improvement of a connective traffic system between means * Use on road improvement projects, such as facility expansion projects for pedestrian and bicycle paths, and roads with high landscape or historical value * Ratio of financial support: Federal government (80%), main or local

		government (20%)

5. Policy Objectives

The intended goal through the improvement of the road traffic facility system is the efficient use of the road. The TSM project initiated in Korea, including Seoul, aims to resolve traffic congestion by improving unreasonable traffic facilities by targeting regions that suffer particularly severe traffic congestion.

For the relief of traffic congestion, there are multi-angled forms of TSM methods, including the improvement of bottleneck and intersection regions, efficiency of traffic operations, signal management, demand management, and ITS, wherein the specific goal is to enhance the driving speed by effectively combining these methods.

Next, the types of improvement policyofroad traffic facilities are categorized in phases. Thus, each policy sets a different goal. However, the ultimate goal is to relieve congestion by constructing a database capable of apprehending the roads prone to traffic congestion, institutionalizing related legislations, and initiating the TSM project.

Table 2. Road policy initiation road map for relieving traffic congestion on urban roads.

Responsive Policy	Short Term	Mid to Long Term
Deduction of implications and analysis of existing similar projects (traffic congestion project, TSM project in Seoul and Gyeonggi)	O	
Reestablishment of the concept of traffic congestion reflecting the properties of urban roads	O	
Preparation of a means to resolve traffic congestion in urban roads	O	
Development of a manual for initiating the means to resolve traffic congestion on urban roads	O	O
Evaluation and documentation of traffic congestion of the main roads in all cities		O
Construction of a database related to traffic congestion on urban roads Construction of a reliable system for researching the rate of road congestion Construction of a reliable database of the rate of road congestion		O
Development of projects resolving traffic congestion on urban roads	O	O
Regular initiation of projects resolving traffic congestion on urban roads		O
Institutionalization of laws related to projects resolving traffic congestion on urban roads	O	O

6. Main Policy Contents

Transport system management, i.e., TSM, is a means of understanding and increasing the harmony between traffic demands and facility supplies by efficiently operating and managing the existing facilities rather than by supplying new road traffic facilities.

In Korean cities, the concept of this transport system was introduced in the mid-1970s to be applied to urban traffic improvement studies. Furthermore, in the early 1980s, the Seoul Traffic Improvement Master Plan was established as a loan project with the International Bank for Reconstruction and Development by the Korea Advanced Institute of Science and Technology's Regional Development and Research Center, and conducted the TSM demonstrative project on three roads (Cheonhodae-ro, Mangwoo-ro, Jongam-dong-gil) in 1984 to 1985.

Primarily by the Korea Transport Institute which opened on 1986, the urban TSM project and the Banpo-axis, Mapo-Yeongdeungpo axis improvement projects had been performed. Thereafter, this remarkable innovation resulted in vast improvements on the formerly unreasonable and inefficient road operation system by conducting the TSM project and research for improved flow and enhanced traffic capacity in main regions of congestion in district cities (Busan, Daegu, Gwangju) as well as sub-urban areas (Gangnam, Yeongdeungpo, Shinchon, Cheongryangri) in the 1990s.

The TSM project conducted in the 1980s to 1990s redistributed roads, adjusted signals, installed traffic islands, and even reduced pedestrian paths with the goal of increasing the capacity of vehicles in most existing supply facilities. However, the priority of pedestrian safety and public transportation was partially violated. Recently, the goal of road traffic improvements, such as the creation of walking paths, has also come to emphasize the qualitative aspect and balance of the entire road traffic environment. Upcoming transport system projects reflect the demands of various road usage classes and focus on the conversion to intellectual traffic improvement projects that can enable the road traffic environment to reach that of the standard of advanced countries.

Seoul TOPIS has enabled the automatic control of a safe distance for vehicles, providing all public transportation information on the internet of mobile phones, as well as traffic predictions by incorporating such advanced electronic communication technology to TSM. These are the measures being taken by Seoul city to not only contribute to promoting the traffic capacity, safety, and demand management, but also to form comfortable roads and an improved urban environment.

