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都市交通 滯症緩和를 爲한 效率的인 輸送體系에 關한 硏究
－컨테이너 輸送時間을 中心으로－

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A Study on the Effective Container Transport System for the Relief of Urban Traffic Congestion
－A Container Transport Time-Oriented－

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Key word ; Container Transport System(컨테이너 수송체계), Transport Time(수송시간), Transport Delay(수송 지체), Urban Freeway System(도시 고속도로 체계), Delay Level(지체 수준), Traffic Congestion(교통 체증), Urban Arterial System(도시 간선도로 체계), ODCY(외부 컨테이너 야적지)

Abstract

우리나라에서는 70년대 이후 컨테이너 수송체계가 도입되어 운영되어 왔으나 차량의 급격한 증가와 더불어 컨테이너 수송체계는 도시교통에 있어서 많은 문제를 야기시키는 것으로 논란이 되고 있다. 특히. 부산항은 우리나라 최대의 국제 무역항으로써 전 컨테이너 수송화물의 90% 이상을 처리하고 있고, 또한 수출입항으로서 제 역할을 다하고 있으나 낮은 도로율(12.45%)과 산재해 있는 30여개의 Off-Dock CY로 인해서 도심을 통과하는 컨테이너 수송차량은 많은 교통문제를 유발시키고 있다.

본 연구는 1) 부산시에 산재해 있는 30여개의 Off-Dock CY에 이르는 주요 도로상에서 컨테이너 수송량의 시간별 분포에 따라 컨테이너의 운행시간대를 첨두 시간대, 비첨두 시간대 및 심야 시간대로 분류하여 각 시간대별 평균 수송시간 및 교통체증으로 인한 수송 지체수준을 확인하였고, 2) 컨테이너 전용부두로 부터 Off-Dock CY에 이르는 도시 고속도로 및 주요 간선도로상에서의 수송시간 및 수송 지체수준을 비교 분석하였으며, 3) 마지막으로, 효율적인 컨테이너 수송체계를 위한 최적 수송시간대 및 도로체계를 제시할 수 있었다. 특히, 컨테이너 수송시간 및 지체수준은 각 운행 시간대에 따라 현저한 차이를 보이고 있었는데, 심야 시간대를 이용하여 컨테이너 수송을 할 경우에는 다른 시간대에 비하여 50%정도의 수송시간 절감효과를 기대할 수 있었으며, 도시 고속도로를 이용할 경우에는 도시 간선도로에 비하여 30%정도의 수송시간을 절약할 수 있었다.

따라서 도시지역의 교통체증을 완화시키기 위해서 심야 시간대에 보다 많은 컨테이너 수송차량이 이용할 수 있는 컨테이너 수송체계가 확립되어야 하고, 산재해 있는 Off-Dock CY를 몇개의 ODCY그룹이나 또는 하나의 대규모 ODCY단지로 통합하여 그 ODCY그룹이나 단지까지 컨테이너 전용 고속도로의 건설이 바람직하다고 생각된다.

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I. INTRODUCTION

Korea, as one of the New Industrializing Economies(NIES), is located at the Far-East area of Asia and is often called "The Korean Peninsula". Also, Korea, as a world trade rival, is a country which is trading more than U$100 billion with foreign countries for a year. With the rapid growth rate of foreign trade since 1970's, the Container Transport System(CTS) has become active as time goes on. However, such an active Container Transport System(CTS) caused container transport vehicles continued to increase at an enormous rate in urban areas of all sizes. So, a large number of container transport vehicles which were rushing through urban public thoroughfares for container transport were creating the serious problems that demanded our immediate attention. What was more, massive container transport vehicle-related traffic delay was occurring everywhere, and the roads including urban arterials and freeway which were becoming saturated with traffic were becoming worsened by container transport vehicles, and mobility resulted in arriving at its worst due to traffic congestion in urban areas.

