Development of Municipal Pavement Management Systems Under Limited Resources in Indonesia: A case of Cimahi city

by

Eliza Rosmaya Puri

March 2016

A dissertation submitted to
Graduate School of Engineering, Kochi University of Technology
In partial fulfillment of requirements for the degree of

Doctor of Philosophy

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Infrastructure Management Systems

Kochi, Japan
March 2016

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Abstract

The study is aimed to develop a set of concise principles for the municipal pavement management systems in Indonesia that face limited access to resources (human resources, budget, equipments, materials, and maintenance methods) in implementing proper and timely city road maintenance work. There is urgent need to shift from reactive maintenance practice to preventive maintenance practice for sustainability of city road maintenance in Indonesia

First, present parameters of road conditions were studied in order to find out the effectiveness of the parameter to communicate conditions of road among different stakeholders. Satisfaction approach was applied to develop open-ended questions in order to elicit information about how road users/citizens feel and perceived road/drainage conditions and its problems. Result of the interview was analyzed and confirmed with the result of survey road conditions in two case studies to obtain the new parameter of road conditions. The new set of parameter of road conditions based on road users/citizens satisfaction consisted of five parameters:

1) Small volume of pavement distress in scattered area
2) Moving road deterioration
3) Seasonal floods and water pond
4) Rapid decay of newly paved road
5) Unconnected road network

In the future, this new set of parameter of road conditions could be apply tobenchmark a city road condition for each parameter and also displays the derived overall road performance.

Second, two case studies of city road in Cimahi city, Indonesia were examined to investigate the road conditions and its association with road maintenance practice Indonesia. Four of five of new set of road conditions parameter that occurred in two streets observed were identified. Association between road conditions and practice of municipal maintenance management in Indonesia were investigated using cause-effect analysis. The causes of each road conditions were investigated through document review, interview and field investigation (rebound hammer test, traffic counting, road survey condition, site observation). Relations between road conditions and factor that directly affecting road performance: structure, traffic, environment, and maintenance were identified. Then, questionnaire and evaluation model

were developed to investigate causes of the identified factors with its practice in maintaining city road. Hypothetical association among three components was proposed: PMS practices, Factors that affect road performance, and Parameters of road conditions. Each of PMS practices was analyzed in order to obtain root constraints of road/drainage maintenance:

- Institutional support for maintenance in initial design and construction.
- Coordination for monitoring & controlling utilization of road network.
- Coordination and careful management (POAC) of limited resources.

The evaluation of the feasibility of the proposed municipal pavement management systems in Indonesia was conducted through mini forum discussion involving Highway Department and Transportation Agency of Cimahi city. The result showed that basically, Municipal Highway Department (HD) can only control 2 constraints among 14 identified constraints related to problems of Original Road Development (ORD) and Pavement Monitoring and Operation (PMRO). Active participation and coordination from all stakeholders is required to solve problem in those problems. The evaluation also showed that HD is required to emphasize on improving their documentation of road condition and frequency of routine maintenance as part of the process of proposed pavement management system. Through better database and inspection of road/drainage conditions, all stakeholders agreed that 24 constraints identified related to Road Maintenance (RM) problem were possibly be solved.

Next, several well-known guidance for road maintenance and rehabilitation management are examined in order to find out the principle and the techniques of municipal pavement management systems for maintaining city roads in Indonesia. Based on the literature reviews and previous findings in this study, a concise principle of pavement management systems for municipal road agencies in Indonesia is developed. Documentation of road condition and routine maintenance was incorporated in the proposed PMS. In addition, awareness of size of road network as a one of root constraints has led to incorporation of Original Road Construction elements in the proposed PMS. The proposed PMS is also driven by the proposed new set of parameter of road conditions as preference for minimum level of service. Hence, the proposed PMS consists of eight elements as follows: (1) Original Road Construction. (2) Performance monitoring & Road operation (3) Mandated of Levels of Service(4) Pavement Inventory and Prediction Model (5) Identification and Prioritization of Needs (6) Budgeting (7) Project Design (8) Project Implementation.

Acknowledgement

This doctoral thesis presents the results of a research conducted in co-operation with Kochi University of Technology (KUT) and Cimahi City Government. A major part of the research was conducted at both institution.

First of all, I would like to express my sincere thanks to my supervisor Professor Tsunemi Watanabe at Kochi University of Technology. Thank you very much for your valuable comments, suggestions, wise advice and never ending patience.

I am also most grateful to the members of the examination committee who have been a constant source of support. The examination committee included Professor Masahiko Kunishima, Professor Steve Rowlinson, Asst. Prof. Takashi Goso and Asst. Prof. Yoshihiro Nakagawa for their supervision and support.

Particular thanks to the Mr. Bambang Ari, Mr. Ison Suhud, Mr. Agus Joko and their staf in the Cimahi city government, particularly Highway Department of Cimahi City, Transportation Agency, Research Institute of Agriculture, Cleaning Department, Police Resort Traffic Unit and all the experts who have been participated in the interviews and contributed their time, experience and ideas.

I also wish to express my gratitude to all my colleges at Bandung Institute of Technology, especially Construction Management and Engineering studies group, Faculty of Civil Engineering and Environment and ITB-JICA scholarship. Appreciation is extended to their valuable scholarship. International Relations Division of Kochi University of Technology are grateful acknowledge for their continuous support during my stay in Japan.

I would also thank all my friends in KUT: Indonesian friends (Ms. Sari Dewi Kurniasih, Ms. Dwiyantari W., Mr. Handityo A. Putra, Ms. Reisa Rahmatu D., Mr Keiichiro A. Reihan), Ms. Nem Kam Dim, Ms. Sathya, Mr. Narith, Ms. Yumi Muroi, laboratory member (Dr. An Tingyu, Dr. Dewi Larasati, Ms. Wang Ling Ling, Mr. Francis Ndamani, Mr. Susumu Nakaya, Mr. Dennis Gain, Mr. Hai, Ms. Hien, and all undergraduate students), and all international friends.

Finally to my family, my wonderful parents, Indira, Kelvin, thanks for your love, for being there for me and endless patience.

Kochi, March 2016

Eliza Rosmaya Puri, Author

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CHAPTER 1 INTRODUCTION

1.1 Introduction

Roads form an integral part of the transport infrastructure. Air transport is fastest, and water transport is most economical means to transport cargo. Railways provide cheaper and comfortable means of transport for citizens. However, roads provide the last mile connectivity, which completes connection from the origin to the destination. All other means of transportation require road connectivity to supplement them. The road connectivity helps in distributing the product from remote location to the urban areas where it will be consumed, and, in return, essential products and facilities can reach the rural areas. Thus, adequately maintaining roads will improve access between regional and rural communities, reduce poverty and ultimately enhance socio-economic growth and development.

For road agency, preserving and maintaining the condition of road network is a vital task to provide a safe, smooth, and sustainable transportation system. Experience in other cities and countries, i.e.: Oslo, Sacramento, Kenya, Tanzania, Southern African Development Communities (SADC) countries, and Sub Saharan Africa countries, has shown that lack of proper and timely maintenance will result in reduction of stable road conditions as well as increasing in travel times, vehicle operating costs, and unreliable road transportation services. Such conditions will result in the need for heavy and costly maintenance treatments in the future. Since the resources available to maintain road networks are becoming limited and public demands are increasing in the future, road agencies worldwide are needed to increase efficiency of ongoing investments in planned maintenance activities (Molenaar 2001, Prarche 2007).

Pavement management systems (PMS) are a systematic asset management practices introduced in 1960-1970 by AASHO. Taken from the American Association of State Highway and Transportation Officials (AASHTO) Guidelines for Pavement Management Systems (1990), PMS are designed to provide objective information and useful data for analysis so that highway managers can make more consistent, cost-effective, and defensible decisions related to the preservation of a pavement network. The typical functional areas of PMS includes: data collection, data process storage, data analysis (PMS software, data analysis, performance prediction) and maintenance programming (budget prediction, engineering plan, action plan). Thus, a database is fundamental to any PMS – without it, one does not have a system.

Application of PMS requires a set of parameters of road conditions/performance measures which are needed to continuously collect, store and analyze by road agency. However, study by Lang (2012) in Finland and some Nordic country stated that there is lack of tool for proper communication about road maintenance among stakeholders. One of the challenges is that the road agencies have not been able to come up with simple and understandable facts/technical information upon which decisions can be based. Within the past decades, numerous initiative have become more customer-oriented, with an increased focus on maintenance outcomes and targeted performance levels to improve maintenance quality and better defend maintenance budget requirements. Study by World Road Association, PIARC (2014) and National Cooperative Highway Research Program, NCHRP (2012) showed diverse areas of road performance measures as a basis of maintenance budgeting and target setting.

- Safety (e.g., number of fatalities and serious injuries)
- Infrastructure condition (e.g., state of good repair)
- Freight mobility and economic vitality (e.g., speed, travel time, and/or reliability on key networks)
- Mobility (e.g., travel time and reliability)
- Environment (e.g., greenhouse gases and storm water runoff)
- Livability (with potential measures to be determined)

In addition to the benefit of PMS, associated costs of implementing and maintaining PMS is listed in the Washington State Department of Transportation (WSDOT) in Local Agency Pavement Management Application Guide (1996). These costs may be broken down as follows: software and hardware acquisition cost, data collection costs, consultant services cost, in-house staff time cost (data processing, data analysis, system maintenance and training), and the actual expenditure made on the pavement network. These have caused fundamental maintenance challenges for many road agencies in both developed countries and developing countries.

1.2 Problem Statement

Many countries face challenges in implementing Pavement Management Systems (PMS). As the database is fundamental to any PMS, the first challenge is to set up satisfactory level of service. In view of the maintenance, road agencies are committed to use certain parameter of road conditions such as riding comfort (International Roughness Index (IRI), Deflection, etc), pavement distresses (amount of cracking, potholes, rut-depth, etc.), safety riding (skid resistance, accident cost, etc.), maintenance cost, vehicle operating cost, time travel, etc. Each parameter requires specific measures such as definition of measures, sampling method, and measurement tolerance.

Road agencies who want to apply PMS faced problems in determining parameters of road conditions to be collected. They should ensure that the data of each parameter could be collected easily. The quality of the data used in road/drainage maintenance decision making is also critically important; therefore, PMS should be able to help ensure the data's reliability and completeness. Moreover, the data should also be used to communicate effectively with both internal (maintenance personnel: inspector, planner, etc) and external stakeholders (road users/citizens, top management, road operational staffs, financial staffs, contractors/consultants).

Besides that, there has been a great deal of variability of constraints faced by road agencies in different countries, such as inappropriate use of technology, shortage of fund, inadequate labor skill, etc. In addition to the technical issues associated with the use of road conditions/performance data to support maintenance decisions, institutional and financial issues may also need to be addressed (World Bank 1988, NCHRP 2012). All constraints should be mapped in a clear problem structure to identify the root constraints. As the root constraints are identified, road agency can prioritize allocation of resources to deal with specific constraint.

1.3 Objectives

The overall goal of this study was to propose municipal pavement management systems for city road agency in Indonesia. The objectives of the present study are:

1. To understand association between city road/drainage conditions and municipal pavement

management practices

a. Develop parameters of road conditions based on citizen/road user satisfaction

b. Formulate a prototype of problem occurrence mechanism of municipal road/drainage maintenance

2. To develop a concise municipal Pavement Management System suitable for city road agency

1.4 Scope of Research

The study consists of five main parts. Chapter 2 discusses methodology used in this study. Chapter 3 discusses development of parameters of road conditions based on citizens/road users satisfaction. Chapter 4 discusses formulation of a prototype of problem occurrence mechanism of municipal road/drainage maintenance. Chapter 5 discusses a concise municipal pavement management system suitable for city road agency. In the last chapter, Chapter 6 discusses conclusions of the study.

1.5 Study Framework

The study was conducted using the following conceptual framework. The study framework was described here.

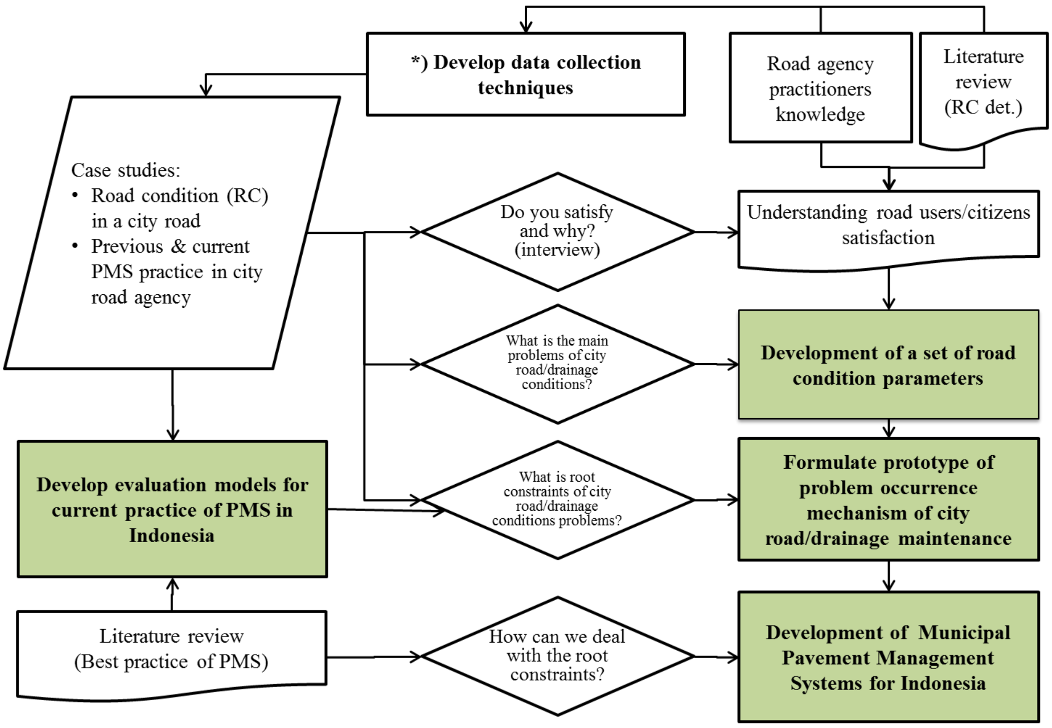

Figure 1 Study Framework

1.6 Expected Contribution

Through the study, it is expected that the knowledge of this research will contributed to:

- Inspection data, data storage process, data simulation and data analysis of Pavement Management Systems should be based on a set of parameters of road conditions which represent road users/citizens satisfaction. Thus, Chapter 3 proposes a new set of parameters of road conditions as a new contribution to Pavement Management Systems to overcome the problem of communication on conditions of road among road users/citizens, road agencies, and other related city agencies.
- In Chapter 4, a prototype of problem-occurrence mechanism of municipal road/drainage maintenance is proposed to increase awareness of the big pictures/systems of problem occurrence mechanism among related stakeholders. It is expected that this awareness can encourage participation from all stakeholders in effective maintain road maintenance.
- The scope of Chapter 5 is development of a concise municipal pavement management system suitable for city road agency. It is expected to be useful to assist road agencies move from reactive maintenance into preventive maintenance.

CHAPTER 2 METHODOLOGY

2.1 Study Area

Cimahi city, located 12 km west of Bandung, West Java province, Indonesia, was selected as a case study. Cimahi city government and Cimahi road agency have conducted many organizational changes and showed high dedication in improving road/drainage conditions in Cimahi city.In 2009, the government established Public Works agency which oversees road agency, so called Highway Department (HD), which has main task to increase road network service through its development, improvement and maintenance.

Table 1 Road Network in Cimahi city

Road status in Cimahi city	Length of road (km)
1. Toll road	17
2. National road	4.32
2. Provincial road	9.36
3. **City road**	**120.45**
4. **District/rural road**	**145.86**
Total	296.99

Source: Highway Department of Cimahi city 2014

Cimahi city faces challenge of high traffic density due to high mobility of citizens, while road capacity is insufficient. Cimahi city is one of Bandung Metropolitan Area (BMA) with primary function as residential, industry, military and trading/service region and identified as a region that has fast development. As described in Table 2.1, the total length of roads in the city in 2014 reached about 296.99 km; out of which, 4.32 km were under the national responsibility; 9.36 km under provincial responsibility; and 120.45 km under city responsibility (Highway Department 2014 and Cimahi city 2005) including approximately 145.86 km district/rural road. In summary, 266.31 km length of roads is under responsibility of Highway Department, and city budget shall be used for its preservation/maintenance. Flexible (asphalt) roadis 469,202 m^2, and Rigid (concrete) road is 84,146 m^2.

In this study, in-depth observations were further conducted in Mahar Martanegara street and Kerkof street. The two streets were selected as case studies because these streets have been frequently reported deteriorated within the past 10 years by Cimahi road agency. The two streets are city roads which are a part of 266.31 km road network in Cimahi city(Highway Department 2013).

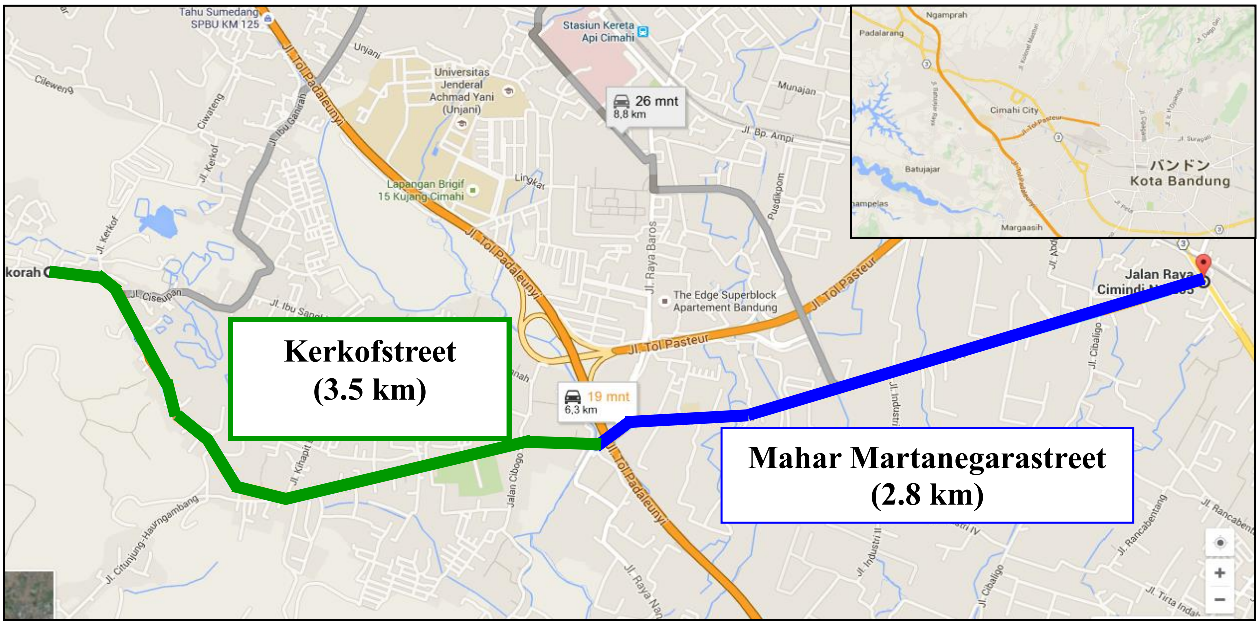

Figure 2 Study Area: Mahar martanegara (MM) street and Kerkof (K) street, Cimahi city, Indonesia (Source: Google Maps)

The two streets are similar in a way that both are ageing roads (>20 years), located in industrial areain South Cimahi district and functioned as primary collector roads. The differences between the two streets can be observed in the length of road and the length of drainage. The lengths of Mahar martanegara street (MM) and Kerkof street (K) are 2.8 km and 3.5 km, respectively. The ratios of rigid pavement in the both streets are 57.4% and 86.7%, respectively. Regarding the drainage, MM has 5,600 m, twice as long as its road length, while K has 4,375 m, 0.63% of its road length. It indicates, thus, that the drainage at MM is more developed than in K. The properties of the two streets are described in the following table.