After 2010, the following methods has been frequently applied to Seoul's traffic system improvement projects: geometry structure, signal system, three-dimensional intersection project

Axis improvement project: Bottleneck region improvement, signal linkage, bypass development, partial capacity increase project, etc.

Construction of infrastructure for improved bus services: bus transfer facilities, BRT route installation, etc.

<u>Urban Freeway Congestion Mitigation</u>

Seoul recently conducted a function improvement construction on the representative habitual congestion secion on urban freeways. As a series of urban freeway function improvement projects, a road was expanded using the extra space, such as the central division and top of the road from November 2012 to May 2013. The comparison of the travel speed in rush hours before and after the construction shows, travel time had shortened the most during the evening rush hour. The speed during 7 am to 9am increased by 59.6% from 27.2 km/h to 44.1 km/h, and the speed during hours 18 to 20 increased by 195.9% from 21.8 km/h to 64.5 km/h. It appears that the speed during the afternoon hours dramatically increased due to the relief of the bottleneck effect caused by the extension of suburb roads where the traffic volume is concentrated during evening rush hours.

Category	Morning Rush Hour (07 to 09)	Evening Rush Hour (18 to 20)	Daily Average (05 to 23)
Before Enforcement	27.7 km/h	21.8 km/h	33.1 km/h
After Enforcement	44.1 km/h	64.5 km/h	58.6 km/h
Increase Rate	16.5 km/h		

Furthermore, it appears traffic flow has been improved partially by the provision of real-time traffic information and bypass information based on the intelligent transportation system (ITS) integrated by 6 road billboards, 6 video detection systems (VDS), and 8 dedicated short-range communications (DSRC) on all regions of the western arterial roads in 2012.

The two areas where construction was completed in 2013 were the Bukbu Arterial Road toward the Muk-dong route and the Dongbu Arterial Road toward the Seongsu route. These areas applied the TSM method, which efficiently operates and additionally secures roads through improving existing road facilities, such as the top of the roads and central divisions, without construction that requires significant financial investment.

The existing route in the downtown direction surrounding the Bukbu Arterial Road toward the Muk-dong IC lacked the necessary road capacity, and resulted in traffic congestion up to the main route of the Bukbu Arterial Road. The broad space used as the shoulder of the Muk-dong IC was used to extend the two lanes to three lanes, and the road and traffic signals on the Hwarangdae intersection located on the end of the route were adjusted to improve the traffic flow.

Upon analyzing the traffic flow before and after the construction, the Dongbu Arterial Road toward the Seongsu route displayed an enhanced flow of vehicles of 29.2% and the Bukbu

Arterial Road toward the Muk-dong route displayed an enhanced flow of vehicles of 71.2%. When converted to currency, this signifies an annual reduction of 1.62 billion won, and accounts for twice the total TSM construction cost.

With respect to the Dongbu Arterial Road, the Yongbi Bridge expansion construction (Yongbi Bridge-Haengdang road construction), which began in March 2007, temporarily opened on November 11, 2015 and was completed on May 31, 2016.

The region on the Dongbu Arterial Road (descending direction), beyond the Yongbi Bridge ramp and toward Seoul Forest and Seongsu Bridge, is a chronically congested area, the congestion of which was to be relieved by increasing the road capacity through the extension of the road. In the past, habitual traffic congestion occurred, such as excessive traffic volumes in comparison to the flow of vehicles and the crossing of vehicles due to the incorporation of the Naebu Beltway, the Dongbu Arterial Road, the Gangbyeon Expressway, and the Dumugae Highway, respectively. However, the extra space near the road between the northern intersection of the Seongsu Bridge on the Yongbi Bridge route was used to extend an extra lane as a short-term means to relieve the congestion between the Yongbi Bridge and the northern end of the Seongsu Bridge. The exclusive right-turn lane toward Seongsu Bridge was also extended from one to two lanes. Furthermore, the four lanes on Yongbi Bridge were extended to six lanes to construct a Northern-Eastern region freeway network

This is an example of the TSM method that increased the road capacity without changing the entire structure of the road network, and was intended to resolve the problem of the traffic chaos through the efficient traffic operations including the use of right-turn lanes.

