Scientific Research and Essays Vol. 5(8), pp. 806-812, 18 April, 2010
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2010 Academic Journals

Full Length Research Paper

Developing the basics of pavement management system in Besiktas district and evaluation of the selected sections

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Accepted 6 April, 2010

Pavement management is in a broader sense, a working program that involves all the procedures of planning, programming, designing, building, maintaining, and rehabilitation. Pavement management concept is first introduced in the 1960's to ensure the best use of existing resources. Today many corporations in USA use managements systems either developed by themselves or modified to fit their climate, traffic, land, equipment, corporate structure and budget constraints. A pavement management system (PMS) arranges tools and methods to be used for determining the best maintenance schedule for the decision makers in a given period. A good pavement management is an integrated system which makes it necessary to think in a systematic and organized way, besides, it ensures that, necessary work is performed on daily basis. In this study, infrastructure distress data which is compatible with the distress identification manual published by American Society for Testing and Materials in 1999 is collected from 20 sections selected from the arterial road network in Besiktas district of Istanbul. The reasons for formation of distress types in the determined network are studied under the headings like axle load, climate and other (material characteristics), and distress evaluations throughout the whole network and each section are carried out.

Key words: Pavement management system, paver system, pavement condition index (PCI), distress types.

INTRODUCTION

In the literal sense, first roads built through Egypt from the South part of the Asia almost after the invention of wheel around 3500 B.C. On the other hand, first road that depends on some scientific rules built by Romans around 300 B.C. The oldest and the longest known road is the "King's Road" which built by Persians. Through the end of the 18th century some basic scientific principles about road construction had been defined by the engineers. During the 1960's AASHO started to determine theoretical roots of road pavement using "AASHO Road Test" results (Haas et al., 1994).

Pavement management concept was first conceived in the mid-1960's to organize and coordinate the activities involved in achieving the best value possible for the available funds. In response to the growing need for highway rehabilitation and maintenance on one hand and shrinking resources on the other, there has been an increased interest in developing a formal management approach to optimize the utilization of highway construction and maintenance resources. The specific component of this approach related to pavement is termed Pavement Management System (PMS). Hence, optimizing the current pavement condition, an evaluation practice will be the first and foremost task of efficient pavement management systems (Terzi, 2006).

Good pavement management is not business as usual. It requires an organized and systematic approach to the way we think and in the way we do in day-to-day business. Pavement management, in its broadest sense, includes all the activities involved in the planning and programming, design, construction, maintenance, and rehabilitation of the pavement portion of a public works program. PMS is a set of tools or methods that assist decision makers in finding optimum strategies for providing and maintaining pavements in a serviceable condition over a given period of time (Haas et al., 1994).

Pavement management comprises two different operating levels which are "network level" and "project level". The Principal aim at network level is to develop programs

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Table 1. Pavement investment costs for Istanbul city.

Years	Hot-mixed asphalt (tn)	Cost (YTL*)	Cost ($)
2005	1.751.860	156.484.983,00	208.125.027,39
2006	2.201.308	204.642.037,00	272.173.909,21
2007	365.451	33.250.835,00	44.223.610,55

*YTL = New Turkish Lira

that have priority and to develop management system work plans. At project level, basically, decisions which are made at network level implemented. The pavement management process consists of the following main tasks, successively, pavement network definition, pavement condition measurement, pavement condition prediction, network level management, project level management (Shahin, 2002).

Pavement is not a cheap part of road network. In U.S, for only intercity road network, pavement investments 30 billion USD had been spent during 1994 (Haas et al., 1994). Besides, more than 1 billion USD has been spent for improving and maintaining these pavements. In Istanbul maintenance, repair and renewal works of pavements has been done by the IBB Road Maintenance and Renewal Office. Amounts of pavement investments' and prices between 2003 - May of 2007 are shown in Table 1.