Table 2 Properties of observed streets

	Mahar Martanegara street(MM)	Kerkof street (K)
Traffic	Cimindi – BundaranLeuwigajah	Leuwigajah – PerbatasanKab Bandung Barat
Road side activity	Industrial area, housing area and shopping area	Industrial area, housing area and shopping area
District	South Cimahi district	South Cimahi district
Total length	2,800 meter	3,500 meter
Width	6-8 meter	5 meter
Type of pavement - **Rigid pavt** - **Flexible pavt**	 11,250 m2 (57.4%) 8,350 m2 (42.6%)	 15,000 m2 (86.7%) 2,500 m2 (13.3%)
Length of drainage	5,600 meter	4,375 meter
Road class	Primary Collector	Primary Collector

2.2 Data Collection

In this study, primary and secondary data were used. All the data were collected in between 2014 and 2016.

Table 3 Data collection

No	Description	Implementation
Primary data		
1	Site visit and interview	I. April 2014 II. 3 Nov 2014 – 12 Jan 2015 III. 1 Nov 2015 - 20 Jan 2016
2	Field sampling and investigation: - Road conditions survey - Rebound hammer test - Traffic counting survey	 6-14 Nov 2014 12 Dec 2014 16-22 May 2015
3	Mini forum discussion	I. 18 November 2015 II. 20 January 2016
Secondary data		
4	Records reviews	3 Nov 2014 – 22 Jan 2015

2.2.1 Site visits and Relevant Personnel Interviews

To begin the investigation, discussions with staffs from Public works agency, Highway department, and Urban planning agency in Cimahi city government were initiated to obtain their thoughts on Cimahi city road conditions, history of pavement management practices conducted by Cimahi city road agency, selection of case studies, and availability of data on the streets being investigated. Data that was considered essential for the overall analysis was included in the following table. Based on the discussion, the availability of data in the agency record was evaluated. For unavailable documents, it was then decided to take other alternatives such as site observations, interviews and field investigations to collect the data or to clarify relevant evidence to support the findings/statements.

Table 4 Data required for study and availability of data

Data required for study		Availability of data	
Subject	**Description**	**Agency records (secondary data)**	**Primary data**
Current Cimahi city road conditions	General information of Cimahi city	Regional Development Plan for Medium Term (RPJMD) and Long Term (RPJPD)	
	Map of Cimahi road network	2012	
	History of road condition in the network	2011-2013	
	Map of road drainage of Cimahi city	NA	Not collected
Case studies data history	Data of construction of original pavement	NA	
	Preservation information	Contract project and budget implementation 2012-2013, Proposal of In-house project unit work	
	Past pavement distress data	NA	Actual road condition survey
	Non-destructive test result	Contract project 2012-2013	
	Pavement design properties	Contract project 2012-2013, Road ledger 2012	
	Pavement material information	Contract project 2012-2013	
	Annual average daily traffic (ADT)	NA	Traffic counting
	Equivalent single axle load (ESAL) – Truck percentage	NA	Traffic counting

	Data required for study	Availability of data	
Subject	**Description**	**Agency records (secondary data)**	**Primary data**
	Relevant construction records (drawing, specification, schedule, QC record, lab material test result, drainage)	Contract project 2012-2013	Condition survey, Schmidt hammer test
	Weather records (rainfall, weather during construction)	Contract project 2012-2013, Rainfall data from RIA	
	Soil and geologic information	NA	Road condition survey
	Designer qualification	Contract project 2012-2013	
	Supervision consultant qualification	Not collected	Interview
	Contractor qualification	Contract project 2012-2013	
Pavement management practice over lifecycle of road	Policy related to road levels of service	RPJMD and RPJPD	
	Road agencies profile (organizational structure, personnel, job description, equipment)	Profile book of Public Work Agency of Cimahi city	
	Relevant original road development records (design analysis, traffic projection, soil investigation, drawing and specification)	NA	
	Relevant maintenance records (survey condition record, prioritization list, budget proposal, budget realization, long term/short term maintenance plan, resources assignment, time schedule)	Budget realization	Interview
	Relevant road operation data	Accident data	
	Procedure of planning, design and construction of original road development	NA	Interview, office observation
	Procedure of maintenance planning, prioritization and budgeting program	NA	Interview, office observation
	Procedure of traffic control program	NA	Interview, office observation

However, much data could not be collected from agencies due to undeveloped database recording systems and the influence of government personnel changes. These unavailable data were original road construction data; historical record of maintenance program and trend line of road conditions over time; traffic design data, data of projected traffic and average daily traffic on the street being investigated; past pavement distress data; drainage condition data; and standard operation procedure for maintenance practice in the Highway department. Hence in this study, site observation, interviews and field investigation were further conducted to provide the missing data/information.

In-depth interview with relevant personnel was then conducted. The following table showed list of organization's staff interviewed.

Table 5 List of Organization's Staff Interviewed

No.	**Stakeholders**	**Involved phase in PMS**	**Number of persons**
1	Road users	ORD, PMRO	60
2	Public works agency	ORD, RM	5
3	Highway department	ORD, RM	15
4	Urban planning agency	ORD, RM	1
5	Transportation agency	PMRO	8
6	City cleaning agency	PMRO	2
7	Research institute of agriculture	PMRO	4
8	Traffic Unit of Resort Police department	PMRO	7
9	Contractor	RM	3
10	Consultant supervision	RM	1
Total			**106**

Note. ORD = Original Road Development phase, RM = Road Maintenance phase, PMRO = Pavement Monitoring and Road operation phase

2.2.2 Field sampling and investigation

The principal objective of a field testing is to determine the in situ properties of pavement type, which may differ from the expected (designed) properties. There are two broad categories of field investigation methods: 1) non-destructive testing, and 2) destructive testing. Non-destructive testing is used to examine a pavement without impairing its future usefulness. Non-destructive methods include conditions surveys, falling weight deflectometer (FWD) surveys, ground penetrating radar (GPR) surveys, Portable Seismic Pavement Analyzer (PSPA) surveys, and Automated Road Analyzer (ARAN) surveys. Destructive testing involves destruction of part or all of the pavement section and necessitating repair of the affected pavement. Coring, dynamic cone penetration (DCP) testing, and trenching are examples of destructive testing used for pavement investigations.

In this study, non-destructive testing was used. The field sampling includes conditions surveys, Schmidt hammer test and traffic counting surveys. Conditions surveys were made to visually examine the pavement conditions of the two case studies being investigated. Appendix 2 summarizes the observations results. Some of the information collected during the conditions survey included:

2.2.2.1 Visual evaluation of the pavement surface by windshield survey

The windshield survey or visual inspection rating (VSR) method was performed by the researchers using a car, driving at the speed limit, but frequently driving at a slower speed on the shoulders along the distressed locations. Frequent stops were made near locations where severe distresses were witnessed. Drainage features at and/or near these locations were inspected to determine if improper drainage was a contributing factor to the distress. In addition, several photographs of the distresses pavements were taken at these locations.

2.2.2.2 Rebound hammer test

The test was applied to provide indications of relative concrete strength at each direction of concrete pavement segment throughout the observed street. It was selected because most of new maintenance treatment built in 2012-2013 in the observed road segment was constructed using concrete. Moreover, it is the most frequently used method for non-destructive testing of concrete. Thus, the unit is easy to use, and a large number of readings can be obtained in a relatively short amount of time. Basically, the Rebound Hammer is a commonly used method for estimating the compressive strength of in-place concrete. In this study, the device which is often referred as a Swiss Hammer measures the hardness of concrete surfaces using the rebound principle in vertical downward. Appendix 3 summarizes the observation results.

2.2.2.3 Traffic counting surveys

The surveys were conducted to obtain the Annual Average Daily Traffic (AADT) on the street being observed. A traffic count is a count of traffic along a particular road, either done electronically or by people counting by the side of the road. In this study, traffic counting survey was conducted manually by 2-3 people counting by the side of the road. The result represented the 2014 actual traffic volume ratio in the street observed. The composition of traffic was passenger cars, motor cycle, heavy vehicle single axle, and heavy vehicle double axles or more. Appendix 4 summarizes the observation results.

2.2.3 Mini Forum Discussions

Mini forum discussions were conducted to disseminate and confirm the results of the study: (a) Proposed parameters of road conditions based on road users/citizens satisfaction, (b) Prototype of problem occurrence mechanism of road/drainage maintenance, and(c) Proposed Pavement Management Systems. It was conducted twice which involves staffs of Highway Department and Transportation Agency as follows:

- In the first Mini forum, 13 Highway Department's personnel attended.
- In the second Mini forum, 5 Transportation agency's personnel and 6 Highway Department's personnel attended.

The mini forum discussions were conducted in the following procedures:

1. Presentation from representative of each agency and researcher.
2. In the discussion session, the questionnaire surveys were given to the respondents.
    - Opinions on each and overall Problem Occurrence Mechanism.
    - Can Highway Department control the ORD and PMRO constraints?
    - Can RM constraints be reduced through inspection and database development?
    - Opinions on proposed Municipal PMS.
3. The responses were collected and discussed with the forum members to draw a conclusion.

2.2.4 Records reviews

Review of records is an important process in the investigation of pavement failure and its causes. It helps to identify any deficiencies in the original development of road and/or maintenance and/or operation of the pavement or any other factors that might have influenced the stability of road conditions. A detailed records review was conducted with the assistance of Highway department personnel to obtain available information for each of case studies.

Records reviews referred to the data that was collected from office files and historical records that can be an invaluable aid in the investigation process. This review was aimed to obtain the following information:

- Current pavement conditions and its historical data (pavement design information, past-distress history, etc.)
- Life cycle management practices of city road
- Factors affecting stability of road conditions on the street being observed

2.2.5 Field Survey Photo

Photos taken in field surveys are shown here.

Highway Department

Road Users/Citizens

Research Institute of Agriculture

Transportation Agency

City cleaning department

Road Condition Survey

Rebound Hammer test

Mini Forum Discussions

Traffic Unit of Resort Police department   Traffic Counting Survey

Figure 3 Field survey photo

CHAPTER 3 DEVELOPMENT OF A SET OF ROAD CONDITION PARAMETERS BASED ON ROAD USERS/CITIZENS SATISFACTION

3.1 Background

Present parameter of road conditions in Indonesia is percentage of total length of stable road in the network. It is used as an indicator for city government performance report. Stable road comprises of roads in good and fair conditions.

However, the parameter does not necessarily represent road users/citizens' demand of high quality road conditions in the present and in the future.For example in Cimahi city, although 94% roads in stable condition (Highway Department 2013), road users/citizens complaints received by Highway Departmenthave been reported increasing each year.

Like many other cities in Indonesia, Cimahi city has a limited number of qualified inspectors and observation measurement tools. As a consequence, the length of road in good and fair conditions is determined based on visual observation and personal record by three districts coordinators and their team. The result is then reported and approved at an annual meeting for maintenance programming. Low quality of data due to high reliance to each personnel recollection was observed from interview and record review due to no official documentation of the observation data, miscalculation, and no measurement guideline referred by different staffs.

In addition to being used in municipal performance report, this condition information is not necessarily used as a basis data in making decision on annual maintenance program. Generally, the more often complaints about a road section is recieved, the more likely the road section will be repaired. Using the present parameter, the urgency of road maintenance treatment for each road section cannot accurately be compared and ranked by road agency. This also indicates that Highway department viewed the data collection of the present parameter as a top management activity that has no purpose at the field level.

3.2 Specific Objectives

Objective of the study is to develop a new set of parameters of road conditions for city network in Indonesia based on the road users/citizens satisfaction. Specific objectives of the study are:

1. To assess the satisfaction level of road users/citizens to the road conditions
2. To determine reasons of satisfaction/dissatisfaction of road users/citizens with the road conditions

3.3 International Perspective on Trends in Performance Measurement of Road Network

Experience in some countries, present parameters of road conditions (length of good road, International Roughness Index (IRI), rut depth, Pavement Condition Index (PCI), skid resistance, accident rate, maintenance cost, road user cost, etc.) do not necessarily include all aspects concerned by road users/citizens. Maintenance serves a large number of stakeholders, and each has different interests and different level of knowledge.

Performance based data collection is gaining attention in the past decades as road agencies promotes a more systematic and transparent process for making road/drainage investment decisions. The attention on performance measures in the world is focused primarily in many areas: Safety, Infrastructure condition (maintenance system), Accessibility and economic vitality, Mobility, Sustainability and Environment quality, and Cost effectiveness. Pavement conditions always come out as the top priority by road users/citizens and many road agencies track performance in the area of infrastructure condition (maintenance) although variety of measures and approaches are used. In the past decades, safety is becoming priority interest in developing countries, such as: Australia, US, New Zealand, Japan and Canada.

It was observed that there is not one measure, or one set of measures, that can be considered the best for all road agencies. Study in Canadian showed that the type of performance measures used and theimplementation practices vary significantly between jurisdictions.For example in Australia, only 71% of councils collected all the parameter set up in Austroads Report IR-28/02. In each case, the performance measures used must depend on the specific conditions of an agency, its goals, its resources, and its audience (Transportation Association of Canada, 2006)

Table 6 Common Performance Measures

Area	Performance Measure	Method of Collection
Safety	- Accident rates - Fatalities rates - Injuries rates - Property Damage Only Incidents - Percent of Incident Involving Truck - Rail Grade Crossing Incidents - Crash reduction - Edge defect - Rutting - Skid resistance - Collision rates	Control section GPS Police report
Infrastructure condition (maintenance system)	- Riding comfort index (RCI)	Infrared Convert IRI to RCI Subjective judgement
	- Surface distress index (SDI)	Infrared Manual observation Automated tool – laser vision system
	- Structural adequacy index (SAI)	Falling weight deflectometer Infrared Benkelman Beam Convert IRI to RCI
	- Pavement condition index (PCI)	Infrared Convert IRI to RCI Visual-manual collection
	- International roughness index (IRI)	Infrared PCI and SDI are used to generate IRI Automated laser visual system
	- Pavement quality index (PQI)	Calculation through PMS Infrared PCI and SDI are used to generate PQI
	- Bituminous index	Manual collection
	- Bridge condition index	Visual inspection Chain drag Half cell
	- Live load rating factor	Bridge Assessment System (BSAII) Funding Need Assessment (FNA)
	- Maintenance condition index	Manual collection Automated collection

Area	Performance Measure	Method of Collection
	- Surface texture	Manual collection Automated monitoring car
	- Crocodile cracking	Manual collection Automated monitoring car
	- Potholes and pothole patches	Manual collection Automated monitoring car
	- Environmental cracking	Manual collection Automated monitoring car
	- Gravel loss	Manual collection Automated monitoring car
	- Sufficiency rating index	Customer survey
Accessibility and economic vitality	- Speed	GPS Spot speed studies
	- Travel time	GPS Spot studies
	- Reliability on key networks	Spot studies
	- Level of service	Calculated using PMS Spot analysis
	- Percent of delay	GPS
Mobility	- Travel time	GPS Spot studies
	- Reliability	Spot studies
	- Average speed	GPS Spot speed studies
	- Traffic volume	Traffic counting Automated permanent counters
Sustainability and Environment Quality	- Greenhouse gases	Spot studies
	- Storm water runoff	Spot studies
	- Noise	Spot studies
	- Environmental evaluation	Fisheries, wildlife, vegetation, wetlands, historical resources
Cost Effectiveness	- Net Present Value	Maintenance cost records
	- Net Benefit/Cost Ratio	
	- Internal Rate of Return	
	- Replacement value	
	- Life cycle cost analysis	

Summarize from:

- Transportation Association of Canada. 2006. Performance Measures for Road Networks: A survey of Canadian Use. Canada: Transport Canada
- NHCRP. 2012. Best Practices in Performance Measurement for Highway Maintenance and Preservation. Lawrenceville: Arora and Associates, P.C.
- PIARC. 2014. The Importance of Road Maintenance. France: World Road Association
- Guideline of Local Government Victoria

Few studies have applied disconfirmation model to citizens'overall satisfaction in public services and especially road construction and maintenance (e.g.: Roch and Poister 2006; Van Ryzin 2005; Hietbrink, M, Hartmann, A, and Dewulf, G.P.M 2012). For example, study by Hietbrink, M, Hartmann, A, and Dewulf, G.P.M (2012) addresses the relationship between stakeholder expectation and satisfaction in road maintenance using expectancy disconfirmation model and case study of arterial road at the ring of Rotterdam in the Netherlands. It is concluded that among satisfaction with process, outcome and information provision,the satisfaction with the outcome plays the most important role in forming the overall satisfaction of stakeholders. The study also recommends a direct measure of expectations, experience, and satisfaction of stakeholders in a specific maintenance project. Previous studies emphasize to better understand the process of stakeholders' satisfaction forming and its relation to stakeholder expectation.

Tothe author's knowledge, however, no study has been conducted for application of road users/citizens satisfaction survey to improve the present parameters of road conditions in Indonesia. Therefore, there is a need to assess the satisfaction level of road users/citizens with the road conditions and investigate the reasons. This information will be useful for road agenciesto better respondto the increase of public demand on city road/drainage maintenance activities.

3.4 Methodology

This research was conducted using two case studies of streets in Cimahi city, West Java province, Indonesia: Mahar martanegara (MM) street and Kerkof (K) street. These two streets were recommended by officers of Cimahi road agency. Moreover, these two streets were selected as case studies due to the similar road function and frequently reported deterioration.Face to face interviews, visual road condition surveys were two main data collection in this study.