The Container Transport System(CTS) which continued to contribute to urban traffic congestion absolutely emphasized the necessity of construction of a large scale of arterials and freeways for the relief of the urban traffic congestion problems. Building only new roads no longer, however, seemed as evident a solution to the traffic congestion problem in urban areas, since these newly constructed roads bred more traffic and exacerbated traffic congestion by stimulating high-density development around new roads that continued to rely heavily on the automobile. Today, the demand for road space had become so intense that new roads filled up with cars almost as soon as the ribbon was cut(4). Instead, traffic demand operations together with providing new facilities and services must be reemphasized such that existing facilities could be efficiently used to help alleviate the growing threat of gridlock in urban areas, since it was proven that the urban congestion problem which could never be eliminated could be mitigated through well-conceived and aggressively promoted Traffic Reduction Programs(TRP), Traffic Signal Management(TSM), or Freeway Surveillance and Control(S & C) Systems(5). If one of five freeway drivers would ride-share, freeway congestion could be reduced by about 65%, and capacity on suburban arterials could be also increased up to 50% by adding left-turn lanes, minimizing parking interaction, and optimizing traffic signal system operation(3).

Some evaluation of traffic characteristics on urban arterials and freeways by private automobiles, public transportation, or trucks has been done using traffic delay as an evaluation parameter(2). However, these analyses were not sufficiently detailed to evaluate urban congestion by container transport vehicles on arterials and freeways. With container transport vehicles hourly distributed and operated on the roads including arterials and freeway in urban areas, data were available to evaluate the Container Transport Delay(CTD) based on the Container Transport Time(CTT) under the on-peak, off-peak, and mid-night periods, respectively(see Fig. 2).

Fig. 2. Container Transport Dist.-
Hourly Container Transport Veh. Dist.

II. SUBJECT AND MAIN TEXT

In our courtry which is a peninsula surrounded by the sea, there are several ports used for transporting import & export cargoes as the overseas trade ports. Of these ports, the Port of Busan has been operating the Container Transport System since a container ship from the US Sea−Land Co. arrived in Busan Port early in 1970's. Especially, the Busan Port which is handling approximately twenty−five percentage of almost all the trade cargoes and more than ninety percentage of all the container transport cargoes plays a key role in speeding up an economic leap, as the biggest trade port in the country.

Continuous increase of the container transport cargoes promoted construction of the exclusive Piers and Container Yard(CY) facilities for these transport cargoes within Busan Port. Thus, the Base Piers(5th and 6th piers) for the container ships must be constructed in 1983. However, with only On−Dock Container Yard facilities within these Base Piers, massive container transport cargoes could not be completely handled(see Fig. 3). Thus, a large scale of Off−Dock Container Yard (ODCY) facility was needed to build up. The Off−Dock Container Yards must be, however, scattered and placed around the City of Busan due to its geographic surroundings faced the sea and lied with the hills. There were approximately thirty Off−Dock Container Yards spread over the City of Busan(see Fig. 1). Of these Container Yards, there were few which were at a distance of less than 1 mile from the Base Piers. But most of the Off−Dock Container Yards were located at a distance of more than 1 mile from there creating urban transportation problems by the container transport vehicles.

Fig. 3 Container Transport Records−Busan Port and Exclusive Container Pier

The purpose of this research is to : identify the average transport times of the container vehicles throughout the study areas during the on−peak, off−peak and mid−night periods, respectively ; compare the container transport vehicle−related delays on the roads including urban arterials and freeway ; and, finally, determine the most appropriate time period and roadway system for the container transport vehicles.

The results of this study will provide a guidance as decisions are made during the planning and implementation of the Exclusive Freeway System for the container transport vehicles in the Port of Busan.

1. Data Collection and Reduction

Container transport vehicle data on the roads including urban arterials and freeway from the Base Piers to 32 Off−Dock Container Yards were culled from the records of the Busan Container Terminal Operation Company(BCTOC). Except the container transport vehicle data, geometric and traffic data to the Off−Dock Container Yards were collected from the Department of Transportation Planning in the City of Busan. Geometric data were geometrically describing the elements of arterials and freeway in study areas. Container transport vehicle data describing Container Transport Times(CTT) and the number of container vehicles to the ODCY within the study areas covered the period July 1989 to Jun 1990. Especially, Container Transport Times from the Base Piers to the Off−Dock Container Yards under the on−peak, off−peak, and mid−night periods covered the period seven in the morning till twelve at mid−night. Traffic data describing the level of use of the roads within the study areas were collected during a period 1989. Data were then reduced and analyzed to eliminate items that were not germane to the study.