PAVEMENT DISTRESSES AND CLASSIFICATIONS

Many of the pavement management offices make periodical surveys within their responsibility areas for tracking pavement condition. These surveys are made by measuring distress at different type, priority level and density. Though, different methods are used, usually measured factors and components shows similarities. Measured factors can be listed as surface defects, permanent deformation or distortion, cracking and patching (Cafiso et al., 2006).

Paver system

Paver system has been widely used as a pavement management system at several airports' and cities/towns of USA and at different countries' which is developed during 1970's by U.S. Army Corporation of Engineers. Paver system developed by taking into consideration of pavement distress data along with some destructive and nondestructive performance test results which also include a computer programmed named "Micropaver".

Paver system use Pavement Condition Index (PCI) for determining current circumstance in a pavement section. The Navy's PCI Guidance provides guidance and direction for implementation of the PCI system for all pavement work including special project validation. The objective is to use the standardized surfaced area maintenance management system to reduce maintenance and repair costs while improving pavement service ability. The PCI is a numerical indicator based on a scale of 0 - 100 and is a measure of the pavement's integrity and surface operational condition. ASTM D 6433 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys" is the standard to follow on performing a survey and to determine the PCI (Cline et al., 2003).

PCI is an index which shows the present condition of pavement according to simultaneously evaluation of distress amount, distress density and distress type as well. While standard PCI scale evaluates pavements within 7 different categories, special PCI scale uses only 3 different categories. Also, different colours have been used by Micropaver to depict different situations within both standard and special scales. Concurrently, present condition, with other words pavement quality, can be described by using words "excellent", "very good", etc. Pavement quality and PCI comparison are shown in Figure 1.

American society for testing and materials (ASTM) distress identification manual

Pavement distress manual for roads and parking areas are published by ASTM in the year 1999 with D 6433–99 code. Distress types gathered in three different categories which names are "axle load", "climate" and "others". At the design phase thicknesses of the layers of a pavement that composed road body determined, depending upon the repeat number of chosen standard axle load. If more traffic uses the road than expected or heavier axle loads uses the road more than calculated axle loads, then "axle load" caused distresses would be observed. Besides, seasonal temperature or daily temperature differences also causes distresses at the pavement which are named "climatological distresses". Table 2 shows the "distress type reasons" and "ASTM distress definition guide". Furthermore, pavements goes bad in time with such reasons which are; construction faults, maintenance faults, material specifications, leaking of oil, gas and other chemical fluids, salting at defrosting works.

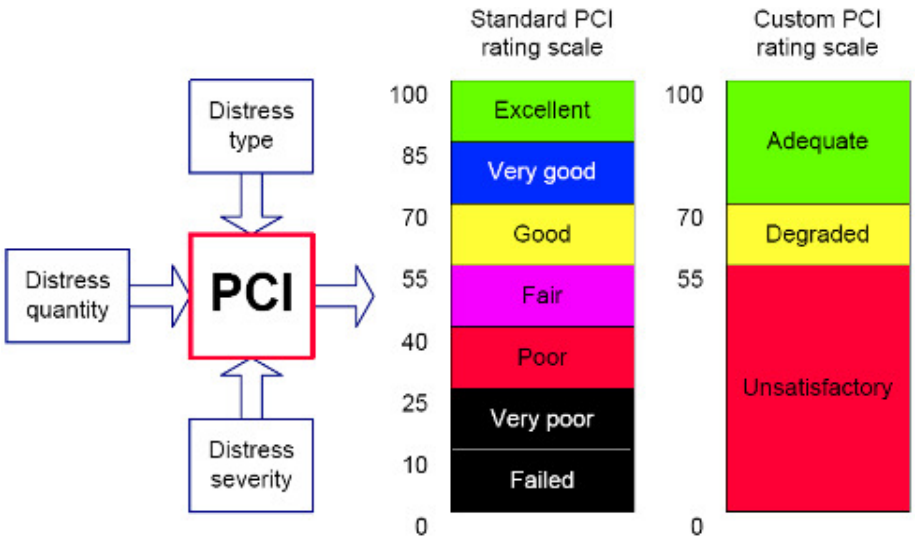

Figure 1. Pavement quality – PCI (Micropaver 5.3 Manual).