3.4.1 Face to Face Interviews

Two key questions were designed for this study and were directed to the road users/citizens through face to face interviews:

a) Are you satisfied with road conditions in each street? Please rate on a scale 1 to 3 (satisfied – neutral - unsatisfied).

b) What are your reasons?

A total of thirty responses (30) for each street was collected and used for the analysis.

3.4.2 Visual Road Condition Surveys

The study involved visual road condition surveys and correlation analyses. The investigations were conducted at an interval of 100 meter in total length of road 6,300 meters. The test was following SK No. 77/KPTS/Db/1990 Technical Guidance for Planning and Programming Regency Road developed by Directorate General of Highway, Ministry of Public Works of Indonesia. The functional and structural performance of the pavement for local road in Indonesia is commonly determined in terms of subjective distress scoring.

In this study, following the guideline, the main components being observed were as follows:

1. Type of surface

   Based on observation, type of surface in each segment was recorded whether Asphalt (A), Concrete (C), Rocks (R), Gravel (G) or Soil (S)

2. Pavement conditions

   Surface conditions of paved road being observed were subjectively assessedas follows:

   Good (G): smooth riding comfort, dense texture.

   Fair (F): fair roughness, open texture, shallow open surface less than 50% of area.

   Fair-Poor (FP): if difficult to differentiate between fair and poor conditions

   Poor (P): rough and exfoliate surface, some are deep.

   Very Poor (VP): crack and exfoliate pavement, many are deep.

3. Level of pavement distress (% of area)

   Type of pavement distress and its severity were measured at the interval of 100 meter using the following rating scores.

Table 7 Rating Score for Paved Road

TYPE OF DISTRESS	PAVED ROAD			
	1	2	3	4
	GOOD	FAIR	POOR	VERY POOR
B. Pothole	0-1	1-5	5-15	>15
C. Uneven surface	0-5	5-10	10-50	>50
D. Crack	0-3	3-12	12-25	>25
E. Rutting	0-3	3-5	5-25	>25

Table 8 Rating score for Unpaved Road

TYPE OF DISTRESS	UNPAVED ROAD			
	1	2	3	4
	GOOD	FAIR	POOR	VERY POOR
F. Potholes	0-3	3-10	10-25	>25
G. Soft spot	0-3	3-10	10-25	>25
H.Surface erosion	0-3	3-10	10-25	>25
I. Rutting	0-5	5-15	15-50	>50
J.Uneven surface	0-3	3-10	10-50	>50

4. Shoulder

   The evaluation of shoulder was conducted using the following scoring system.

   1 = Good shape and slope

   2 = Poor shape and slope

   3 = Shoulder is too high/low < 10 cm, debris/garbage

   4 = Shoulder is too high/low >10 cm or no road shoulder although it is necessary

5. Superelevation/Cross slope

   The evaluation of superelevation of roadway cross slope was measured using the following scoring criterion

   1 = Good: 4%-2%

   2 = Moderate: 2%-0%, (almost flat)

   3 = Poor: uneven surface, poor slope

   4 = Very poor: no shape

6. Drainage

   Drainage condition was evaluated using the following scoring criterion

   0 = None, unrequired

   1 = Good

   2 = Fair (cleaning is required)

   3 = Poor (small repair is required)

   4 = Heavy damage

   5 = None, but required

3.4.3 Data analysis

As shown in table 2, the satisfaction level can take on a value of 1-3 to represent unsatisfied, neutral and satisfied, respectively. The score was calculated by multiplying the number of respondent and the scale. The average score of users/citizens' satisfaction levels with conditions of each road was then obtained.

Next, the reasons of the satisfaction level from the interview were analyzed. Each type of cause of dissatisfaction was distinguished from other type of causes, including its associated physical road conditions. Analysis of road condition surveys was conducted in order to confirm the road users/citizens perception with existing road conditions on site. Analysis of road conditions surveys in two streets consisted of (1) correlation analysis between road drainage conditions and road surface conditions and (2) planning of maintenance required.

3.5 Findings and discussion

3.5.1 Assessment of the satisfaction level of road users/citizens to the road conditions

The study showed that the satisfaction level of road users/citizens with MM street and K street are 2.53 and 1.67, respectively. Satisfaction level of MM street is higher than that in K street.It indicated that road conditions of MM street was perceived better than that of K street. To confirm this perception, the road survey conditions were conducted.

Table 9 Satisfaction level of road users/citizens about the two observed streets

Satisfaction	MM street		K street		Total Score
	Number of Resp.	Score (scale*no)	Number of Resp.	Score (scale*no)	
1 = Unsatisfied	3	3	10	10	13
2 = Neutral	8	16	20	40	56
3 = Satisfied	19	57	0	0	57
Total	30	76	30	50	126
Average score	2.53		1.67		2.10

3.5.2 Identification of reasons of satisfaction/dissatisfaction of road users/citizens to the road conditions

Satisfaction levels are associated with conditions of physical road/drainage and their functions. Well functioned physical conditions of road/drainage give satisfaction to road users/citizens. In contrast, unstable road conditions make road users/citizens unsatisfied. There were two main maintenance problems that are expressed by respondents: late deferred maintenance and inappropriate maintenance.

a. Late deferred maintenance. This is related to slow response of road agency to repair poor road conditions. Road users/citizens associated this type of maintenance problem to several physical conditions of road/drainage:

1. Small volume of pavement distress in scattered area

   Limited resources may prevent immediate response of road agencies from repairing small volume of pavement distress which scattered in different and far location. Road agency tends to postpone the repair until the area of pavement distress becomes larger or until complaint emerges. Most of the time, in-house repair work was very ineffective because of internal and external factors in the Cimahi city's road agency. The internal factor is basically related to poor quality of maintenance caused by implementation of wrong maintenance treatment, selection of poor material quality, and execution of poor maintenance construction. The external factors are heavy traffic and rainwater. These always accelerate deterioration of road conditions.
2. Moving road deterioration

   While gradual road repairmen fixes pavement distress in one location/segment of a street, pavement conditions in different location/segment have also changed. Other segment which is not repaired could be changed from fair to poor condition, which causes a large disparity on surface conditions between road segments in a single road section/street. The main cause of this phenomenon is basically related to ageing road and discontinuity of maintenance treatment. Moreover, the influence of heavy vehicle traffic and water infiltration to pavement is also accelerating the rate of deterioration.
3. Seasonal floods and water pond caused by slow drain of rainwater

   In some area after rain, small water pond had been experienced by road users. Rainwater does not flow into existing ditches due to small inlet, clogged inlet, higher elevation of inlet than road elevation, small capacity of available ditches and disconnected drainage. The rainwater stays flowing on the roadways during rain and slowly drained from the roadways. In some cases, small water ponds were formed after rain stopped. These make water infiltrate to the sub-base and reduce the pavement strength. The main cause of this phenomenon is basically related to inadequate drainage, uneven pavement surface, or insufficient elevation of super elevation in cross-section of road (usually 1-2%). Inadequate maintenance treatment by road agencies (e.g. patching without improving drainage network) were usually contributed to frequent occurrence of seasonal floods and water pond.

b. Inappropriate maintenance. Although maintenance treatment has been performed, in some cases, it did not solve the road/drainage problem. The poor condition of road/drainage remains exist. Road users/citizens also felt that maintenance work was slow and conducted by unskilled workers causing traffic jam. Road users/citizens associated this type of maintenance problem to several physical rapid decay of newly repaired pavement. Rapid decay of newly repaired pavement was defined as a condition that a newly repaired road segment show signs of premature pavement distress or weak spot less than one year of operation. This should not happen if proper selection and execution of maintenance treatment were conducted based on reliable traffic data and hydrology data. In many cases, heavy traffic and rainwater always accelerate this type of deterioration.

Geological conditions in South Cimahi district are vulnerable to erosion. Worst experience in other cities in Indonesia, natural disaster has damaged the road and disconnected road access of an entire village to the central business area. Hence, unconnected road network due to natural disaster (erosion, flood, etc.) was considered important as one of the cause of dissatisfaction to the road conditions. Particularly in unpaved road, a heavy rain could also disconnect road network. The summary of overall reasons from road users/citizens is shown in the following table.

Table 10 Reasons from Road Users/Citizens

Reasons of satisfaction: good and well functioned physical conditions of road/drainage.
Reasons of dissatisfaction: unstable road conditions.

Caused by	Description	Physical conditions of road/drainage
Late/Deferred maintenance :	Slow response by road agency to repair	• Small volume of pavement distress in scattered area
		• Moving road deterioration
		• Seasonal floods and water pond caused by slow drain of rainwater
Inappropriate maintenance :	• Maintenance treatment did not solve the road/drainage problem	• Rapid decay of newly paved road
	• Slow process of repair and unskilled workers	
Natural disaster:	Disconnected road network	• Unconnected road network

3.5.3 Validation analysis: statistical approach

The results of opinions on the proposed parameter of road conditions showed that seasonal flood was the main physical condition disturbing mostly road users/citizens in both streets. Small pavement of distress in scattered area was the second most serious parameter that occurred in both streets. All road users/citizens perceived that all the parameters occurred in

K street. Results of MM street showed more variation: only 17 and 16 respondents had experienced moving road deterioration and rapid decay of newly paved road, respectively. All respondents answered that they never experienced disconnected road network in both streets.

Table 11 The Number of Opinions

Proposed parameter of conditions of road	Number of opinions		Other sources
	MM	K	
• Small volume of pavement distress in scattered area	23	30	-
• Moving road deterioration	17	30	
• Seasonal floods and water pond caused by slow drain of rainwater	30	30	
• Rapid decay of newly paved road	16	30	
• Disconnected road network	0	0	Newspaper articles

3.5.4 Validation analysis: road condition survey

a. Satisfaction level and Length of road in good and fair conditions

Ratio of length of road in Good : Fair : Poor were evaluated by following the guidance of pavement conditions assessment in section 3.4.2 of this chapter. The following criterion is

Good (G) : smooth riding comfort, dense texture.

Fair (F) : fair roughness, open texture, shallow open surface less than 50% of area.

Fair-Poor (FP) : if difficult to differentiate between fair and poor conditions

Poor (P) : rough and exfoliate surface, some are deep.

Very Poor (VP) : crack and exfoliate pavement, many are deep.

Summing length of roads for each condition, ratio of length of road in good : fair : poor conditions for MM and K street can be drawn as follow 75 : 14.3 : 10.7 and 31.4 : 34.4 : 34.3. It means good condition of road in MM street was longer than K street. It was consistent with the higher satisfaction level in MM street. This result also provides initial indication that the reasons of satisfaction/dissatisfaction by road users/citizens can be used as basis to develop a new set of parameters of road conditions.

b. Parameter of road conditions and Visual road condition survey

All the parameters of road conditions, except moving road deterioration can be observed in both case studies based on the result of road conditions survey.

a. Small volume of distress in scattered area

The bigger rating of pavement distress meant poorer conditions. From both road survey conditions tables, small pavement distress can be identified through the score of drainage and pavement distresses. Any result of evaluation that has score ≥ 3 as shown in yellow box in the following table indicated small pavement distress. Definition of score ≥ 3 was explained as follows:

Table 12 Definition of score ≥ 3

TYPE OF DISTRESS	PAVED ROAD (% area)	
	POOR (score 3)	VERY POOR (score 4)
B. Pothole	5-15	>15
C. Uneven surface	10-50	>50
D. Crack	12-25	>25
E. Rutting	5-25	>25
L. Shoulder	high/low <10 cm, debris/garbage	>10 cm or no road shoulder
K. Slope	flat but uneven	no shape

From the table, area of small pavement distresses in MM street was less than in K street. The area of small pavement distresses can be obtained through detailed measurement on site or estimation (area*percentage*number of distresses spot).

b. Seasonal floods and/or water pond

Correlation analysis was conducted to find the relationship between score of drainage (Column M) and total score of pavement distresses, shoulder and super elevation (Column B, C, D, E, L, K for paved road and Column F, G, H, I, J, K for unpaved road). Correlation analyses of the data showed a closely dependent relationship between drainage conditions and pavement distress/other component conditions: 0.53 in MM street and 0.74 in K street. The location of poor and very poor drainage conditions can also be observed in the table which was marked in green box which is associated with the physical conditions of seasonal floods and/or water pond.

c. Moving road deterioration

Different conditions of road segment are the result of gradual maintenance activity. Thus, moving road deterioration can be observed from historical record of road condition survey and maintenance activity. From the historical record of road condition survey, the information can be elicited from identification of different condition of road segment and/or transition area between old and new pavement.

For example, result of road condition survey in K street suggested that there may be at least four road segments: STA. 0+000 – 1+300, STA. 1+300 – 2+000, STA. 2+000 – 3+100, and STA. 3+100 – 3+500. Poor condition of road can be observed in two segments: STA. 1+300 – 2+000 and STA. 3+100 – 3+500, which marked by orange box. The same method cannot be easily applied to M street, but visual observation on site can provide the evidence of gradual maintenance activity. Historical data of the road condition survey and maintenance activity shall provide better understanding of this physical condition.

d. Rapid decay of newly paved road

   Some newly paved road repair in 2013 has showed some pavement distresses as shown in the documentation in Figure 3..

e. Disconnected road network

   As explained above, unconnected road network did not occur in both case studies. However, based on high risk of natural disaster in the city in Indonesia, this parameter was considered necessary to be used as parameter of road conditions.

Figure 4 (Left) Water pond in MM and K street (Right) Pavement distress in MM andK street

Table 13 Result of road condition survey in Mahar martanegara street

ROAD CONDITION SURVEY

Date : November 2014

Street : Mahar Martanegara street

TIME	KM	ROAD SURFACE Type	ROAD SURFACE Condt.	ROAD SURFACE Width (m)	VIDEO MIN	ROAD CONDITION SUMMARY Odometer	Drainage M	Pothole B / Pothole F	Uneven C / Soft G	Crack D / Erosion H	Rutting E / Rutting I	Shoulder L / Uneven J	Slope K / Slope K	SCORE (max 29)
							5	4	4	4	4	4	4	
9:27		A	G	8	9:14	2+800	1	1	1	1	1	1	2	8
		A	G	8	8:55	2+700	1	1	1	1	1	1	2	8
		A	G	8	8:35	2+600	1	1	1	1	1	1	2	8
		A	G	5	8:13	2+500	4	1	1	1	1	3	2	13
		A	G	5	7:50	2+400	5	1	1	1	1	3	2	14
		A	G	5	7:32	2+300	5	1	1	1	1	3	2	14
		A	G	5	7:19	2+200	3	1	1	1	1	3	2	12
		A	G	5	7:01	2+100	3	1	1	1	1	2	2	11
		A	F	6	6:50	2+000	4	1	1	2	1	2	2	13
		A	F	6	6:30	1+900	2	2	2	3	1	2	2	14
		A	F	6	6:13	1+800	3	1	2	3	1	1	2	13
		C	G	6	5:30	1+700	3	1	2	1	1	2	2	12
		A	P	6	5:06	1+600	3	1	2	2	1	2	2	13
		A	P	6	4:51	1+500	5	4	2	2	1	4	2	20
		A	P	6	4:30	1+400	5	2	2	2	1	4	2	18
		C	G	6	4:08	1+300	4	1	2	2	1	3	2	15
		C	G	6	3:52	1+200	3	1	2	2	1	2	2	13
		C	G	6	3:45	1+100	2	1	1	1	1	3	2	11
		C	G	6	3:32	1+000	2	1	1	2	1	2	2	11
		A	G	5	3:14	0+900	2	1	1	1	1	2	2	10
		A	G	5	3:08	0+800	2	1	1	1	1	2	2	10
		A	G	5	2:58	0+700	2	1	2	1	1	3	2	12
		A	G	6	2:48	0+600	3	1	2	1	1	3	2	13
		A	G	6	2:36	0+500	4	1	1	1	1	3	2	13
		A	G	6	2:10	0+400	3	1	2	1	1	2	2	12
		A	G	6	1:54	0+300	2	1	2	1	1	2	2	11
		A	G	6	1:25	0+200	2	2	1	1	1	2	2	11
		A	G	6	1:07	0+100	3	1	1	1	1	2	2	11
9:17		A	F	6	0:26	0+000	2	2	3	1	1	2	2	13

Table 14 Result of road condition survey in Kerkof street

ROAD CONDITION SURVEY

Date : November 2014
Street : Kerkof street

TIME	KM	ROAD SURFACE			VIDEO MIN	ROAD CONDITION SUMMARY Odometer	5 Drainage M	4 Pothole B	4 Uneven C	4 Crack D	4 Ruttin g	4 Shoulder L	4 Slope K	SCORE (max 29)
		Type	Condt.	Width (m)				Pothole F	Soft G	Erosion H	Ruttin g	Uneven J	Slope K	
		A	VP	5	10:29	3+500	5	4	4	4	1	4	2	24
		A	VP	5	9:50	3+400	5	4	4	4	1	4	2	24
		A	VP	5	9:35	3+300	5	4	4	4	1	4	2	24
		A	VP	5	9:22	3+200	5	4	4	4	1	4	2	24
		A	VP	5	9:02	3+100	5	4	4	4	1	4	2	24
		C	G	5	8:54	3+000	2	1	3	2	1	3	2	14
		C	G	5	8:35	2+900	2	1	1	2	1	3	2	12
		C	G	5	8:22	2+800	2	1	1	2	1	3	2	12
		C	F	5	7:58	2+700	2	1	2	3	1	3	2	14
		C	G	5	7:30	2+600	2	1	1	2	1	2	3	12
		C	G	5	7:18	2+500	2	1	2	2	1	2	2	12
		C	G	5	7:00	2+400	2	1	2	2	1	2	2	12
		C	G	5	6:47	2+300	2	1	2	2	1	2	2	12
		C	G	5	6:30	2+200	3	1	2	2	1	2	2	13
		C	G	5	6:09	2+100	3	1	2	2	1	2	2	13
		C	VP	5	5:40	2+000	4	4	4	4	1	4	2	23
		C	VP	5	5:23	1+900	4	4	4	4	1	4	2	23
		C	P	5	4:55	1+800	3	2	3	3	1	3	2	17
		C	P	5	4:40	1+700	3	2	3	2	1	3	2	16
		C	F	5	4:20	1+600	4	2	2	2	1	2	2	15
		C	P	5	4:03	1+500	4	3	3	2	1	2	2	17
		C	P	5	3:51	1+400	4	2	4	4	1	3	2	20
		C	P	5	3:31	1+300	4	2	3	3	1	3	2	18
		C	F	5	3:23	1+200	2	1	3	2	1	2	2	13
		C	F	5	3:10	1+100	2	1	3	2	1	2	2	13
		C	F	5	2:50	1+000	2	1	2	2	1	2	2	12
		C	F	5	2:39	0+900	2	1	2	2	1	2	2	12
		C	F	5	2:20	0+800	2	2	2	2	1	2	2	13
		C	F	5	2:08	0+700	2	1	2	2	1	2	2	12
		C	F	5	1:55	0+600	2	3	2	2	1	2	2	14
		C	G	5	1:39	0+500	3	1	1	2	1	2	2	12
		C	G	5	1:22	0+400	3	1	1	2	1	0	2	10
		C	F	5	0:56	0+300	3	1	1	2	1	0	2	10
		C	F	5	0:46	0+200	3	1	1	2	1	0	2	10
		A	F	5	0:20	0+100	4	2	2	2	1	4	2	17
9:40		A	G	5	0:05	0+000	4	1	1	1	1	4	2	14

3.7 Recommendation

The study recommended the five physical conditions of road/drainage as a new set of parameters of road conditions for city network in Indonesia. The new set of road condition parameters can be applied to benchmark a city road condition and also displays the derived overall road performance. The new set of road condition parameters allows comparisons within the city road network (with the option to display city's best road condition) on each five parameters and the overall road performance. Furthermore, the road performance can be measured as the weighted average of the city scores on the five key parameters:

1) Small volume of pavement distress in scattered area
2) Moving road deterioration
3) Seasonal floods and water pond
4) Rapid decay of newly paved road
5) Disconnected road network

The research was based on a small amount of data. However, on the basis of the characteristic of the observed streets and management practices, it can be concluded that the two streets may represent city road network. In order to apply the parameters of road conditions in municipal PMS, it requires each road agency to further determine specific measurement and set up its tolerance level of service for guiding road/drainage maintenance decision making.