Figure 1. Yongbi Bridge Extension Construction (Yongbi Bridge-Haengdang Road Construction)

Source: Yongbi Bridge-Seongsu Bridge

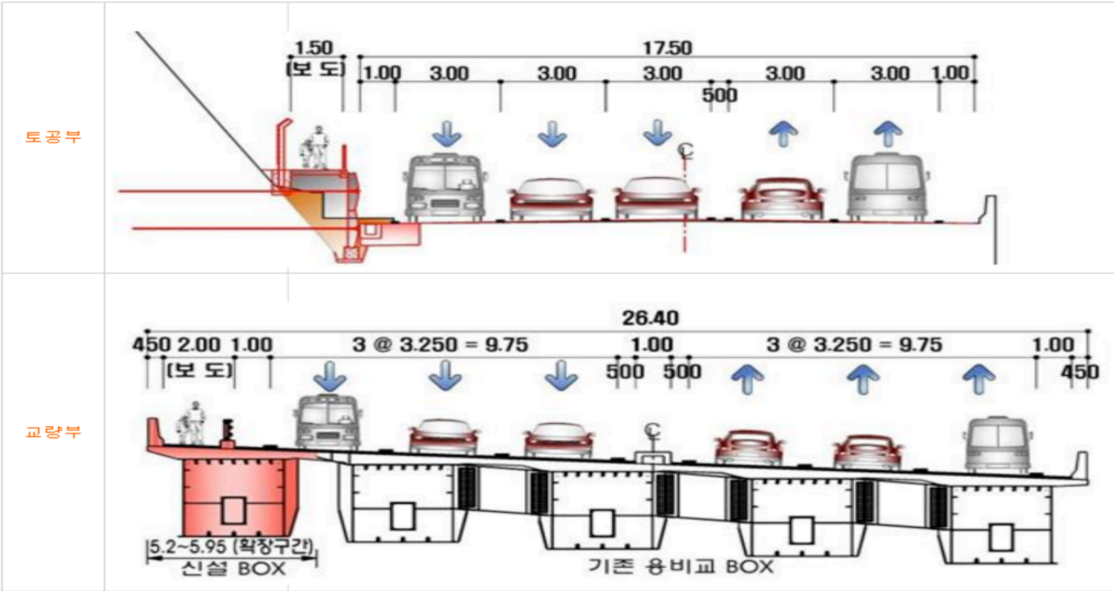

Figure 2. Cross-section Diagram: Yongbi Bridge-Seongsu Bridge

The construction to improve the traffic flow as performed by Seoul city from 2013 to 2014 included the Jangan Bridge route on the Dongbu Arterial Road and the Gunja Bridge route as seen in the drawing below.

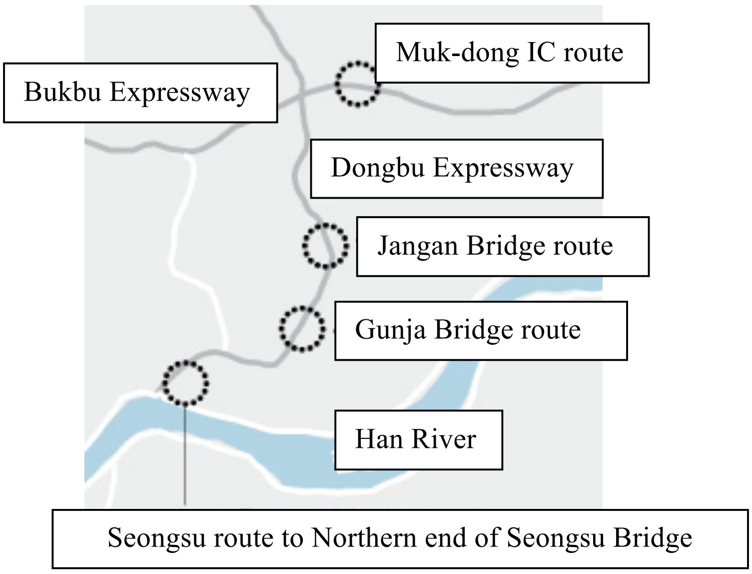

Figure 3. Urban Highway Congested Region Improvement

Source: Kyunghyang Shinmun (2013)