Table 2. Paver distress classification for roads and parking areas (Shahin, 2002).

Code	Distress	Unit of measure	Defined severity levels?	Cause
01	Alligator cracking	m^2	Yes	Load
02	Bleeding	m^2	Yes	Other
03	Block cracking	m^2	Yes	Climate
04	Bumps and sags	m	Yes	Other
05	Corrugation	m^2	Yes	Other
06	Depression	m^2	Yes	Other
07	Edge cracking	m	Yes	Load
08	Joint reflection	m	Yes	Climate
09	Lane/shoulder drop-off	m	Yes	Other
10	Longitudinal and transverse cracking	m	Yes	Climate
11	Patching and utility cut patching	m^2	Yes	Other
12	Polished aggregate	m^2	No	Other
13	Potholes	number	Yes	Load
14	Railroad crossings	m^2	Yes	Other
15	Rutting	m^2	Yes	Load
16	Shoving	m^2	Yes	Load
17	Slippage cracking	m^2	Yes	Other
18	Swell	m^2	Yes	Other
19	Weathering and Raveling	m^2	Yes	Climate

APPLICATION TO THE BESIKTAS DISTRICT

First task of developing a PMS is determining the size and boundaries of network. For being base for our work, the total of 20 arterial streets chosen, belong to Besiktas district. According to paver system's network definition rules, our network first split to divisions then to sections. The most important parameter used for fulfilling this process is the sections which are determined by the Istanbul greater city municipalities' road maintenance and renewal office. The office accepts boulevard names and arterial street names as sections, and then they planned their whole investment and budget plans according to this assumption. We used the same assumptions in order to be able to taking advantage of using previous years' data.

GIS technique used for visualizing and emphasizing the results of our work. After determining sections and then using them in GIS, every section further divided sample areas as pointed out in Shahin (2002). After the

Table 3. Section's PCI value.

Section No.	1	2	3	4	5	6	7	8	9	10/1
PCI Value	69	80	96	79	93	85	85	62	67	77
Section No	10/2	11	12	13	14	15	16	17	18	19
PCI Value	73	58	85	72	77	71	67	50	62	61