Here was an example of rating system using the proposed parameter of road conditions. Score of maintenance shall be based on pavement conditions. The score of pavement conditions is the sum of all score. In order to produce maintenance score, the pavement conditions is corrected by five factors: traffic, climate, work zone duration restriction, treatment performance and cost. Each road agencies should develop their own correction systems for traffic, climate, work zone duration restriction, treatment performance and cost. It should be adjust to the local conditions. The following is equation of maintenance score:

Maintenance score = Score of pavement condition * F traffic * F climate * F work zone duration restriction * F treatment performance * F cost

Table 15 Example of Rating system using the proposed parameter of road conditions (author)

	Method of data collection	Measures		Example of scoring system for pavement condition				
				1	2	3	4	5
• Small volume of pavement distress in scattered area	- Road condition survey	Size of pavement distresses in 100 meter (% of area)	Pothole	0-1	1-5	5-15	>15	
			Uneven surface	0-5	5-10	10-50	>50	
			Crack	0-3	3-12	12-25	>25	
			Rutting	0-3	3-5	5-25	>25	
• Moving road deterioration	- Historical record of road condition survey - Historical data of maintenance activities	Change in total length of good and fair conditions ((Lt-Lo)/t)		> -25%	≤ -25%	-50%	-75%	
• Seasonal floods and water pond caused by slow drain of rainwater	- Road condition survey during rainy day and sunny day	- Treatment requirement - Size of water pond per drain time		No drainage, unrequired	Good drainage (cleaning is required)	Poor drainage (small repair is required)	Heavy damage	No drainage, but required
• Rapid decay of newly paved road	- Road condition survey - Historical data of maintenance activities	Size of pavement distresses in 100 meter that newly paved (% of area)	Pothole	0-1	1-5	5-15	>15	
			Uneven surface	0-5	5-10	10-50	>50	
			Crack	0-3	3-12	12-25	>25	
			Rutting	0-3	3-5	5-25	>25	
• Unconnected road network	- Historical record of road condition survey	Connecting problems		No problem	There is some disturbance but still can be used by car	Difficult to pass by car	Cannot be passed	

CHAPTER 4 FORMULATION A PROTOTYPE OF PROBLEM OCCURRENCE MECHANISM OF MUNICIPAL ROAD/DRAINAGE MAINTENANCE

4.1 Introduction

Road agency with limited resources struggles to cope with many maintenance issues. World Bank study by Harral (1988) identified institutional, technical and financial constraints as the root cause of failure to maintain roads which lead to road deterioration both in developed and developing countries. Moreover, Asian Development Bank (2013) also stated that improving road maintenance involves overcoming reluctance to change the way things are carried out and financed at a systemic level.

The ADB reported that the requirements for road maintenance differ from country to country and from place to place. Many researchers from different countries have also provided a long list of variables of maintenance issues which can be classified into at least four groups: (a) maintenance planning (inadequate maintenance, overloading, poor road design, road asset management system, untimely maintenance, limited construction materials), (b) maintenance capacities (limited capacity and number of qualified staff, lack of institutional capacity, need for strong private sector participation), (c) financing (lack of funding) and (d) other issues (natural disaster, war/conflict) (ADB 2013, Abubakar 1998, Devres 1993).

In the theory of constraints, every complex system consists of multiple linked activities, one of which acts as a constraint upon the entire system. Every process has a constraint (bottleneck), and focusing improvement efforts on that constraint is the fastest and most effective path to improve benefit. Tools such as 5-why, five focusing steps and thinking processes are commonly used in the theory of constraints.

Therefore using a case study of Cimahi city government, this study addressed perception of road agency and other related institutions in a municipal government that impedes the ability to correctly solve problems. Identification of constraints perceived by road agency and other related institutions is expected to provide better insight of the overall problems and help them to achieve the goal of road/drainage maintenance work.

4.2 Specific Objectives

The overall goal of this objective is to formulate a prototype of problem occurrence mechanism of municipal road/drainage maintenance. More specifically, the research objectives are to:

1. Investigate parameter of road conditions, factors affecting road performance, and pavement management systems practice
2. Identify the relationship among road conditions, factors affecting road performance, and pavement management systems practice
3. Formulate a prototype of problem occurrence mechanism of municipal road/drainage maintenance

4.3 Hypothesis

The study was conducted with a hypothesis that PMS practices influence several factors that lead to problems of road conditions. Theoretically, PMS practices were divided into three groups: Original Road Development (ORD), Road monitoring and operation (PMRO), and Road maintenance (RM). Following Haas (2003), factors affecting road performance can be classified into five: structure, construction, traffic, environment, and maintenance. For the parameters of road conditions, the result of previous Chapter 3 was used.

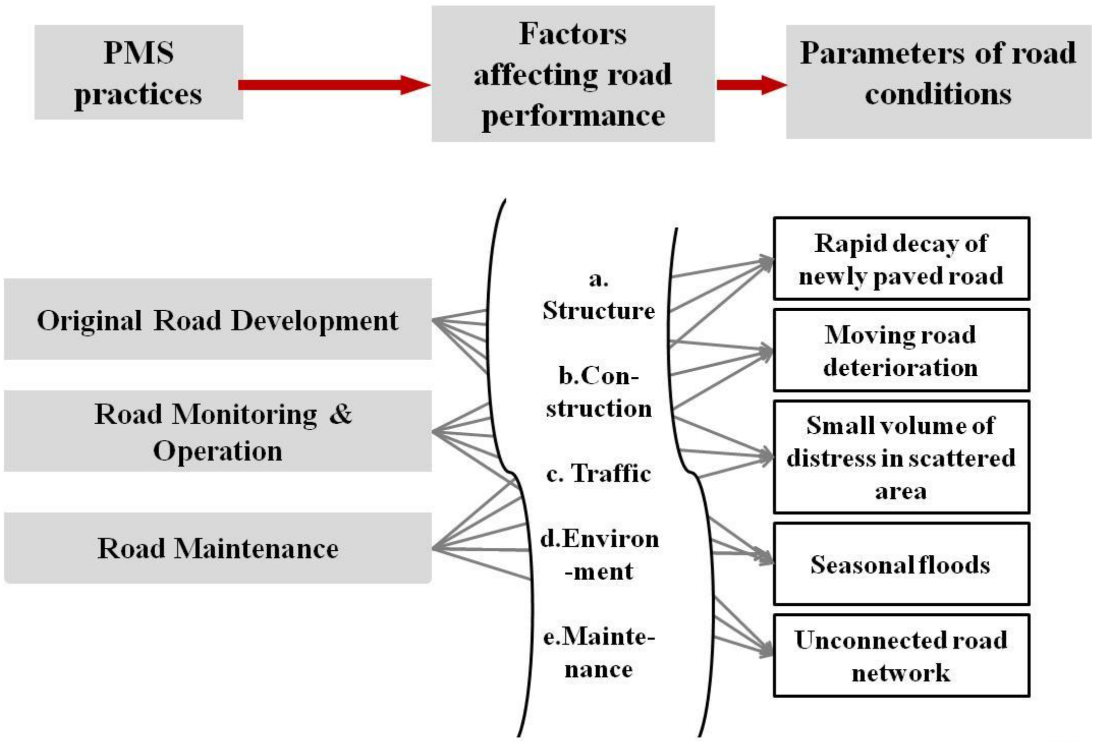

Figure 5 Hypothesis of association between road conditions and PMS practices

4.4 Data collection

The data for this study involves three elements in the hypothesis. Data of two streets: MM street and K street were used in this study. Detailed method of data collection was described in the following table.

Table 16 Method of data collection and analysis

Data		Method of data collection and analysis
Parameters of road conditions		Interviews Road condition surveys
Factors affecting road performance	Structure	Review record of road ledger Interview with Highway Department (HD) staff Site observation
	Construction	N.A
	Traffic	Traffic counting
	Environment	Site observation Review record of rainfall data
	Maintenance	Review record of road ledger, contract document Interview with HD staff Site observation Literature study
PMS practices		Interview with city road stakeholders

4.5 Findings and discussions

4.5.1 Investigation of Parameters of road conditions

Based on the result from previous Chapter 3, four out of five conditions were observed in MM and K streets.

1. Small volume of pavement distress in scattered area
2. Moving road deterioration
3. Seasonal floods and water pond caused by slow drain of rainwater
4. Rapid decay of newly paved road

These parameters were used in this study.

4.5.2 Investigation of Factors affecting road conditions

Like all structures, road pavement deteriorates over time. Typically, pavement deteriorates at an ever-increasing rate. At first very few distresses are present only on the surface (surface deterioration due to abrasion and loading by vehicle traffic, weather, etc.) and the pavement stays in relatively good condition. But as it ages, more distresses develop with each distress and make it easier subsequent distresses to develop. In this natural process, load bearing capacity of pavement structure gradually decreases due to infiltration of rainwater and groundwater and repeated loading. The structural deterioration naturally accelerates the deterioration of pavement surface. This structural deterioration rate can be slowed down by correcting small pavement distress before they can worsen and contribute to failure although it can never be stopped. It is recognized that routine maintenance, periodic maintenance and rehabilitation efforts may be needed to preserve a pavement's surface quality and ensure that the structure lasts through the design life.

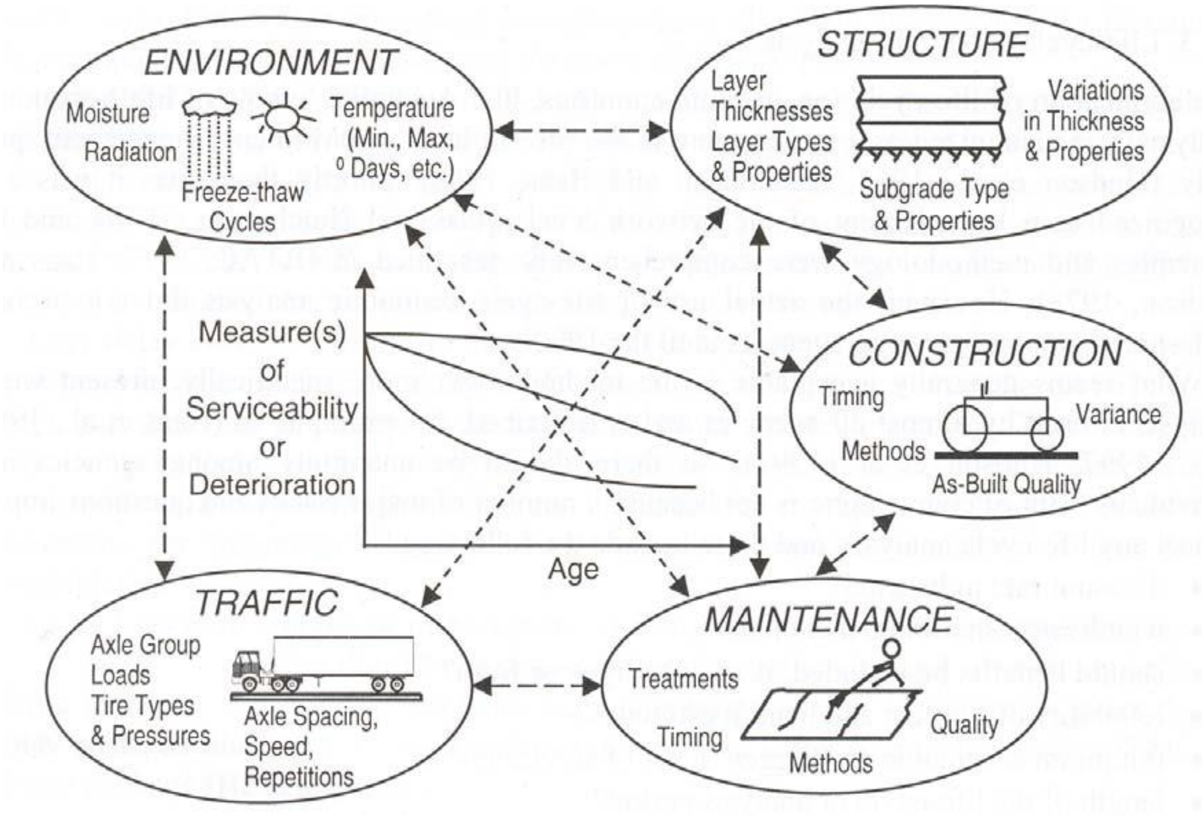

Figure 6 Factors affecting road conditions (Haas, 2003)

Investigation of sub-factors in each affecting factor was described in this study. The investigation was meant to evaluate effects of road agencies strategy to the road condition. The analysis of the result is as follows:

a. Structure

In this study, investigation was conducted on two properties of pavement structure:

pavement type and sub grade type. Road ledger did not provide sufficient information on the pavement structure; thus, interview with HD staff and site observation were conducted. Focusing on the negative effects of structure to road conditions, the results were as follows:

- As originally, both streets are flexible pavement type. Flexible pavement is vulnerable to water disturbance and heavy traffic load compared to rigid pavement. Rigid pavement is known to have high resistance to moisture influence because of its impermeable properties. Reconstruction of some road segment to rigid pavement type in two streets has started in 2011. Due to unawareness of the extent of impact of traffic and water influence to the pavement strength, however, the pavement structure in those road segments did not last long.
- Ageing pavement (>20 years). Although no documentation, both streets are assumed by road agencies to construct 20 years ago. Theoretically, ageing pavement accelerates faster deterioration due to decrease of load bearing capacity of pavement structure over the time. Small pavement distress can be found scattered in some weak spots. Over time, the distress progressively becomes larger and severe that has caused road conditions in poor state.

b. Construction

Most of data related to original road construction factors (structure and construction) is untraceable due to poor historical data documentation in city government. This factor was not investigated further in this study.

c. Traffic

In this study, percentages of heavy vehicle and vehicle repetition were observed in order to seek negative effects of traffic to road conditions. In the field of transportation engineering, traffic counting is a well-known method for collecting traffic volume. The survey provided data of Annual Average Daily Traffic (AADT) and the composition of traffic. Detailed procedures of traffic counting were explained in Chapter 2 and Appendix 4. Analysis of the traffic counting data identified several destructive effects of actual traffic in both road conditions being observed.

- Domination of heavy vehicle or truck in the two streets is ≥ 30%. Small percentage of overweight trucks will significantly decrease serviceable life of a road because the exponential impact of excessive weight on the road. The damaging effects by these vehicles make it clear that these trucks are the principal cause of traffic-related deterioration on the road.

- Actual traffic is much higher than the Indonesian standard of maximum traffic repetition in city roads (4x bigger). The actual traffic repetition accelerates road deterioration much faster than the initial design of standard city road. This will significantly reduce the service life of road.

Table 17 Result of Traffic counting

Name of street			Mahar martanegara street			
Day		Time	Number of vehicles			
			Motor - cycle	Passenger cars	Heavy vehicles	
					Single axle	Double axle or more
Monday	18-May-15	07:00 - 23:00 (16 hours)	38764	7634	1732	6593
Tuesday	19-May-15		38400	7520	1662	6880
Wednesda	20-May-15		39523	8653	1643	7120
Thursday	21-May-15		36876	7456	1701	6903
Total (vehicle)			153563	31263	6738	27496
Total (pcu)			76782	31263	8759	35745
Percentage			50%	20%	6%	23%
Total (pcu)			152549			
ADT			40144			
AADT			**44761**			

Name of street			Kerkof street			
Day		Time	Number of vehicles			
			Motor - cycle	Passenger cars	Heavy vehicles	
					Single axle	Double axle or more
Monday	18-May-15	07:00 - 23:00 (16 hours)	18765	6543	1567	13541
Tuesday	19-May-15		19200	7250	1600	13760
Wednesda	20-May-15		20174	6745	1564	13245
Thursday	21-May-15		18432	8732	1763	14129
Total (vehicle)			76571	29270	6494	54675
Total (pcu)			38286	29270	8442	71078
Percentage			26%	20%	6%	48%
Total (pcu)			147075			
ADT			38704			
AADT			**43155**			

d. Environment

In tropical countries, environment effect to road conditions mostly relates to the moisture attack to the pavement. Infiltrations of water weaken the load bearing capacity of pavement structure. In addition to destructive effect of water to the pavement structure, the larger area of water pond in the roadway also reduces the serviceability of vehicle to pass the road. Based on site observation, negative effects to road conditions were related to uncontrolled moisture (small/big water pond, seasonal floods). The result of correlation analysis in Chapter 3 also provides evidence that there is a strong correlation between pavement distress and drainage conditions. Correlation coefficients are 0.53 in MM street and 0.74 in K street.

Figure 7Uncontrolled Moisture in MM street (right) and K street (left)

e. Maintenance

The effect of maintenance to the road conditions were observed in four aspects: treatment, timing, method and quality. Negative effects to road conditions were related to:

- Maintenance treatments: None
- Maintenance timing:
    - Gradual/deferred maintenance and lack of continuous planning of further maintenance have caused segmental pavement distress in each street. For example, based on road condition survey, poor condition of road can be observed in two road segments in K street, namely STA. 1+300 – 2+000 and STA. 3+100 – 3+500.
    - Same year design-execution. Highway Department of Cimahi city did not

consider period of heavy rainfall falls (October-May) in making decision of schedule for maintenance execution which resulted into high risk of water disturbance during execution. If not properly handle, it can reduce the strength of pavement structure and cause rapid decay of pavement.