2. Before−and−After Grouping

A. Before Grouping

a. Container Transport Time(CTT)

Container transport time−related data of the

Group 3 were about 48 min. during the on−peak period, 34 min. during the off−peak period and 20 min. during the mid−night period. There appeared to be severely different in the average container transport times between the groups. Because all of the Off-Dock Container Yards in the first group were located at a distance of less than 1 mile, but those in the third group at a distance of about 7 miles from the Base Piers. Also, for comparison of urban Arterial System with Freeway System, the container transport time−related data were selected from the sub−data base in the third group and reviewed. The average container transport times on urban arterials were 52 min. during the on−peak period, 37 min. during the off−peak period and 20 min. during the mid−night period, respectively. Those on urban freeway were, however, 35 min. during the on−peak period, 26 min. during the off−peak period and 18 min. during the mid−night period. There appeared to be a severe reduction in the container transport times on urban Freeway instead of urban Arterials in the third group(see Table Ⅲ, Ⅳ, and Ⅴ).

b. Container Transport Delay(CTD)

Based upon the Delay Levels categorized in the above, the average container transport delays of the Group 1 were about 4, 6 and 10 min. at the Delay Levels 1, 2, and 3. Also, those of the group 3 were approximately 13, 14 and 27 min. at the same Delay Levels. There appeared to be a marked difference in the container transport delays of each group depending on the Delay Levels.

Sub−data base selected from the third group for comparison of urban Freeway System with Arterial System was also used for the statistical analysis. The average container transport delays on urban Freeway were 9, 8 and 17 min. at the Delay Levels, but those on urban Arterials were 15, 17 and 32 min., respectively. These data indicated a significant difference in the average container transport vehicle delays between these two Roadway Systems, according to the paired t−tests.

3. Statistical Analysis

The primary statistical methods employed in this study were the paired t−test and two−sample t−test. These tests determined whether the mean of one group was significantly different from that of the other group. For the paired t−test to be valid, the study locations for these groups must be the same.

The null hypothesis for these t−tests was that no significant difference existed between one group and the other group. Essentially, this resulted in a comparison of a critical t−value, based upon the number of locations and a selected level of confidence, to a calculated t−value derived from the means and variances of the groups selected. If the calculated t−value was greater than the critical t−value, the null hypothesis should be rejected. When the calculated t−value was less than the critical t−value, the null hypothesis should be accepted. Acceptance to the null hypothesis arrived at the conclusion that the study tested was not effective.

Paired t−tests were performed for the container transport times and delays. Especially, two−sample t−tests were performed for the container transport times between urban Freeway and Arterials. All tests were conducted at the 0.01 level of significance.

Ⅲ. CONCLUSIONS

Tables Ⅰ, Ⅱ, Ⅲ, and Ⅳ show the results of the paired t−tests for the container transport times and delays during the peak−time periods selected for analysis, respectively. Table Ⅴ, also, shows the results of the two−sample t−tests for the container transport times on urban Freeway and Arterials.

In rejecting the null hypothesis in these cases, the conclusions are that shifting the operating period of the container transport vehicles from the on-peak or off-peak periods to the mid-night period was effective in reducing the container transport times and delays in urban areas, and urban Freeway System for the container transport vehicles was most effective in alleviating urban congestion and increasing traffic capacity on urban thoroughfares.

Ⅳ. DISCUSSION

Regardless of the peak-time periods in the above, the City of Busan has been experiencing a severe traffic congestion in the urban areas. Most of the urban transportation problems in Busan City were caused by 1) the low rate of road (12.45%), 2) the overpopulated Central Business Districts(CBD) and 3) the container transport vehicles rushing through the center of the city though partly caused by the wrong Transportation Plannings and Implementations in urban areas.

Especially, the rate of road in the City of Busan was too low to keep pace with the rapidly increase of traffic in urban areas. Also, most of the office buildings and shopping malls were located at the Central Business Districts(CBD) generating severe traffic congestion. What was most, urban traffic congestion was worsened by a large number of the container transport vehicles operated throughout the thoroughfares in Busan City. Of these serious problems confronted, relieving traffic congestion by the container transport vehicles became the most important problem which should be solved.

Period of Time : The Container Transport Times (CTT) and Delays(CTD) were found and compared for statistical analysis. The container transport times ranged from 10 to 56 min. during the on-peak period, 8 to 40 min. during the off-peak period and 3 to 24 min. during the mid-night period, respectively (see Fig. 4). The container transport delays also ranged from 4 to 16 min. at the Delay Level 1, 5 to 16 min. at the Delay Level 2, and 7 to 32 min. at the Delay Level 3, respectively (see Fig. 5). There appeared to be a severe difference in the container transport times and delays between the peak-time periods. These results indicated when traffic congestion occurred severely and that there existed about 50% reduction in the average container transport times when the container transport vehicles were operated during the mid-night period instead of the on-peak or off-peak periods.