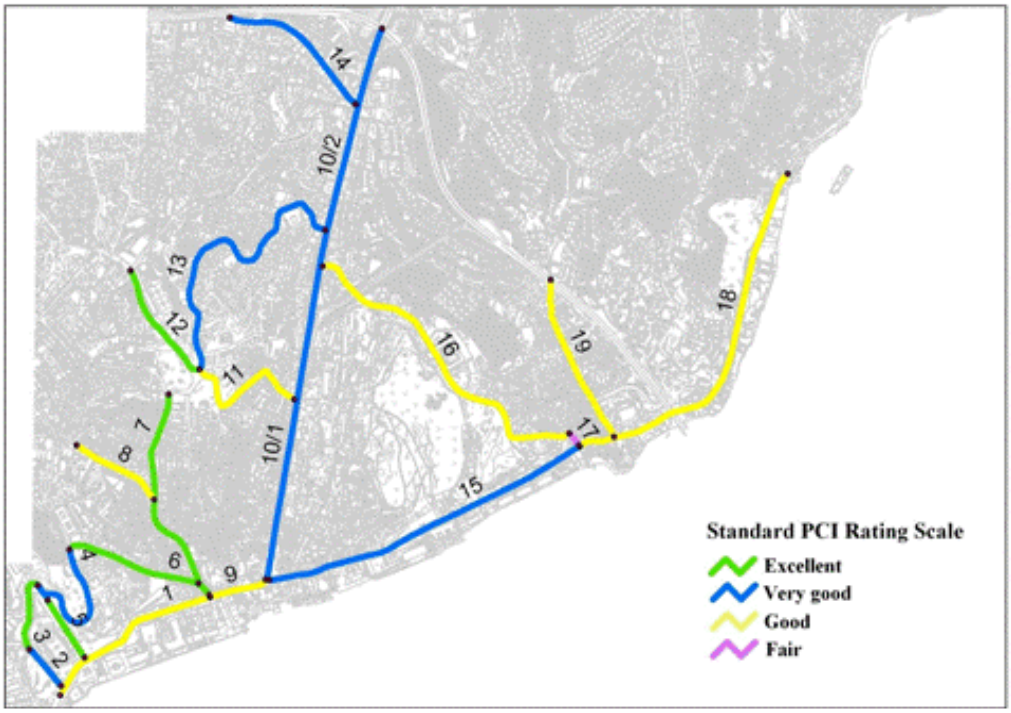

Figure 2. Sections situation for standard PCI rating scale.

finding of sample areas' number, the number of minimum sample area's found by using PCI standard deviation σ=12. Namely, by choosing PCI interval as 30 then the minimum number of sample areas' found. Considering "systematic random" the principle paver system suggests, the number and location of sample areas' determined. Then, site work plans prepared for every section. In the light of this site, work plans distress data gathered at every sample area and recorded into "pavement condition observation sheet".

Also, some additional sample areas has been added to our original sample area group if an area does not belong to our sample group at first hand but it observed with dense distress. 1017 sample areas determined at first, then, 307 of them selected for our sample group according to "systematic random" principle and finally, 13 additional areas selected by observations to reach a total of 320 for examinations. After gathering data with site work, then sections' PCI values calculated as explained in detail in Shahin (2002). Table 3 shows calculated PCI values.

Calculated PCI values classified according to standard and special PCI scales. According to standard PCI scale existing conditions of the pavement can be seen in Figure 2. Besides, to display and to make deductions from the present condition of pavement, it's been assumed that in the special PCI scale that, if the grades between 100 and 70, called as sufficient and considered in good condition, if the grades between 70 and 55 called as deteriorated and considered as need rehabilitation, if the grades between 55 – 0 called as insufficient and considered as need total renewal. Pavement condition of our network can be shown in the Figure 3. These assumptions do not reflect any governmental office's decision. These kinds of decisions can be given in the light of previous PMS experience of the office and considering the budget constraints as well. However, in the first establishment phase of any PMS some border values or scales have to be assumed for making decisions. In the light of the assumptions to be made at Figures 2 and 3, it can be considered that the pavement is in good condition. Then, some comments about management strategies have been given after the evaluation of obtained distress data from the sample areas. For this aim, first of all distress