- Maintenance methods:
  - Poor construction: connection between new road and old road was constructed poorly. Besides influencing riding comfort, it was also worn out the edge of old and new pavement. This is one of the causes of rapid decay of edge side of new paved road.
  - Uneven surface, less concern to super elevation. All pavement surfaces in two streets are flat and in some area, wavy surface and patch were found. This influences ride comfort for the road users.
  - Position to ditch inlet. Some ditch inlet is being covered by new pavement. This can reduce amount of water flow to the drainage significantly.
  - Fast open to traffic

    Variation of concrete strength is considered moderate (± 60 kg/cm2) especially at the edge of roadway. It indicated un-uniformity of concrete, low strength. Error in maintenance execution method and fast open to traffic could be a reason for this variation.
- Maintenance quality: None

Table 18 Hammer Schmidt Test

Name of street	Maintenance			Rebound hammer test result		Analysis
	Year	Quality	Location	Quality (kg/cm2)	Min	
Mahar Martanegara st.	2012	300	1	297 ± 62.85	234.15	Average compressive strength was slightly lower. Weak spot was found especially in the edge road side with high variance
			2	297 ± 62.85	234.15	
	2014	400	3	453 ± 70.65	382.35	Average compressive strength was higher than design. Weak spot was found especially in the edge road side with high variances.
			4	435 ± 69.75	365.25	
Kerkof st.	2012	350	5	417 ± 68.85	348.15	Average compressive strength was extremely higher than design.
	2013	350	6	435 ± 69.75	365.25	

Figure 8 Poor Connection between old and new pavement in MM street

From the previous analysis in two streets in Cimahi city, the association between road condition and factors affecting road performance was described as follows:

- Moving road deterioration = f (structure, traffic, environment, maintenance)
  = f (Structure (Pavement type and ageing pavement) + Traffic (Domination of truck, High repetition of traffic) + Environment (Water pond) + Maintenance (Gradual/deferred maintenance, same year design-execution))
- Rapid decay of newly paved road = f (traffic, environment, maintenance)
  = f (Traffic (Domination of truck, High repetition of traffic) + Environment (Water pond) + Maintenance (Gradual/deferred maintenance, same year design-execution, Lack of drainage cleaning, Poor execution method))
- Small volume of distress in scattered area = f (structure, traffic, environment, maintenance)
  = f (Structure (Pavement type and ageing pavement) + Traffic (Domination of truck, High repetition of traffic) + Environment (Water pond) + Maintenance (Gradual/deferred maintenance, same year design-execution, Lack of drainage cleaning, Poor execution method))
- Seasonal floods/ slow drain = f (structure, environment, maintenance)
  = f (Structure (Pavement type and ageing pavement) + Environment (Water pond) + Maintenance (Lack of drainage cleaning, Poor execution method)))

Detailed results of analysis of the investigation are shown in the following table.

Table 19 Evaluation of Factors Affecting Road Performance and Road conditions

Factors affecting stability of municipal road conditions		Description		Effect to road conditions		Parameters of road conditions			
		Mahar martanegara st.	Kerkof st.	Mahar martanegara street (MM)	Kerkof street (K)	Rapid decay	Moving road deterioration	Small pavt. distress	Slow drain of water runoff
Structure	Pavement type	- Original road construction is flexible pavement and rigid pavement. - Flexible pavement is likely to age of 10 years (Indonesian standard) - Recently more and more road segment is constructed by rigid pavement which is likely to age > 20 years.	- Original road construction is flexible and rigid pavement. - Flexible pavement is likely to age of 10 years (Indonesian standard) - Recently more and more road segment is constructed by rigid pavement which is likely to age > 20 years.	--	--		v	v	V
	Subgrade type & properties	- No report of subgrade problems. - It is considered good by the observer (California Bearing Ratio, CBR> 5%). - High traffic repetition may increase soil density	- No report of subgrade problems. - It is considered good-fair by the observer (CBR < 5%) because partial settlement occurred in some road segment. - High traffic repetition may increase soil density	++	+				

Factors affecting stability of municipal road conditions		Description		Effect to road conditions		Parameters of road conditions			
		Mahar martanegara st.	Kerkof st.	Mahar martanegara street (MM)	Kerkof street (K)	Rapid decay	Moving road deterioration	Small pavt. distress	Slow drain of water runoff
	Variation in thickness & quality	Not observed	Not observed						
Construction	Timing	Data can’t be traced							
	Methods								
	Variance								
	As-Built								
	Quality								
Traffic	Percent of truck/heavy vehicle	- Ratio of motorcycle: passenger cars: HV single axle: HV double axle is 50:20:6:23 - Percentage of heavy vehicle of approximately29% indicated moderate rate of deterioration.	- Ratio of motorcycle: passenger cars: HV single axle: HV double axle is 26:20:6:48 - Percentage of heavy vehicle >50% indicated high rate of deterioration.	-	--	v	v	v	
	Tire types and pressures	Not observed	Not observed						
	Axle spacing	Not observed	Not observed						
	Speed	10 - 40 km/hour.	10 - 40 km/hour.	+	+				
	Repetitions	- According to traffic counting, AADT is more than 44,761 pvu/year.	- According to traffic counting, AADT is more than 43,155 pvu/year.	--	--	v	v	v	

Factors affecting stability of municipal road conditions		Description		Effect to road conditions		Parameters of road conditions			
		Mahar martanegara st.	Kerkof st.	Mahar martanegara street (MM)	Kerkof street (K)	Rapid decay	Moving road deterioration	Small pavt. distress	Slow drain of water runoff
		- Actual AADT is more than Indonesia standard ADT for city roads 4/2 UD width=6 meter which is 10,000 pvu/year	- Actual AADT is more than Indonesia standard AADT for city roads 4/2 UD width<6 meter which is 10,000 pvu/year						
Environment	Moisture	- A few spots of temporary runoff and location of waterpond were identified: inadequate drainage, uneven surface, no superelevation. - There was a heavy rain during Oct 2012 to May 2013 which was most likely to accelerate rate of deterioration.	- A few spots of temporary runoff and location of water pond were identified: inadequate drainage, uneven surface, no superelevation. - There was a heavy rain during Oct 2012 to May 2013 which was most likely to accelerate deterioration.	--	--	v	v	v	v
	Radiation	No exposure to radiation.	No exposure to radiation.						
	Freeze-thaw cycles	Tropical country, no snow.	Tropical country, no snow.						
	Temperature	17-30°C. The effect of temperature change is less significant to pavement conditions.	17-30°C. The effect of temperature change is less significant to pavement conditions.	+	+				

Factors affecting stability of municipal road conditions		Description		Effect to road conditions		Parameters of road conditions			
		Mahar martanegara st.	Kerkof st.	Mahar martanegara street (MM)	Kerkof street (K)	Rapid decay	Moving road deterioration	Small pavt. distress	Slow drain of water runoff
Maintenance	Treatments	- Concrete pavement is mostly used for pavement reconstruction, shoulder widening and drainage works. - Laston and Lapen were generally used for overlay. - Drainage system is quite well developed (5600 m)	- Concrete pavement is mostly used for pavement reconstruction, shoulder widening and drainage. - Laston and Lapen were generally used for overlay. - Drainage system is minimum (4375 m)	++	++				
	Timing	- Based on record review, construction is commonly conducted in Aug to Dec. Rainfall data in June 2012 to Dec 2014 shows December usually has many rainy days (>8 days/month). It is also the end of closed book. Project is commonly forced to complete to fit the schedule. - Gradual annual maintenance treatment was	- Based on record review, construction is commonly conducted in August to December. Based on rainfall data June 2012 to Dec 2014, December usually has many rainy days. It is also the end of closed book. Project is commonly forced to complete to fit the schedule. - Gradual annual maintenance treatment was conducted to ±300	-	--	v	v	v	v

Factors affecting stability of municipal road conditions		Description		Effect to road conditions		Parameters of road conditions			
		Mahar martanegara st.	Kerkof st.	Mahar martanegara street (MM)	Kerkof street (K)	Rapid decay	Moving road deterioration	Small pavt. distress	Slow drain of water runoff
		conducted to ±300 meters (10%) of 2,800 m total length in the road section/street. - No continuous planned of maintenance treatment - Quality control was conducted based on slump test and compressive strength. There was less concern with proper construction method process, check list on superelevation, or surface elevation to ditch inlet.	meters (5%) of 5,900 m total length in the road section/street. - No continuous plan of maintenance treatment						
	Methods	- Field investigation on December 2014 and contract document showed that rigid pavement was constructed using manual cast in situ method and self compacted ready mix. - Rigid pavement	- No maintenance implementation was observed during field investigation.	-	-	v	v	v	v

Factors affecting stability of municipal road conditions		Description		Effect to road conditions		Parameters of road conditions			
		Mahar martanegara st.	Kerkof st.	Mahar martanegara street (MM)	Kerkof street (K)	Rapid decay	Moving road deterioration	Small pavt. distress	Slow drain of water runoff
		moulded on top existing pavement without site clearance. - Road segment was opened for traffic 4 day construction. - Quality control was emphasized on slump test and compressive strength, less concern to proper construction method process, check list on super elevation or surface elevation to ditch inlet.							
	Quality	- Only new rigid pavement is observed based on review document 2012-2013. - The design for new rigid pavement is K-300 and K-350, thickness 20-35 cm. - Based on hammer schmidt test, the variation of concrete strength is considered	- Only new rigid pavement is observed based on review document 2012-2013. - The design for new rigid pavement is K-350, thickness 30 cm. - Based on hammer schmidt test, the variation of concrete	+	+				

Factors affecting stability of municipal road conditions		Description		Effect to road conditions		Parameters of road conditions			
		Mahar martanegara st.	Kerkof st.	Mahar martanegara street (MM)	Kerkof street (K)	Rapid decay	Moving road deterioration	Small pavt. distress	Slow drain of water runoff
		high (± 100 kg/cm2) especially on the edge roadway.	strength is considered high (± 100 kg/cm2) especially on the edge roadway.						

4.5.3 Investigation on PMS practices

Further discussions were made to identify relationship between factors that directly affect road performance and the managerial factors. The findings are given as follows.

Decision made during original road development (ORD) influences road performance. Some structural problem may inherit from the planning of the pavement, such as those related to selection of pavement type for specific road function and initial design of drainage capacity. To deal with such conditions, road agencies generally have three options: (a) do nothing, (b) negotiate responsibility transfer with provincial government which has more resources, (c) obtain additional source of fund. According to the site observation in the case study, road agency has attempted to negotiate the responsibility transfer with provincial government because observed roads of MM and K streets serve as intercity roads. In principles, thus, they are considered more suitable to be managed by provincial government. However this proposal was rejected; as consequences the provincial government gives its commitment to allocate more budgets to these streets which will be managed by the city government.

Traffic and environmental problem was influenced by decision in pavement monitoring and road operation. Based on interview, in terms of pavement monitoring and road operation, road agencies and related agencies may have three options: (a) do nothing, (b) coordinate with other agencies for managing traffic (design of traffic engineering/law enforcement) and garbage (road/drainage cleaning), (c) develop railway/logistic transportation. From further observation on the case study, it was found that there were actually no actions to control traffic and environmental problem made by related stakeholders. For example, garbage is clogged the drainage inlet. Cleaning clogged drainage was ignored., Traffic control was only emphasized on administration compliance. Restriction of heavy traffic was not considered possible because of no alternative route and other transportation mode to support industrial activities.

Maintenance problem was also influenced by decision in road maintenance. Based on survey, road agencies have three options to deal with maintenance problem: (a) no maintenance (b) inadequate maintenance (c) adequate maintenance (proper and timely maintenance. In the observed streets, it is found that current road agency has conducted some maintenance works although the result varied. In some road segment, the treatment was sufficient and could solve the problems but in other segment. The treatment was still insufficient as shown in the result of road condition surveys.

The summary of problem occurrence mechanism was described in the following figure. Furthermore, the causes of each managerial problem were examined in order to identify constraints of management. The result was described in the following section.

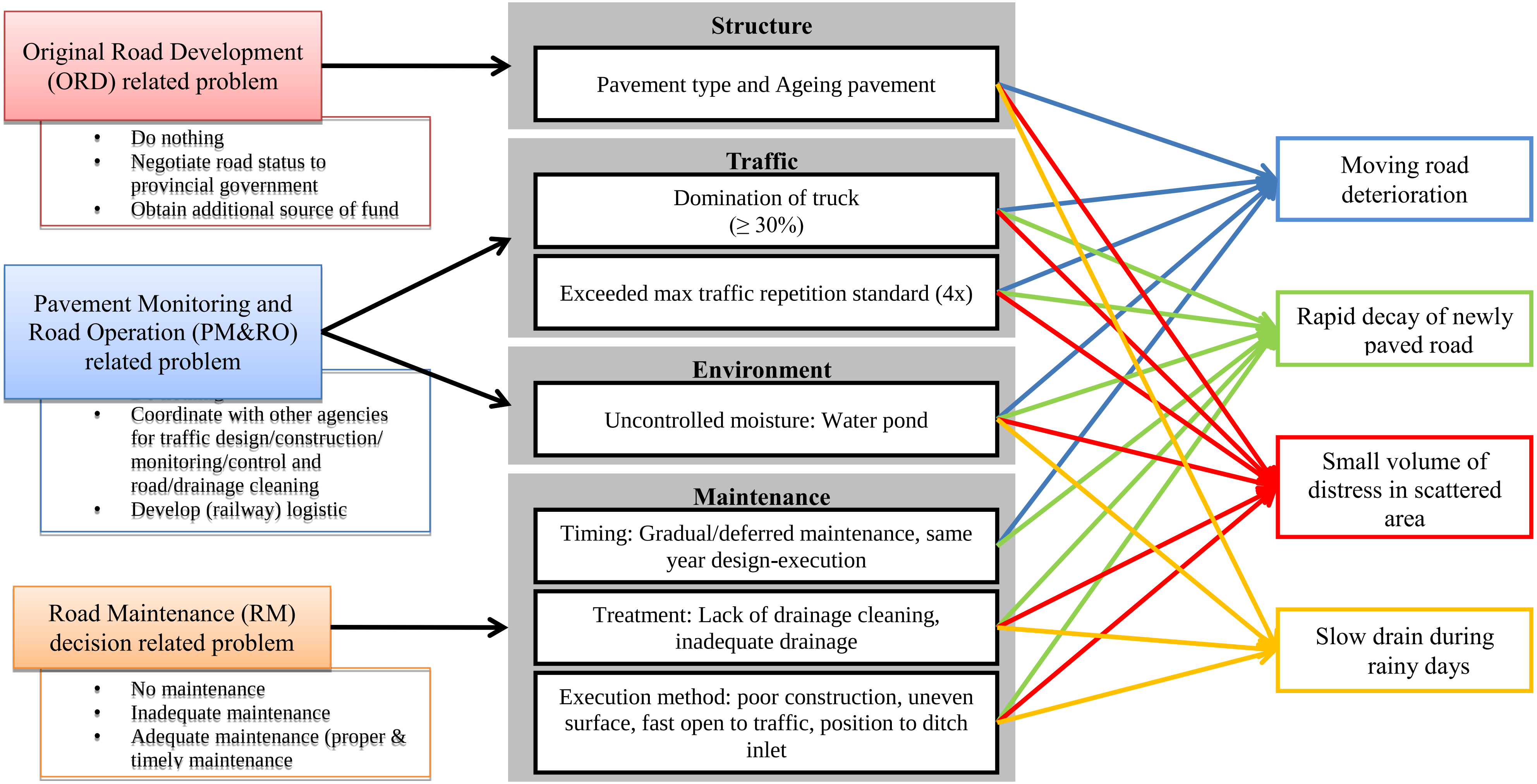

Figure 9 Summary of Problem Occurrence Mechanism of Municipal Road/Drainage Maintenance

4.5.3.1 Problem Occurrence Mechanism of Original Road Development (ORD)

Original Road Development related problem basically influences maintenance workload.

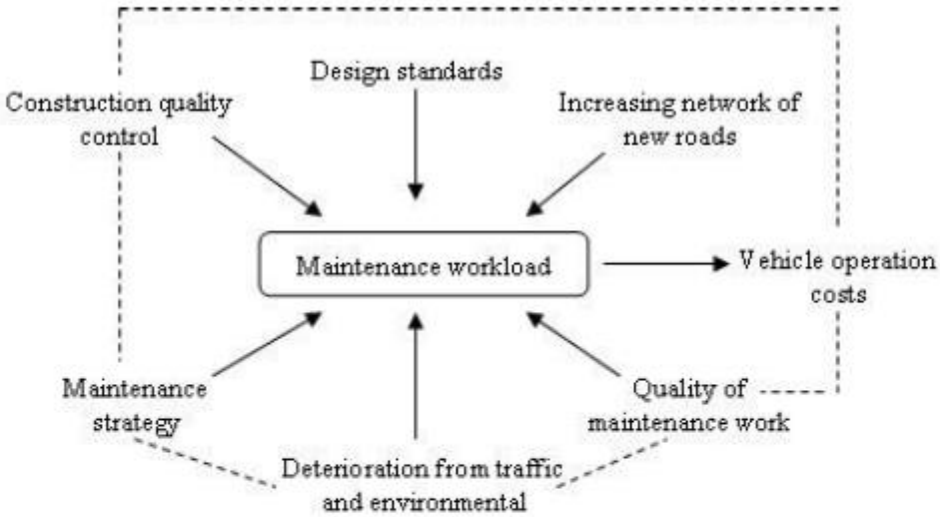

Figure 10 Development of maintenance workload (Freer-Hewish 1986)

According to Freer-Hewish (1986), there are many factors contributing to maintenance workload. In the observed maintenance management practice of Highway Department (HD of Cimahi city), there are three factors: road network, capacity of HD, and road maintenance budget.

Regulation determines the responsibility to manage road in Indonesia. The Indonesian regulation divides the responsibility in managing road onto three types of governments: national roads are managed by national government, provincial roads are managed by provincial government, and city/regency/rural roads are managed by city/regency government. Thus, characteristics of road network such as length, width, structure and its problems are absolutely given conditions for HD.