Dongbu Arterial Road Extension Construction

Seoul city entirely controlled the linkage ramp toward Seongsu on the Dongbu Arterial Road on Nowon Bridge from 10:00 on January 5, 2015 to expand the Surak overpass within the region of the Dongbu Arterial Road extension construction.

The demolition of the Nowon Bridge linkage ramp, which was constructed in 1994, began on January 5, 2015, and was completed on March 10; its reinstallation will be completed in late May of 2017. The extension construction of the Surak overpass was completed in late-May 2016. In order to minimize the inconvenience and discomfort of the regional residents due to the noise and du demolition st demolition caused by noise and dust, special construction methods using the diamond wire saw was performed to cut the structure. The removed parts were then moved to another region to be disintegrated.

Meanwhile, the Dongbu Arterial Road expansion construction began in February 2008 with a budget of 383.5 billion won and is planned to be completed in December 2017.

Business Outline

- Location: Dongbu Expressway Surak overpass
- Nowon Bridge linkage ramp (toward the Dongbu route) demotion and reinstallation
- Extension of the Surak overpass

4-lane, 6-lane

- Construction period: 850 days after commencement (Jan 2015 – May 2017)
- Constructor: Sewon Constructor Co., Ltd.

Figure 4. Outline of the Dongbu Expressway Surak Overpass

Source: Seoul City (2014) https://infra.seoul.go.kr/archives/20999

8. Policy Effects

The effect of improving traffic congestion based on the traffic operation technique was verified by the signal improvement project (traffic flow increased by 17%) to relieve the congestion in the Ansan Banwol Industrial Complex route. A study reportedly demonstrates that the transportation improvement program aiming to build synchronized system had increased traffic speed to the entrance ramp from 36.6 km to 42.9 km by changing signal order at the Doil intersection, optimizing the signal timing at Ansan Intersection, and minimizing the vehicles' waiting queue on the road.

(Banwol Shinmun 2011).

The transport system improvement projects conducted by Seoul city in the habitual congestion regions also displayed noticeably reduced congestion and improved the overall traffic flow.

1) Yongbi Bridge Extension Construction (Yongbi Bridge-Haengdang Road Construction)

An effective flow between the regions was achieved by resolving the bottleneck effect in the northern end of Seongsu Bridge, a region of habitual congestion, and the traffic flow was thereby enhanced by 29% from 22.7 km/h to 29.3 km/h.

2) The effect of improved traffic flow from the Bukbu Expressway Muk-dong route and the Dongbu Expressway Seongsu route

Seoul city analyzed the change in traffic flow and volume at different times for two weeks before and after construction and, from this, calculated the socioeconomic profit based thereon.

The morning traffic flow toward the Hwarang University intersection increased by 71.1% 32.5km/h → 55.6km/h, 23.1km/h) by the Bukbu Arterial Road Muk-dong route construction and the traffic flow toward Yongbi Bridge increased by 29.1% (22.7km/h → 29.3km/h, 6.6km/h) by the Dongbu Arterial Roadto Seongsu route.

This saved time is tantamount to an annual reduction of 1.62 billion won, which is exceptional in terms of cost when seen against the construction cost of 830 million won.