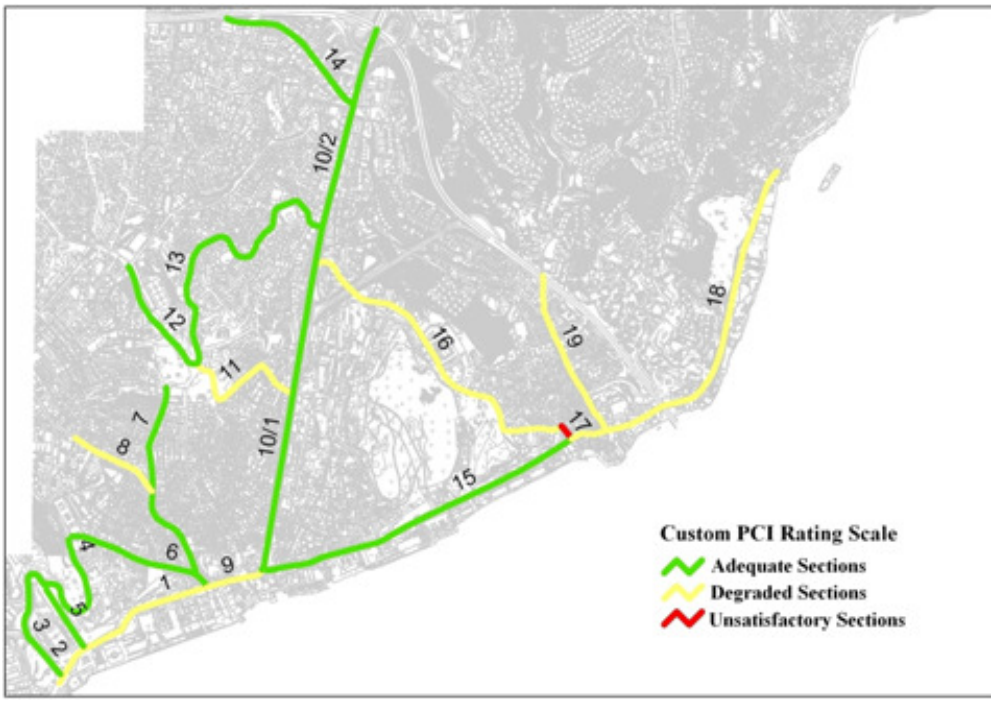

Figure 3. Sections situation for custom PCI rating scale.

Table 5. Distress type weights that existing the sections in Network (%).

Distress code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
In Network	5	0	0	1	4	2	1	0	0	13	28	20	10	0	5	0	0	0	9

Table 4. Reasons for distresses at the pavement.

	Cause		
	Load (%)	Climate (%)	Other (%)
In Network	21	23	56

types (load, climate, others) denoted as percentages which are obtained by the ratio of amount of the distressed area to amount of the sample area.

Table 4 shows the whole picture of the network according to distress causes. Besides, in Figure 4 is an evaluation of the sections according to distress types that can be seen graphically. Throughout the network, axle load caused distresses are about 21%, climatologically distresses are about 23% and other types (that is, labour, materials' specifications, defrosting works) are about 56%. As easily can be seen most of the distresses are caused by "other" kind of reasons. So, in the light of these findings one can say that most of the distresses arises because of "other" type of reasons which could be labour, materials' specifications, defrosting works etc. Furthermore, one can also say defrosting chemicals should be inspected carefully before spilled over the pavement. At the last part of the work, the weights of distress types in the sections inspected and then design strategies are developed based on this inspection. In the developed chart (Table 5) distress codes are used instead of distress names. Distress weights are calculated for the whole network as well.

It can be concluded that, when one thought that, the road patches applied to road surfaces for the restitution of distresses that come in to being in years and again "Polished aggregate" seen at roads after years of repetitive vehicle axle loads effects the pavement of our network that can be said to proliferated with periodical maintenance and it can also be said to be old. The most important phase at the project level evaluation in a PMS is the single evaluation of the sections. For that reason, at the end of the evaluation, taken this into consideration of the distress will causes new design strategies that developed for a renewal work at all sections. These evaluations and the situation of the network are based on