Commitment of the city major to manage city road network was important as all the decision and budget of maintenance program shall be approved by the city major. The city mayor in Cimahi city has high commitment to maintain the whole road network. As a result, the city mayor has initiated change in organizational and management personnel, government officer recruitment, technical assistance, and collection of city’s source of fund. Organizational change had been experienced in Cimahi city in 2009. Previously road maintenance was under responsibility of Transportation agency. After 2009, however, new agency, Public Works agency was established which has Highway Department with specific tasks to manage road maintenance. As the top management in HD, a person was selected with sufficient qualifications to lead the department and all his tasks. The leaders also initiated a technical assistance from expert to assist the organizational reform in Public Work agency including HD. This program has resulted in increasing capacity of HD. Realizing the need to increase road maintenance budget, the city major has also pushed financial agency to increase fund collection through mainly tax and retribution. Nowadays, there is sufficient budget for maintenance works but not enough personnel to manage more maintenance works. Recruitment of personnel is required recruitment in HD.

City budget is not specifically allocated for road maintenance. Competition to obtain budget among other needs, such as new road development, education, health, etc. was identified. To ensuring success in gaining allocated budget, maintenance proposal has to be written based on reliable description of road conditions and their related factors such as traffic, change in city land use, weather, and environment change. The HD also can always get better bargaining position in obtaining the budget by emphasizing the importance of road function for mobility and economic growth.

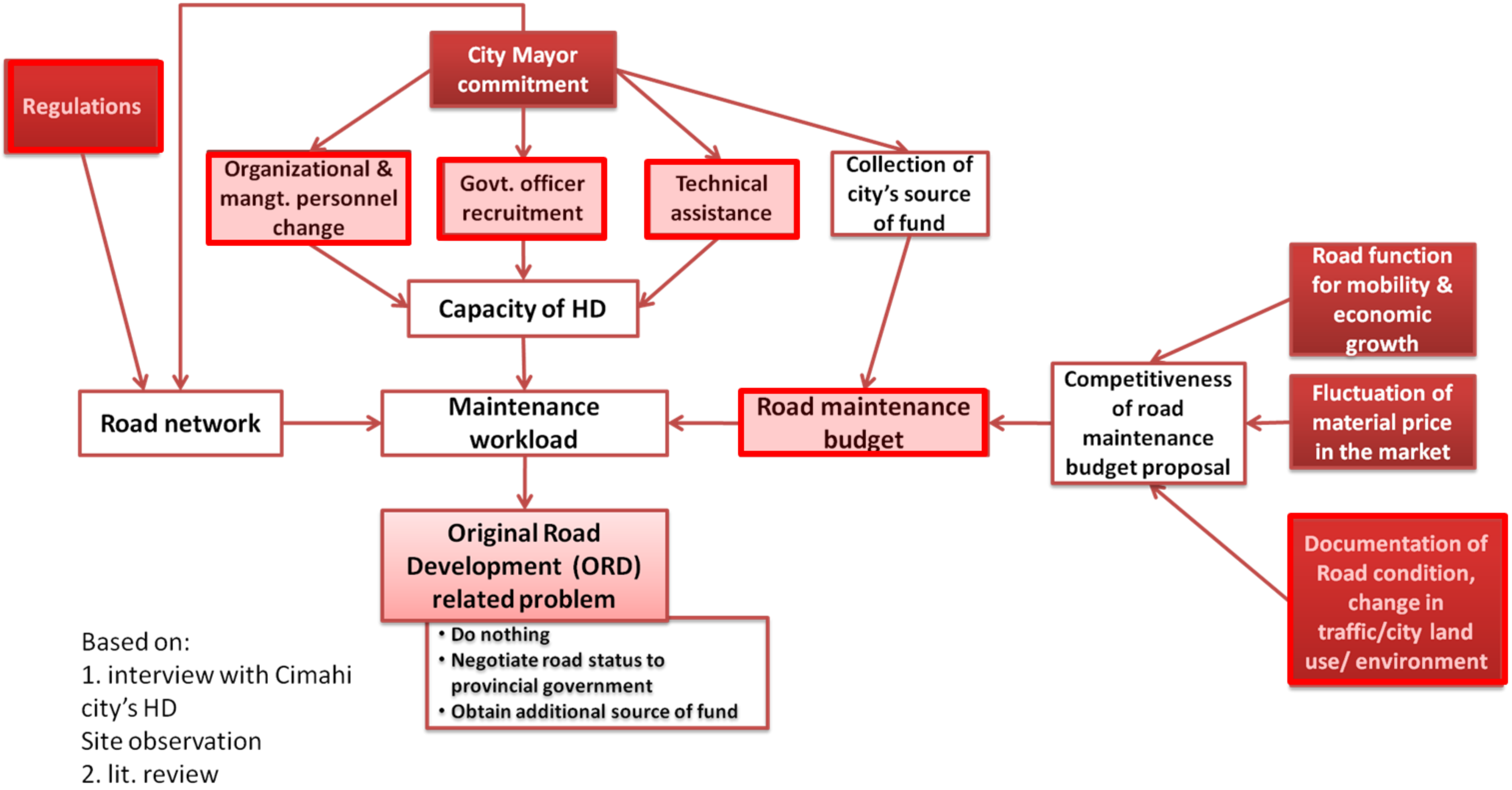

Figure 11 Problem Occurrence Mechanism of Original Road Development

4.5.4.2 Problem Occurrence Mechanism of Pavement Monitoring and Road Operation (PMRO)

Problems on pavement Monitoring and Operation are caused by the two factors: heavy vehicle traffic conditions and insufficient road drainage function.

Heavy vehicles are a major cause of pavement damage. High percentage of overweight trucks will significantly decrease serviceable life of a road because of the exponential impact of excessive weight on the road. As shown before, in the observed roads, the traffic volume of truck is high since they pass industrial areas. Actually, truck traffic dominated the traffic volume (> 30%). However, there is less control for overweight truck. Thus, there is no wonder about faster rate of road deterioration. The damaging effects by these vehicles and less control of traffic make it clear that these trucks are the principal cause of traffic-related deterioration on the road.

To control traffic of heavy vehicles requires effective traffic management that is supported by commitment by City Mayor, Transportation Agency, Police Department, Railway Corporation, Provincial Government and National Government. Regulation of truck, and traffic control tools and signs had been established by Transportation agency of Cimahi city. However, enforcement of those regulations by Transportation Agency and Police Department is still weak. Development of alternative routes or transportation mode for logistic distribution requires long term commitment and big investment from many stakeholders. Logistic transportation network within the city and connecting to provincial/national logistic transportation is necessary to be developed. However so far, it is a challenging task to provide a feasible project assessment of development of logistic transportation network.

Water is also the biggest enemy of pavement. Once it infiltrates, water reduces the soil sub grade capacity to handle the traffic repetition and traffic load. To control water, road drainage plays an important role. Unfortunately, the priority of providing and maintaining proper function of road drainage was still low among repair pavement distress. Maintenance program in the observed streets had included drainage works to repair the inlet, and dimension of drainage. All of which contribute to reduce the rate of pavement deterioration. However, it was still insufficient. Misusage of road drainage was found that road drainage was being used together with utility such as electricity cable and optical cable, which reduces the capacity of road drainage to collect water. Garbage was usually found in the road drainage. This causes clogging. Since the city cleaning agency has a limited capacity, it cannot clean up the enormous amount of garbage in the drainage. Currently Cleaning department has two main priorities: to collect garbage at the garbage station and to clean the public area. The task for cleaning the drainage was also getting less interest from Highway Department. Lack of awareness of impact of garbage to drainage also causes an ineffective function of road drainage. Change in land-use also contributes to condition of drainage network which requires bigger capacity since reduction of green area increases the runoff water.

Summary of the problem occurrence mechanism explained above was described in the following figure.

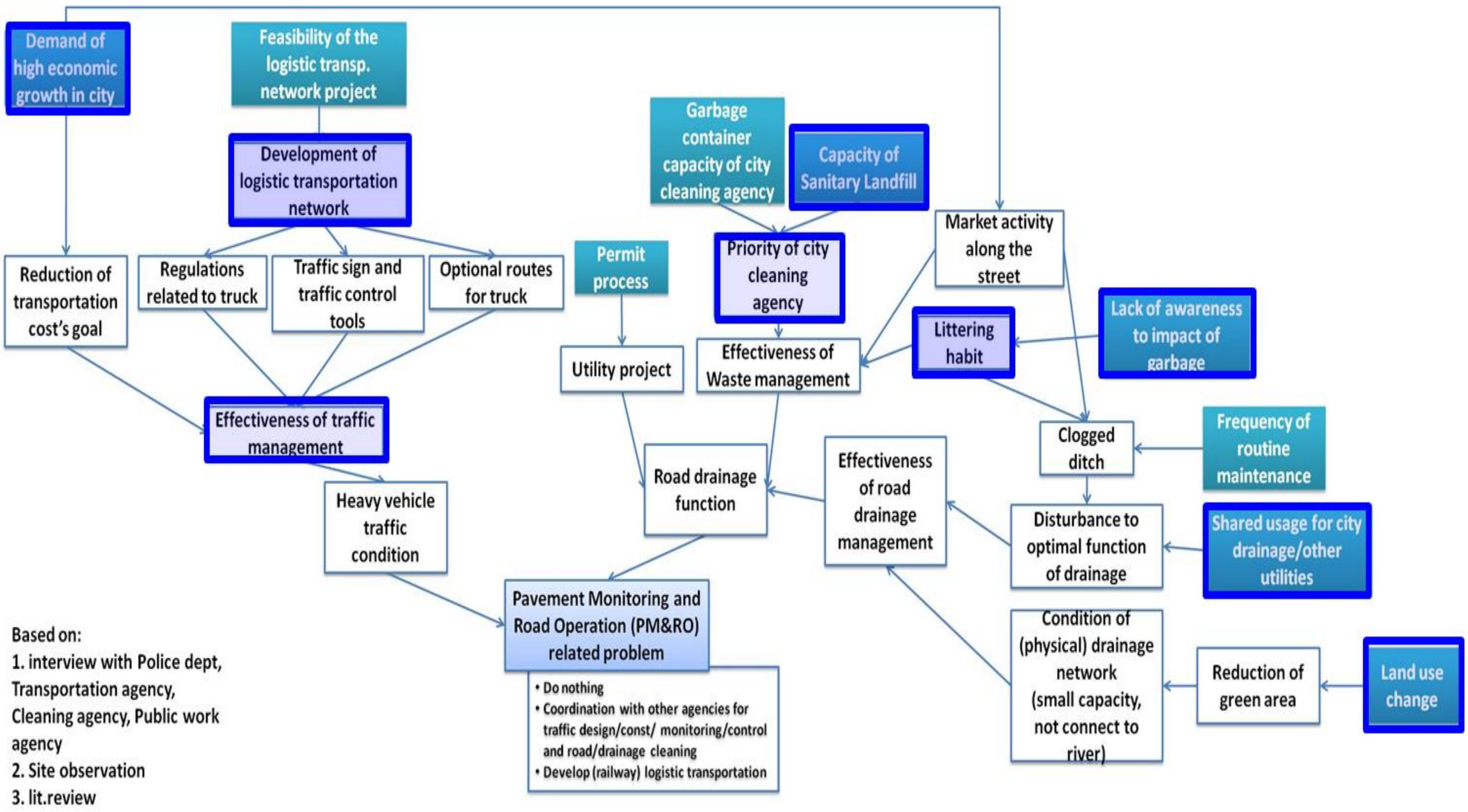

Figure 12 Problem Occurrence Mechanism of Pavement Monitoring and Road Operation

4.5.4.3Problem Occurrence Mechanism of Road Maintenance (RM)

Road maintenance problem was related to the type of road maintenance management being conducted by HD. To draw the problem occurrence mechanism of road maintenance, the author adopts the well-known concept of Pavement Management Systems. Questionnaire design was developed for this purpose. The questionnaire includes eleven main questions which were classified into nine elements. Further evaluation was conducted in this section as follows.

Original development of the city road

How is maintenance workload compared to resources in local road agency?

Highway Department (HD) is responsible to maintain city roads and district/rural route (266.31 km). Ageing road is one of the problems faced by HD. Most of roads are 10-20 years old. Those roads suffered from deferred maintenance, therefore currently the deferred maintenance has multiplied the fund and capacity required to repair the roads. HD received many maintenance complaints/requests from citizens. In 2014, from 160 complaints, 90 responses could be responded by HD. In average, maintenance budget is 2.9 billions IDR/year, which is still insufficient to properly maintain whole network.

Performance monitoring and Road operation

1. How the road being operated?

   Result : a) Road operation is mainly involved with traffic control and road cleaning. Traffic control is under management of Transportation department assisted by Traffic Unit of Resort Police Department support. Especially for weight restriction, it is commonly controlled based on two types of assessment: administration compliances (driving license released by Police department and truck condition check up report released by Transportation department) and visual observations (such as safety wrapping, tire condition, speed and compression level of shock-breaker). Within 2 years (2012-2014), inspections in the street observed were reported twice. Several issues elicit from interview that hinder consistent traffic enforcement such as unavailable tools to assess load of heavy vehicles (such as weighing bridge or weight in motion tools), no clear traffic sign/marker to restrict weight restriction and tolerance of weight restriction made by National Transportation department. Truck percentage in street observed is very high and

AADT is four times higher than standard road class. However, strong pursuit of weight restriction cannot be done. No alternative route to support the traffic demand exists, and there would be a big concern of increase in commodity price due to higher transportation cost.

b) Road cleaning is daily provided by Cleaning Department; however, their priority is to collect garbage from the garbage station due to limited capacity to load the garbage. As a consequence, the activity of cleaning the garbage in the pavement or blocked road ditches got less attention. It should be under routine maintenance. Since routine maintenance was not conducted by Highway department, however, piles of garbage in the ditch or river were also found. It is also reflection of low awareness of citizens and related agencies on impact of littering. Clogged ditch or unconnected drainage was commonly found which contributed to temporary rainwater runoff during rain and slow drained rainwater to river. No maintenance action was observed to clean water trapped in some road segment.

Source : Interview, Field observation, Rainfall data,

Figure 13 Drainage problem

Establishment of levels of services

The review consists of a series of questions to obtain a better understanding of the levels of service (LoS) to be achieved in regard to pavement condition referred by the Cimahi city Highway Department (HD). The information explains the city road agency orientation to the customer preferences, strategic directions and the condition of the pavement network.

Mandated standards and service levels of road

2. Are there any standards levels of service referred by HD?

   Result : A minimum service standard (Standar Pelayanan Mutu, SPM) defined by Public Works Ministry Regulation No. 14 year 2010 is used in the Cimahi city HD. The SPM consists of two standards: (1) SPM for road network: accessibility, mobility and safety (2) SPM for road section: road condition and speed.

Table 20 Minimum service standard for road in Indonesia

Type of Basic Public Service			Minimum Service Standard		Target	Notes
			Indicator	Score		
II. Road	Network	Accessibility	Road connecting the centers of activity in the district/city	100%	2014	Performed by local government regency/city
		Mobility	Road that allows people to travel	100%	2014	
		Safety	Road that ensures road users to drive safely	60%	2014	
	Section	Road Condition	Road that ensures the vehicle run safely and comfortably	60%	2014	
		Speed	Road that ensures the trip can be done with the speed plan	60%	2014	

Source: Public Works Ministry Regulation No. 14 year 2010

Minimum road condition levels

3. Did HD translate the standard into minimum road condition levels?

Result : No. HD classifies road conditions into Good, Fair, Poor and Very Poor based on area percentage of pavement distress. Minimum road condition is Fair (pavement distress is occurred in maximum 15% of area). In this condition, the road is still comfortable with intermittent bumps or depressions.

Source: Interview.

Presence of pavement inventory

4. How frequently did HD collect and record the actual road conditions in a year?

Result : No scheduled formal data collection had been conducted although the coordinator of each sub-district sometimes made personal note based on their observation passed the road. The reason of such practice lies on preoccupied staffs with other tasks (no time).

In 2014, with 20 permanent staffs in HD and 40 personnel occasionally hired, HD is proposing establishment of an In-house Maintenance Team whose part of the job is to conduct a timetable for site inspection.

Source: Interview, Proposal of In-house Maintenance Team 2014.

5. Did HD collectively update the road inventory?

Result : Once a year before the submission of annual department report, the road inventory is updated.

However, it was found that the results of maintenance program 2011-2013 in three cases study were not updated into road inventory. The public complaints of deteriorated roads were also unlikely to update into road inventory. In summary, updating both the result of preservation program and reported pavement distress into the road inventory were not automatically done.

Source: Interview, Cross check between maintenance program and road inventory.

Table 21 Road inventory

Year	Level of deterioration	Overall percentage of road condition in the network	Case study: road conditions (meter)	
			Mahar Martanegara street (2.8 km)	Kerkof street (3.5 km)
2011	Good	72%	2,100	2,350
	Fair	19%	200	350
	Poor	8%	500	200
	Very Poor	1%	-	600
2012	Good	70%	2,100	2,350
	Fair	20%	200	350
	Poor	8%	500	200
	Very Poor	1%	-	600
2013	Good	73%	2,000	2,350
	Fair	21%	200	350
	Poor	6%	600	800
	Very Poor	0%	-	-

Source: Road Inventory in Cimahi city 2011-2013

Table 22 Maintenance program in the street being observed

Year	Type of work	Maintenance program in the street being observed			
		Mahar Martanegara st. (2.8 km)		Kerkof st. (3.5 km)	
2012	Pavement work	297 m	Shoulder widening with concrete K-300	373.5 m	Reinforced concrete pavement K-350
		23 m	Rigid pavement K-300		
		?	LASTON AC-WC 4-5cm		
	Drainage work	85 m	Closed channel at Cihujung	200 m	Open channel
		40 m	Open channel at Cihujung		
		10 m	Crossing channel		
		130 m	Open channel at Cimindi		
		?	Channel		

Year	Type of work	Maintenance program in the street being observed			
		Mahar Martanegara st. (2.8 km)		Kerkof st. (3.5 km)	
			normalization		
2013	Pavement work	680 m	Laston AC-WC 4 cm	345 m	Rigid pavement K-350
	Drainage work		-	70 m 30 m	Open channel Closed channel
2014	Pavement work	350 m	Rigid pavement K-350		-
	Drainage work				-

Source: Rehabilitation contract documents 2012-2013 in two case studies, Field survey, TPJ presentation 2014

Presence of pavement performance prediction

6. Did HD have a pavement performance prediction model?

   Result : No. Data is not well measured and documented.

   Source: Interview

Identification of need and prioritization

This is a series of questions to obtain a better understanding of how the Cimahi city Highway Department (HD) determine which of the candidate projects will be recommended and put in the annual M&R program.