Type of Road : Of the Off-Dock CY groups, the third CY group was reviewed for the statistical analysis. The container transport times on urban Freeway ranged from 32 to 40 min. during the on-peak period, 23 to 28 min. during the off-peak period and 15 to 20 min. during the mid-night period, respectively. Also, the container transport delays on urban Freeway ranged from 7 to 12 min. at the Delay Level 1, 6 to 9 min. at the Delay Level 2, and 15 to 20 min. at the Delay Level 3, respectively. However, the container transport times on urban Arterials ranged from 45 to 56 min. during the on-peak period, 32 to 40 min. during the off-peak period and 15 to 24 min. during the mid-night period, respectively. The container transport delays ranged from 13 to 17 min. at the Delay Level 1, 13 to 19 min. at the Delay Level 2, and 28 to 34 min. at the Delay Level 3, respectively. There appeared to be about 30 % reduction in the average container transport times when the container transport vehicles were operated on urban Freeway instead of urban Arterials.

Table Ⅰ. Paired t−Test Results based on Transport Times

Comparisons of Means and Variances for Each Transport Period

Transport Periods	Mean(in Min.)	Variance
On−Peak period	34	202
Off−Peak period	24	103
Mid−night period	13	42

Comparisons of Calculated t−values at 99% Confidence Level

Paired periods	Critical t at 99% C. Level	Calculated t−value	Null Hypothesis
On−Peak vs Off−Peak	2.453	13.33>t	reject
On−Peak vs Mid−night	2.453	14.18>t	reject
Off−Peak vs Mid−night	2.453	14.27>t	reject

Table Ⅱ. Paired t−Test Results based on Transport Delay

Comparisons of Means and Variances for Each Transport Deley Level

Transport Delay Level	Mean(in Min.)	Variance
D1=On−Peak — Off−Peak	10	18
D2=Off−Peak — Mid−night	11	19
D3=On−Peak — Mid−night	21	71

Comparisons of Calculated t−values at 99% Confidence Level

Paired delay	Critical t at 99% C. Level	Calculated t−value	Null Hypothesis
D1 vs D2	−2.453	−3.40>t	reject
D2 vs D3	−2.453	−13.33>t	reject
D1 vs D3	−2.453	−14.27>t	reject

Table Ⅲ. Paired t−Test Results for Transport Times on Urban Freeway

Comparisons of Means and Variances for Urban Freeway

Transport Periods	Mean(in Min.)	Variance
On−Peak period	35	19
Off−Peak period	26	4
Mid−night period	18	7

Comparisons of Calculated t−values at 99% Confidence Level

Paired periods	Critical t at 99% C. Level	Calculated t−value	Null Hypothesis
On−Peak vs Off−Peak	2.453	7.41>t	reject
On−Peak vs Mid−night	2.453	13.86>t	reject
Off−Peak vs Mid−night	2.453	12.32>t	reject

Table Ⅳ. Paired t−Test Results for Transport Times on Urban Arterials

Comparisons of Means and Variances for Urban Arterials

Transport Periods	Mean(in Min.)	Variance
On−Peak period	52	12
Off−Peak period	37	8
Mid−night period	20	6

Comparisons of Calculated t−values at 99% Confidence Level

Paired periods	Critical t at 99% C. Level	Calculated t−value	Null Hypothesis
On−Peak vs Off−Peak	2.453	42.34>t	reject
On−Peak vs Mid−night	2.453	42.84>t	reject
Off−Peak vs Mid−night	2.453	26.85>t	reject

Table Ⅴ. Two−Sample t−Test Results between Freeway and Arterials

Means and Variances for Urban Arterials

Transport Periods	Mean(in Min.)	Variance
On−Peak period	52	12
Off−Peak period	37	8
Mid−night period	20	6

Means and Variances for Urban Freeway

Transport Periods	Mean(in Min.)	Variance
On−Peak period	35	19
Off−Peak period	26	4
Mid−night period	18	7

Comparisons of Calculated t−values at 99% Confidence Level

F vs A at Peak period	Critical t at 99% C. Level	Calculated t−value	Null Hypothesis
F vs A at On−Peak	2.681	84.76>t	reject
F vs A at Off−Peak	2.681	53.61>t	reject
F vs A at Mid−night	2.681	10.87>t	reject