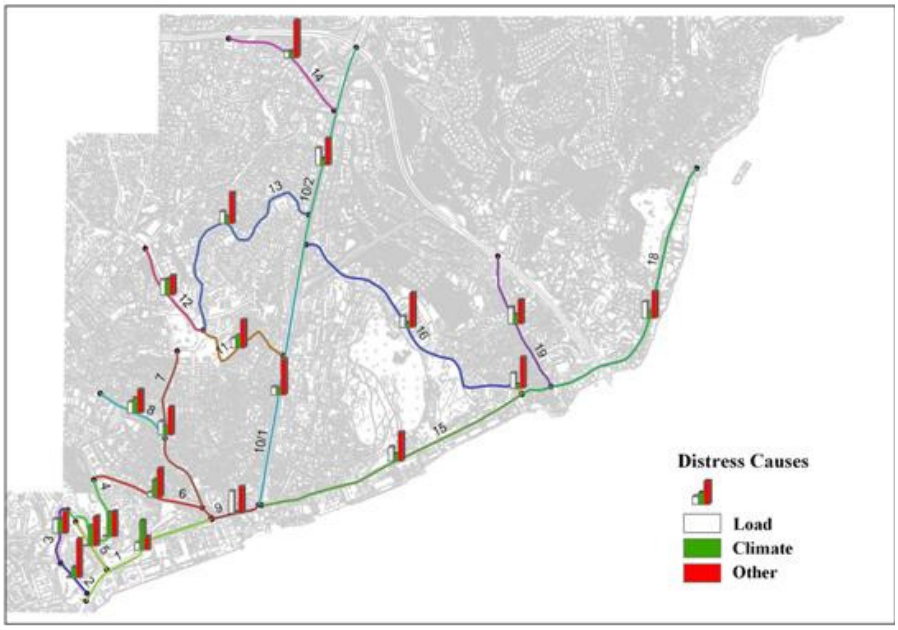

Figure 4. Distribution of the distress causes.

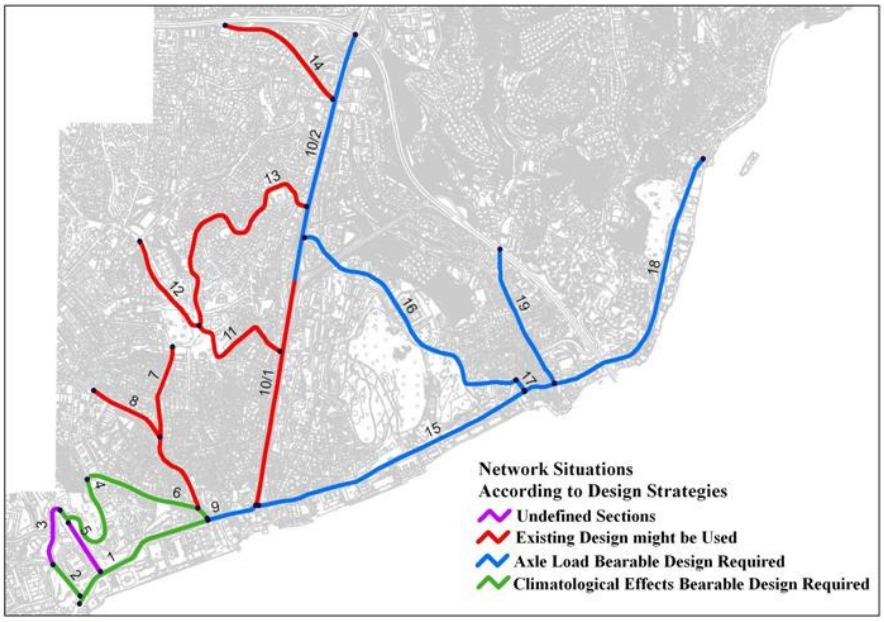

Figure 5. Situation of networks according to improved design strategy.

developed strategies as shown in Figure 5.

Conclusion

Paver system has examined 19 different types of distress and described 3 types of distress severity (low, medium, high) for 18 of them (excluding polished aggregate). Concerned distress types have been published by ASTM in 1999 with D 6433-99 standard code. In standard distress types that have been detailed and described with associated pictures. In this study, distress data have been collected and evaluated according to the standard. Paver system is a management system, which can decide pavement's condition, only evaluating pavement distress, without using information about climate and

traffic load. This ability is the greatest advantage of it.

It can be said that at the end of all evaluations, in 12 sections of total 20, the pavement condition can be accepted as good, in 7 sections the pavement needs some maintenance and rehabilitation, and finally, only in 1 section the pavement needs total renewal. Again, it is believed that, most of the distresses seen on the pavement caused by “other” types of reasons (almost 51%) then we can say pavement design for the whole network in general can be considered as appropriate (Kirbas, 2007).

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