Identification of needs

7. How did HD identify the right section to be maintained in a year? (the right section at the right time)

   Result : In the Cimahi city, needs of M&R was basically identified from:

   - Pesan Penduduk (Pesduk), an online citizen complaint services was introduced in the Cimahi city government in 2009. High-level management demand active response and action from relevant agency to answer each case became possible.
   - Personal request to the HD's staff
   - Formal request letter from sub-district/rural administrator
   - Request from legislative or high-level management

   For example in 2014, the report from public reached 163 requests. The pressure was high, and giving good response required large efforts. The data is initiatively compiled by the current Head of HD.

This recapitulation has been used mainly as input for preparing annual maintenance and rehabilitation program. Each case from the recapitulation was reviewed and investigated separately by each sub-district coordinator and team to determine scale of deterioration and appropriate pavement preservation treatments to be carried out. The locations of deteriorated roads in a single road section are often scattered in small volume; hence in some cases repair may be deferred due to cost effectiveness, resource availability and workability consideration. However in 2014, HD had proposed establishment of In-house Maintenance Team which is expected to respond quickly to the request of surface overlay or small volume of repair works.

In addition, major roads were also reviewed; currently most of them are in good and fair conditions. Few meter of road sections were found in poor condition but since the preservation is more expensive, the preservation is usually deferred.

Source: Interview, The Head of HD's recapitulation 2014, Proposal of In-house Maintenance Team 2014.

Table 23 The Head of HD's recapitulation of citizen complaints/reports 2014

NO	URAIAN PEKERJAAN DAN LOKASI	KET.
1	Depan SPBU Citeureup air meluap, karena saluran didepan SPBU tsb sempit dan sewaktu normalisasi saluran 2012 tidak dikerjakan	Laporan Kantor Kel. Citeureup
2	Tebing jalan menuju RT.7 RW.5. Kel. Citeureup mengalami longsor, dg ketinggian sekitar 10 m dan lebar 15 m	
3	Perbaikan Jalan Terusan Sudirman dan drainasenya yg menuju Kampus Unjani	Rektor Unjani
4	Perbaikan Jalan Ibu Sangki RW.013 Kel. Cibeber	Surat Ketua RW. 013
5	Perbaikan Jaling RT. 02 RW. 05 Kel. Cibeber	Surat Ketua RW. 05
6	Perbaikan Jalan di RW. 13 Kel. Pasir Kaliki (Kompleks Cimindi Raya)	Surat Ketua RW. 13
7	Perbaikan Jaling Gg. Alpakah RW. 03 Kel. Citeureup	Warga
8	Pengamanan Pagar Jembatan pintu air RW. 08 Kel. Karang Mekar	Surat Lurah Karang Mekar
9	Perbaikan Jalan di RW. 08 KPAD Sriwijaya Kel. Setiamanah. Jl. Sriwijaya VII sekitar 125 m; Jl. Sriwijaya IX sekitar 150 m; Jl. Sriwijaya XII sekitar 150 m	Surat Ketua RW. 08
10.	Dibuatkan bak control persis pada pertemuan got saluran air hujan (di tikungan jalan rorojonggrang raya ke cibaligo)	Surat dari Andreas Suparno, di koord deg Kimrum
11	Perbaikan Jalan Sambi sari I sekitar 225 m dan Jalan Sambi sari II sekitar 225 m	Dulur uing
12	Trotoar di Jln Citeureup, dari SPBU sampai dg bengkel cat mobil tergerus banjir	Pesduk
13	Usulan median jalan di cisangkan dibongkar saja, karena membuat jalan jadi sempi dan banyak terjadi kecelakaan	Pesduk
14	Perbaikan Jaling di RW 28 Kel. Cipageran	Pesduk
15	Perbaikan jalan dan gorong2 di RW 18 RT 5 Kel. Cibeureum dan RW 34 RT 4 Kel. Melong	Aep Dewan
16	Perbaikan Jaling RT 01 Gg Mesjid, RT 02 Gg Cempaka RW 11 Kel. Melong	H. Redi

8. How did HD determine the right treatment?

Result : Treatment is conducted based on trial based design (engineering judgment) due to lack of well documented data and lack of time for proper investigation. Currently HD tends to use rigid (concrete) pavement rather than flexible (asphalt) pavement to rehabilitate or reconstruct deteriorated road section reactive maintenance. This material is also used to construct culvert. Concrete may be more expensive to construct but less expensive in life cycle cost analysis. In addition, some HD' consideration for using concrete is given as follows:

- Pavement was already in poor condition;
- High durability to water infiltration and heavy load resulted in low annual maintenance and less loss time for repair;
- Quick to build with less risk of error construction. Familiarity of local constructor labor to construct this type of pavement is one of the reasons.
- Closing the road for road repair can disturb existing traffic flow, particularly in high traffic volume road, the congestion disturbance is enormous. By using concrete, HD confident to open the rigid (concrete) pavement for traffic

within 2 days after construction; while keep guarantee the pavement performance.

- The number of concrete batching plants in the Cimahi city and surrounding area are more than asphalt mixing plant (AMP).

For surface overlay work (preventative maintenance), HD prefers to use Hotmix (AC-WC) and Penetrasi Macadam (Lapen). Familiarity of local constructor labor to construct this type of overlay and availability of supply/equipment are the main consideration.

Source: Interview, Rehabilitation contract documents 2012 to 2013

Budgeting activities

This is a series of questions to obtain a better understanding of how the Cimahi city Highway Department (HD) secures the budget and controls spending.

9. How is the budgeting activity conducted?

Result : Several intensive meetings and field investigation are annually conducted in January-March every year to build the list of candidate pavement preservation projects. It involves discussion with the Urban planning agency, the Public work department, and the Financial department to ensure conformity with budget availability, political promise during campaign, and etc.

Because the number of citizen complaints was enormous which demand immediate response, HD made a simplification of budget scheme as shown in the following table.

Table 24 Budgeting scheme

	Description
Contractual and in-house work scheme	- Design work (package contract ≤ Rp.50 millions) - Supervision work (package contract ≤ Rp.50 millions) - Contractual construction works o Bidding scheme (individual contract ≥ Rp.200 millions) o Direct appointment scheme (Rp.50 million < individual contract < Rp.200 millions) - Construction in house work (package work < Rp.50 millions)
Workload	2012 : - 13 packages of design/supervision work - 3 packages of updating road ledger

	- 86 packages of city road rehabilitation - 83 packages of districts and rural road rehabilitation 2013 : - 18 packages of design/supervision work - 60 packages of city road rehabilitation - 63 packages of district and rural road rehabilitation

Source: Interview, budget realization report 2012-2013

Project design and implementation

10. How was the design being conducted?

Result : Maintenance treatment was selected by HD after inspection of the site of citizen complaints. HD had a generic maintenance treatment due to availability of material on the market, familiarity of labor of the technique, and price of work. Detailed design is conducted by designer in contractual packages for 5-10 streets to formulate project budget plan for construction, drawing and technical specification. Generally designer was given 30 days to complete the documents required. This design–construction process was commonly conducted in the same year, for example, design process in May to June and construction in July to December.

Source: Interview, Design Contract report

11. How is the construction being conducted?

Result : Construction is conducted in two schemes: in-house scheme and contractual scheme with supervision. In-house construction was mainly conducted based on the reported deterioration on road or drainage. A minimum amount of budget is secured for this purpose which is mainly used to order material and labor fee. Twenty labors were also prepared by HD.

Contractual construction work was conducted with supervision. It is commonly conducted in July to December. Quality control for rigid pavement is mainly conducted by slump test for fresh concrete and coring test for measuring concrete strength. The rebound hammer test data showed good quality of place concrete; however, in some road segment observed, variances of concrete strength was found.

Evidence of supervision activity was recorded in the slump test. However no evidence was found that showed control on readiness of site for molding, elevation before/after molding, super elevation and drainage condition. Several issues during construction were emerged from the interview such as less concern to constructability (disturbance from 24/7 traffic, local activity, rainfall, restriction of the delivery schedule from AMP/BMP). Rainy day during construction often required additional treatment to the base, and concrete molding during rainy day could cause increase in water cement ratio in concrete which reduces the strength of concrete. Thus, it is necessary to select proper period in month for construction and better order-delivery schedule arrangement. December is closed book time, it is recommended to do construction earlier.

Source : Interview, Design and Construction Contract report, In-house maintenance proposal, Rebound hammer test

Summary of the evaluation of the current PMS in Cimahi city was shown in the following table.

Table 25 Evaluation of current PMS in Cimahi city road agency

	PMS aspect	Questions	Cimahi city road agency	Scoring criteria	Score (0-2)
1	**Original road construction**	*How is maintenance workload compared to resources in local road agency?*	- Imbalance: ageing road, large network (266.31km) and deferred maintenance in the past have multiplied the fund and capacity required. - 160 Complaints, 90 responses. - Budget is 2.9 billions IDR/year, no increment.	0 = highly imbalance, network too large, low HD capacity 1 = fairly balance 2 = balance, successful handling	0
2	**Performance monitoring/ Road operation**	*How is the road being operated?*	- Weak control for traffic - Lack of road and drainage cleaning - Littering	0 = none 1 = inconsistent traffic control and monitoring or road/drainage cleaning 2 = routine and sufficient traffic control and monitoring, sufficient road/drainage cleaning	0
3	**Mandated Levels of Service**	*Are there any standards levels of service (LoS) referred by HD?*	National Minimum Service Standard for road	0 = none 1 = inconsistent usage 2 = always use	2
		Did HD translate the standard into minimum road condition levels?	Good-Fair-Poor-Very Poor, but no clear measurement	0 = no 1 = yes, but not clear 2 = yes, clear measurement	1
4a	**Pavement inventory**	*How frequently did HD collect and*	- No scheduled collection - Individual data collection	0 = none 1 = irregular, not cover all network	0

	PMS aspect	Questions	Cimahi city road agency	Scoring criteria	Score (0-2)
		record the actual road condition in a year?	based on citizen complaint - Poor records	2 = frequent & sufficient, cover all network	
		Did HD collectively update the road inventory?	Once a year based on citizen complaint	0 = none 1 = irregular 2 = automatic update	1
4b	**Presence of pavement performance prediction**	*Did HD have a pavement performance prediction model?*	No	0 = no 1 = yes, but not well calibrate to existing condition 2 = yes, it is reliable	0
5	**Identification of needs**	*How did HD identify the right roads to be maintained in a year? (right section at the right time)*	Depend mainly on citizen complaint related to deteriorated road/drainage	0 = not clear 1 = based on worst case response, partial road condition survey 2 = based on road condition survey & prediction	1
6	**Prioritization of needs**	*How did HD determine the right treatment?*	Engineering judgment, available resources in market	0 = insufficient, less technical consideration, poor road condition 1 = fair engineering judgment, fair road condition 2 = sufficient engineering judgment, optimizing local resources utilization, good outcome	2
7	**Budgeting**	*How is the budgeting activity conducted?*	- Several meetings with relevant agencies, - Competition with other budget needs	0 = not reasonable 1 = fair, unclear process 2 = reasonable, coordination with other agencies	2

	PMS aspect	Questions	Cimahi city road agency	Scoring criteria	Score (0-2)
8	**Project Design**	*How is the design being conducted?*	- Design defined by in-house planning mgt., - Detailing by consultant in package contract (less concern to constructability causes differences in between design documents and actual conditions)	0 = insufficient, create constructability problems 1 = fair, result limited to cost estimation and drawing 2 = sufficient time, budget and scope	1
9	**Project Implementation**	*How the construction being conducted?*	- In-house management - Supervision contract (weak supervision)	0 = poor construction process and quality 1 = fair, good construction quality 2 = good construction (time, budget and scope)	1
T O T A L S C O R E (max. 24)					**11**

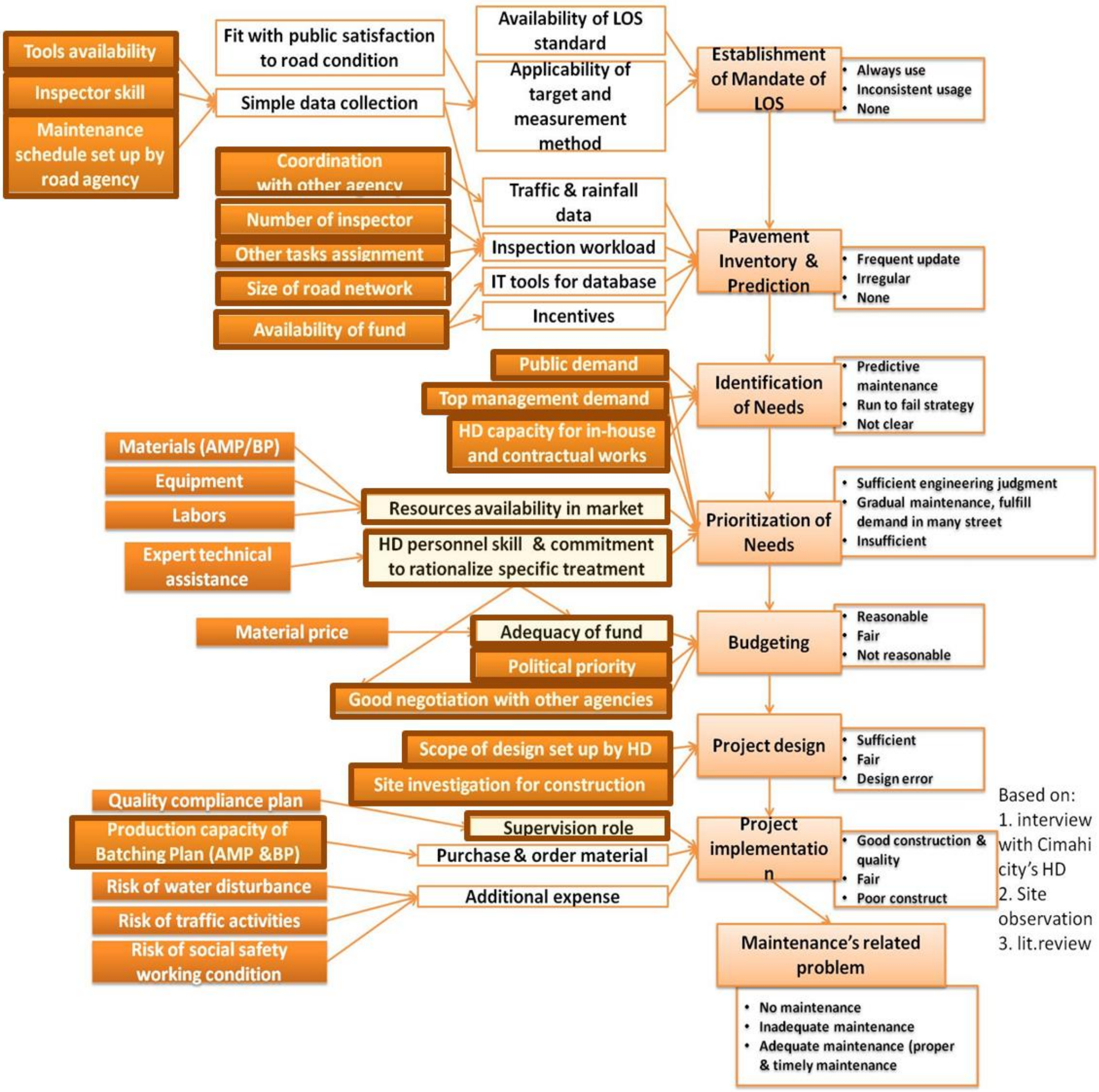

Figure 14 Problem Occurrence Mechanism of Road Maintenance

Prototype of problem occurrence mechanism of local road/drainage maintenance can be derived from the above analysis. The investigation has changed the initial hypothesis. The association of three components of PMS practices (ORD, PMRO and RM), factors affecting road performance (Structure, Traffic, Environment and Maintenance) and parameters of road conditions is not in a straight line. It is proven that ORD related problem influence structural capacity of pavement, PM&RO related problem influence Traffic and Environment, and RM related problem influence Maintenance treatment-timing-method-quality. And in the end the factors influence road/drainage conditions. However the investigation was identified two more relationships: The relation between structural capacity as the result of ORD related problem to RM related problem and the relation between traffic and environment to RM related problem. Coordination

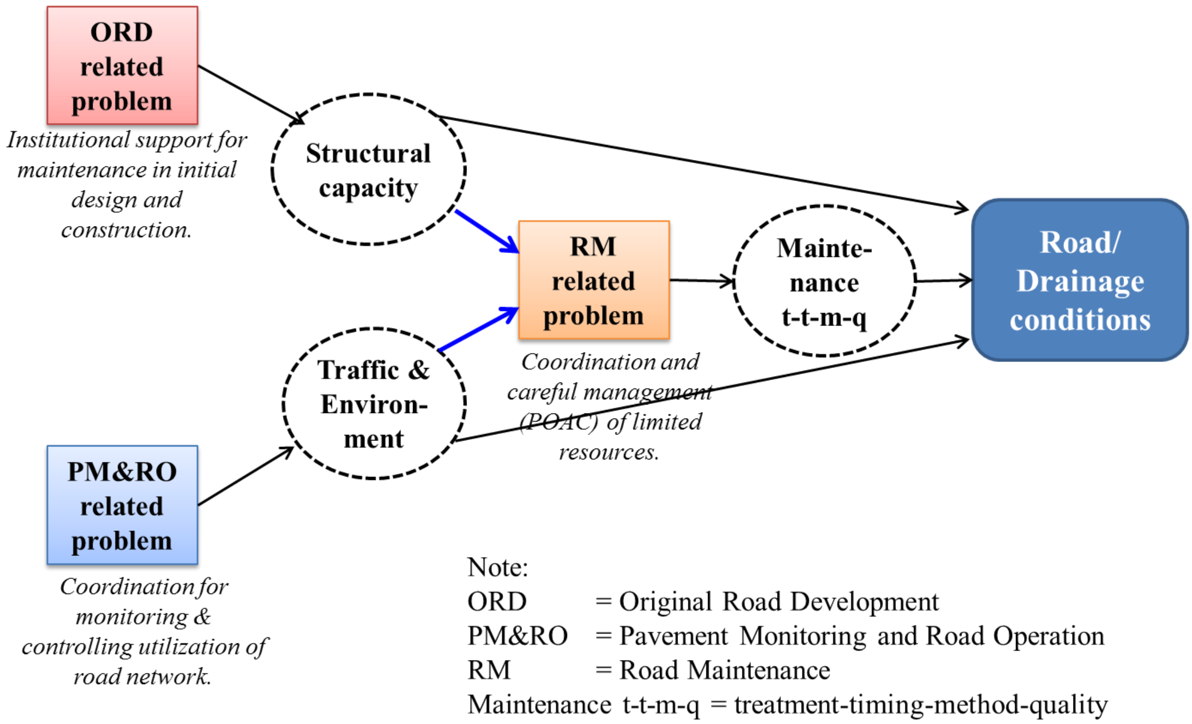

Figure 15 Prototype of problem occurrence mechanism of local road/drainage maintenance

4.6 Constraints analysis

Success degree of practicing a process system is best evaluated through measuring its feasibility to be executed and effectiveness to achieve the desired goal based on the available resources in the organization. Effectiveness of the proposed municipal PMS was assessed based on the possible effects of identified constraints to the whole processes in the proposed municipal PMS. Two main questions of effectiveness of the proposed municipal PMS were: (A) Can the Municipal Highway Department control the constrains of Original Road Development (ORD) and Pavement Monitoring and Road Operation (PMRO) (B) Can constraints be reduced by Inspection and Database development.