In addition to the profit from the time reduction, the effect of cost reduction in the following items was also analyzed:

- Commuting time: 1.6 billion won
- Vehicle driving cost: 0.21billion won
- Atmospheric contamination cost: 90 million
- Reduced accidents: -460 million won

3) The Road Surrounding the Seocho IC, Seoul

Nambu circuit road operation improvement surrounding Seocho IC in Seoul

The region on the Seoul Arts Center three-way intersection around the Secho-gu Office three-way intersection of the Nambu circuit road is a habitually congested region of approximately 2km. It is also known to cause delays and congestion on the main Gyeongbu expressway and Banpo lanes.

It was observed and understood that a lack of road capacity during rush hours and delays based on the crossing of vehicles in the lower regions of the Seocho IC were the main causes of habitual congestion.

As a means of improvement, the Korea Transport Institute proposed a '2.53 billion won' road operation improvement project comprising the following:

- The width of the lanes was adjusted from 2.9-4.0m to 3.0-3.25m in order to add another lane. Another lane was added by adjusting the width of the lane of the Nambu circuit from Seocho IC to the Seoul Arts Center and partially setting back the pedestrian path.
- Separation of the crossing of vehicles in lower Seocho IC and extension of lanes.

Separation of the main line in the region where vehicles frequently cross one another in lower Seocho IC and enhanced traffic flow by increasing the number of lanes in certain regions

Smooth traffic flow in the main lane obtained by constructing lanes on the Gyeongbu highway entry-exit ramp region (achieved by the relocation of subway ventilation facilities)

The analysis of the effect of traffic relief of the Nambu circuit surrounding the Seocho IC shows the average delay before the improvement in the region was 287 seconds, which has been reduced by 13.2% to 336 seconds upon improvement. Furthermore, the average traffic flow has been improved from 13 km/h to 15.7 km/h. The region near the Seocho IC of the Gyeongbu Expressway also displayed a positive reduction of 42.5% from an average delay time of 40 seconds per vehicle to 23 seconds upon improvement, and the average traffic flow improved from 34.5 km/h to 43.0 km/h.

Table 3. The effect of flow relief on the Nambu Circuit in Seocho IC

Category		Average Delay Time (Sec)	Average Traffic Flow (km/h)	Average Traffic Time (Sec)
Before	Nambu Circuit	387	13.0	488.8
	Gyeongbu Highway	40	34.5	68.5
After	Nambu Circuit	336	15.7	386.1
	Gyeongbu Highway	23	43.0	55.9
Effect	Nambu Circuit	-51(13.2%)	+2.7(20.8%)	-102.7(21%)
	Gyeongbu Highway	-17(42.5%)	+8.5(24.6%)	-12.6(18.4%)

Upon analyzing the economic effect of the Nambu circuit surrounding the Seocho IC, an annual profit of 52 trillion won occurred, and thus, the improvement effect in the congested region is significant.

Table 4. Annual profit on the Nambu circuit surrounding Seocho IC

Category	Annual Benefit			
	Relief of Traffic Flow	Reduced Energy Consumption	Reduced emission of Air Pollutants	Total
Improvement	50,218,898	1,166,297	640,065	52,025,260

The traffic congestion in urban CBD causes significant economic loss at a national level. The cost of Korea's national traffic congestion is 27.9 trillion won (as of 2009) - among which 17.6 trillion won is consumed in the six metropolitan cities, including Seoul. In this context, central and local government should join hands to mitigate congestion at the chronically congested section. Given the 'cost to congestion improvement effect', it will be desirable to continue public transportation improvement program and transportation operation program instead of construction new roads.

<u>Reference</u>

- ‘Urban Traffic Congestion Road Improvement Project Initiation Plan’ – The Korea Transport Institute
- Central Government and Local Cooperation System’s Construction Plan in the Urban Traffic Section - The Korea Transport Institute
- The 100 Footsteps of Traffic Development - The Korea Transport Institute
- ‘Development of a Road Policy Means for Relieving Urban Traffic Congestion’ - The Korea Transport Institute
- Banwol Shinmun 2011 “Improvement of the Chronic Traffic Problem in the Banwol Industrial Complex”, Mar 4, 2011