In this research, 39 constraints were identified from the investigation of factors affecting city road performance. Those constraints were later evaluated by using the two above main questions. Basically, Municipal Highway Department (HD) can control 2 constraints among 14 identified constraints. Documentation of road condition and frequency of routine maintenance were part of the process of proposed pavement management systems which need to be emphasized in the future. Through better inspection of road/drainage conditions, 21 constraints related to Road Maintenance problem were possibly satisfied. It is possible to conduct routine inspection through better scheduling of routine maintenance and gradual improvement of resource, i.e. staff training, procurement of equipment, adoption of a database PMS application software and incentives. If the HD can achieve this improvement, it will improve the decision making of road/drainage maintenance treatment which relies on rational engineering judgment. Other constraints may also be satisfied by increasing participation of related parties by using the result of the proper inspection and database.

Table 26 Summary of evaluation of effectiveness of the proposed municipal PMS

A.		**Can HD control the constraint?**	**Controllable**	**Uncontrollable**
ORD constraints	1	City major commitment		V
	2	Road function for mobility and economic growth		V
	3	Fluctuation of material price		V
	4	Documentation of road condition	V	
	5	Regulation		V
PMRO constraints	6	Demand of economic growth		V
	7	Feasibility of logistic transportation network project		V
	8	Utility permit process		V
	9	Garbage container capacity		V
	10	Capacity of sanitary landfill		V
	11	Lack of awareness to impact of garbage to road condition		V
	12	Frequency of routine maintenance	V	
	13	Shared usage of drainage		V
	14	Land use change		V
B.		**Can constraint be reduced by Inspection & Database development?**	**Possible**	**Not possible**
RM constraints	1	Fit with public satisfaction to road condition	V	
	2	Tools availability	V	

	3	Inspector skill	V	
	4	Maintenance schedule set up by HD	V	
	5	Coordination with other agency	V	
	6	Number of inspector	V	
	7	Other tasks assignment	V	
	8	Size of road network		V
	9	Availability of fund	V	
	10	Public demand	V	
	11	Top management demand	V	
	12	HD capacity for in-house and contractual works	V	
	14	Equipment	V	
	15	Labors	V	
	16	Expert technical assistance	V	
	17	Material price	V	
	18	Political priority	V	
	19	HD personnel skill & commitment	V	
	20	Scope of design set up by HD	V	
	21	Site investigation for construction	V	
	22	Quality compliance plan	V	
	23	Risk of water disturbance	V	
	24	Risk of traffic activities	V	
	25	Risk of social safety working condition	V	

CHAPTER 5 DEVELOPMENT OF A CONCISE MUNICIPAL PAVEMENT MANAGEMENT SYSTEM SUITABLE FOR CITY ROAD AGENCY

5.1 Introduction

In order to spend the available resources for road maintenance in an optimal way, pavement maintenance systems are essential (Molenaar 2001). However, there still have been many challenges in PMS which has experienced both developed and developing countries. The challenges are related to inspection, database, management cycle, pavement deterioration forecasting, life cycle cost analysis (LCCA), accountability of optimization procedures, and even political issues. Many researchers have been conducted in the above specific challenges and some come out with innovations in data collection, prediction model, etc. (Salpisoth 2014, Mapikitla 2007, Dekker 1996, Abubakar 1998).

Associated costs of implementing and maintaining PMS is listed in the Washington State Department of Transportation (WSDOT) in Local Agency Pavement Management Application Guide (1996). These costs may be broken down as follows: software and hardware acquisition cost, data collection costs, consultant services cost, in-house staff time cost (data processing, data analysis, system maintenance and training), and the actual expenditure made on the pavement network. In addition, institutional issues may need to be addressed such as those related to factors associated with personnel, organizational structure, or mayor commitment/policies that may hinder the adoption of new approaches. These have caused fundamental maintenance challenges for many road agencies in both developed countries and developing countries.

Resources in city road agencies in Indonesia are limited.Regardless of the length of roads and their maintenance workload, limited resources become one of the root constraints to bring poor maintenance process, as identified in the previous chapter. Therefore, a concise municipal PMS suitable for city road agency is needed to develop. This proposed PMS can be an initial step to shift from reactive maintenance into preventive maintenance.

5.2 Specific Objectives

Objective of this study is to develop a concise municipal Pavement Management System suitable for city road agency.

5.3 Materials and methods

In this study, data was collected through several methods:

- Literature review on Pavement Management Systems and practice of maintenance management in Highway Departments
- Results of evaluation of PMS practice (shown in chapter 4)
- Results of constraint analysis (shown in chapter 4)

A concise municipal pavement management system which is considered suitable for the city road agency in Indonesia was obtained based on analysis of evaluation of PMS practice and constraint analysis. The proposed PMS then confirm in the mini Forum Discussions.

5.4 General Principles of Pavement Management Systems

Well known guidance for road maintenance and rehabilitation management has been referred for national road network M&R management in many countries which was then adapted for provincial and city/municipal condition, such as the Pavement Design and Management Guide (the Transportation Association of Canada, 1997) and the Pavement Management Guide (American Association of State Highway and Transportation Officials, AASHTO 2001).

AASHTO Guide for Design of Pavement Structures (1993) has defined Pavement Management System as a set of tools or methods that assist decision makers in finding optimum strategies for providing, evaluating and maintaining pavements in a serviceable condition over a period of time.

A study by Hajek, Hein &Olidis (2004) developed a best practice for Canadian municipalities in preserving road network (Figure 5.1). There are eight basic steps in the yearly management cycle: (1) review or establishment of levels of service, (2) pavement inventory, (3) identification of needs, (4) prioritization, (5) budgeting, (6) project design, (7) project implementation and (8) performance monitoring. The first five steps of the management cycle represent network-level management activities whose objective is to ensure that the right pavement sections receive treatment at the right time. The rest of the steps (6 to 8) represent project-level activities that ensure that right sections receive the right treatment.

The followings are general description of eight basic steps of PMS:

Step 1. Establishment of levels of service (LoS)

At the start of the priority planning process, it is important to consider the objectives. What level of service is the road agency expected or mandated to provide could be varied. Basically, a city or municipal council should review and approve the policies on levels of service used by a road agency. In this way, all subsequent pavement preservation needs are derived from and are mandated by the approved levels of service.

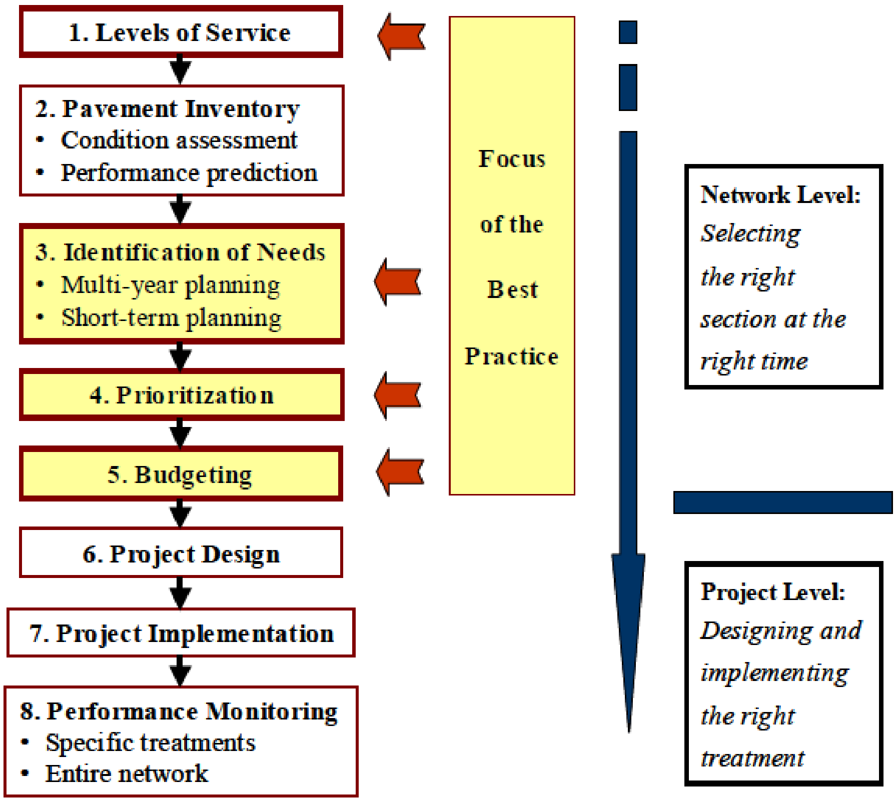

Figure 16 Decision making framework for pavement preservation

Step 2. Pavement Inventory

Pavement inventory is the key building block for pavement decision making. A complete inventory includes the description (size and type) of pavement assets as well as their current (pavement condition evaluation) and future conditions (pavement performance prediction).

Pavement condition evaluation serves two purposes: to identify maintenance and rehabilitation needs and to monitor the health of the pavement network. Briefly, conditional evaluation requires the identification of individual pavement distress, such as cracks and the evaluation of their severity and extent. Monitoring of the health of the pavement network must be objective and repeatable to produce true trends. It typically involves assessment of roughness and pavement distresses. Generally road condition rating is classified into the following classification: very good, good, fair, poor, and very poor. Definition of each classification can be difference among jurisdiction. The following is example in US countries.

- Very good: pavement structure is stable, with no cracking, no patching, nor no deformation evidence. Roadways in this category are usually fairly new. Riding qualities are excellent. Nothing would improve the roadway at this time.
- Good: Stable, minor cracking, generally hairline and hard to detect. Minor patching and possibly some minor deformation are evident. Dry or light colored appearance, riding qualities are very good. Rutting is less than ½”.
- Fair: Pavement structure is generally stable with minor areas of structural weakness evidence. Cracking is easier to detect. The pavement may be patched but not excessively. Although riding qualities are good, deformation is more pronounced and easily noticed. Rutting is less than ¾”.
- Poor: Areas of instability, marked evidence of structural deficiency, large crack patterns (alligator crack), heavy and numerous patches, and deformation are very noticeable. Riding qualities range from acceptable to poor. Rutting is greater than ¾”.
- Very poor: Pavement is in extremely deteriorated condition. Numerous areas of instability. Majority of section is showing structural deficiency. Riding quality is unacceptable (probably should slow down).

Pavement performance prediction is a critical requirement for the identification of future pavement preservation needs. Although there is generic pavement prediction performance model developed by World Bank HDM-4, Austroad, it should be noted that pavement performance depends on many local factors and is not easily transferable.

As a minimum, the pavement inventory should include the followings:

- the location, road class, length, width, and area of the pavement section;
- the date of the original construction and the dates of subsequent rehabilitation treatments;
- a description of the original pavement structure and the subsequent pavement preservation treatments;
- pavement conditions (past and current); and
- traffic data (e.g., estimated annual average daily traffic and the percentage of commercial vehicles)

Steps 3 and 4. Identification of needs and prioritization

The identification and prioritization of needs can be described into two types: (a) the multi-year identification of needs for time horizon of about five years or more, and (b) the short-term identification of needs for shorter periods. The process yields a list of candidate pavement preservation projects.

(a) Short term identification of needs and prioritization

Because of the complexity of multi-year planning procedures, it may be easier for municipalities just to start implementing pavement management systems to use short-term planning and prioritization procedures. The typical step by step description presented the best practice for short term planning and prioritization (Figure 17).

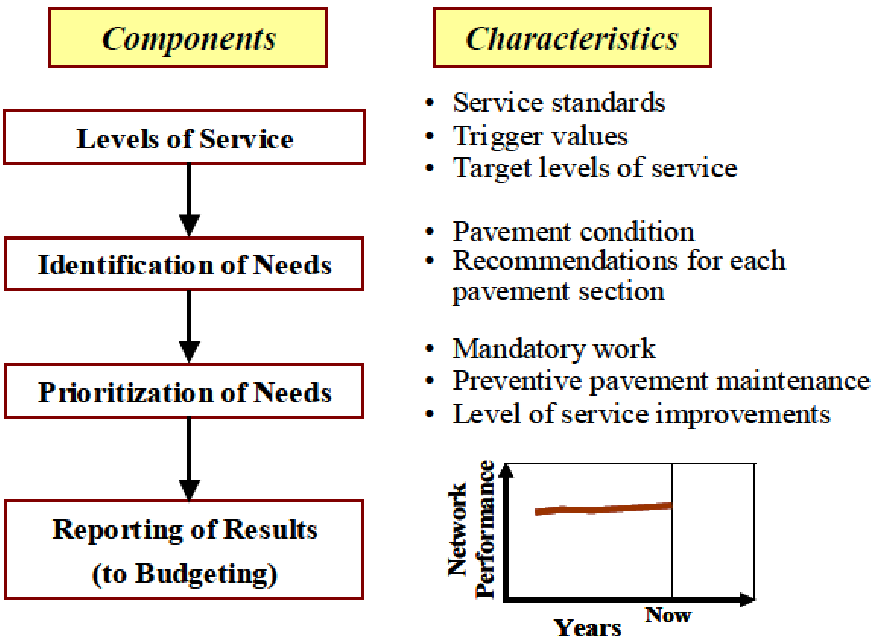

Figure 17 Short term planning and prioritization

In general, all road maintenance and rehabilitation activities that can be planned at least a year in advance should be included. Each road section in the inventory is reviewed to determine if the section requires a pavement preservation treatment in the next few years. Many sections may not require any treatment. Some sections may require a preventive maintenance treatment (e.g., crack or joint sealing).Some may require other types of maintenance or rehabilitation. The candidate treatments can be identified using engineering judgment, agency-specific guidelines and decision trees, and general guidelines. The best treatment for the given section should be selected. The selection of the treatments must be realistic and must consider the appropriate levels of service. It is important to realize that the identification of needs is not a creation of a wish list, but a documentation of the needs that are necessary on the basis of approved and mandated standards and levels of service. Each section and its recommended treatment are described in terms of location, treatment type, recommended construction year, estimated cost and very importantly priority level.

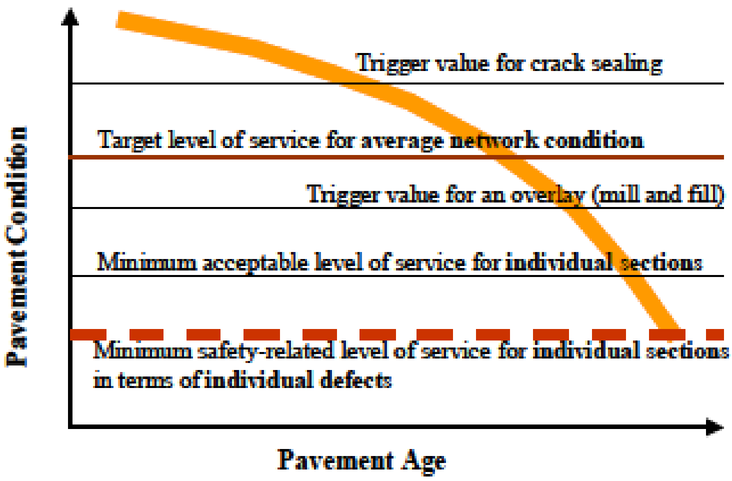

Figure 18 Types of service levels and trigger value

The priority level shows the main reason why the treatment is recommended for implementation. One of the following priority levels should be assigned to each recommended pavement preservation treatment (Figure 18):

- minimum safety-related levels of service need to be met;
- minimum acceptable levels of service need to be met;
- there are preventive maintenance and cost effectiveness concerns (includes projects where timing is very important to achieve cost effectiveness); or
- projects are initiated to achieve a target level of service.

If it is expected that some projects may not be funded because of limited funding, the list needs to be prioritized. Projects that address minimum safety-related levels of service are typically considered mandatory and are not prioritized. There are many ways to prioritize projects. The priority levels, together with road classes already convey basic priorities. Typical prioritization criteria include the following considerations that can be applied individually or in combination:

- pavement conditions (in relation to the level of service);
- road class;
- traffic volume and percentage of commercial vehicles; and
- cost effectiveness (benefit-cost ratio).

(b) Multi-year identification of needs and prioritization for time horizon of about five years or more

Multi-year prioritization analysis can consider several treatment options in each analysis year (FHWA, 1997). Multi-year planning also improves engineering and economic decision making because it enables the agency to evaluate the long-term impacts of accelerating or postponing projects from one year to another, to evaluate the trade-offs between lower-cost treatments that have to be paid for now versus costlier treatment that will need to be paid for later, or the impact of diverting funds to preventive maintenance.

An important feature of multi-year prioritization analysis is its ability to prioritize (or optimize) competing treatments using the cost effectiveness of individual treatments. To do this, each treatment is characterized by its cost and benefit. The cost aspect of the treatment should be based on its life cycle cost as much as possible (Zimmerman et al., 2000). However, in practice, agencies use only initial treatment costs and perhaps routine maintenance costs because the exact nature of the treatments is not known in the planning stage (at network level). Benefits or effectiveness of the treatment are the additional pavement life the treatment is expected to provide, and may include the reduction in user costs. For example, if two projects provide the same benefit in terms of additional pavement life, the project on the road serving a higher traffic volume may be chosen first. The candidate projects included in multi-year analysis should also include preventive and other maintenance activities.

Depending on funding, the projects not funded one year are considered for funding in the subsequent year (or years). By changing the amount of funding, the amount of work will change, and so will the condition of the pavement network. However, regardless of funding, the list of prioritized projects still represents the best value for the money. The results of multi-year prioritization can show the relationship between the pavement investment and the resulting level of service provided to the community.

Step 5. Budgeting

The selection of projects to be included in the budget should be based on the efficient allocation of resources to different programs and to different assets. The efficient allocation of resources and the ability to evaluate the consequences of different budget allocations is a principal premise of asset management.

Budgeting builds on the results of planning and prioritization activities and produces a budget – a financial document that determines how the money will be invested in the infrastructure. Budgeting combines technical and financial decision making. While historical budget allocations assist in providing an overall indication of available resources, the main input to the budgeting process should be the list of documented and prioritized needs and not last year's budget. The primary budgeting activities are schematically illustrated in Figure 19.

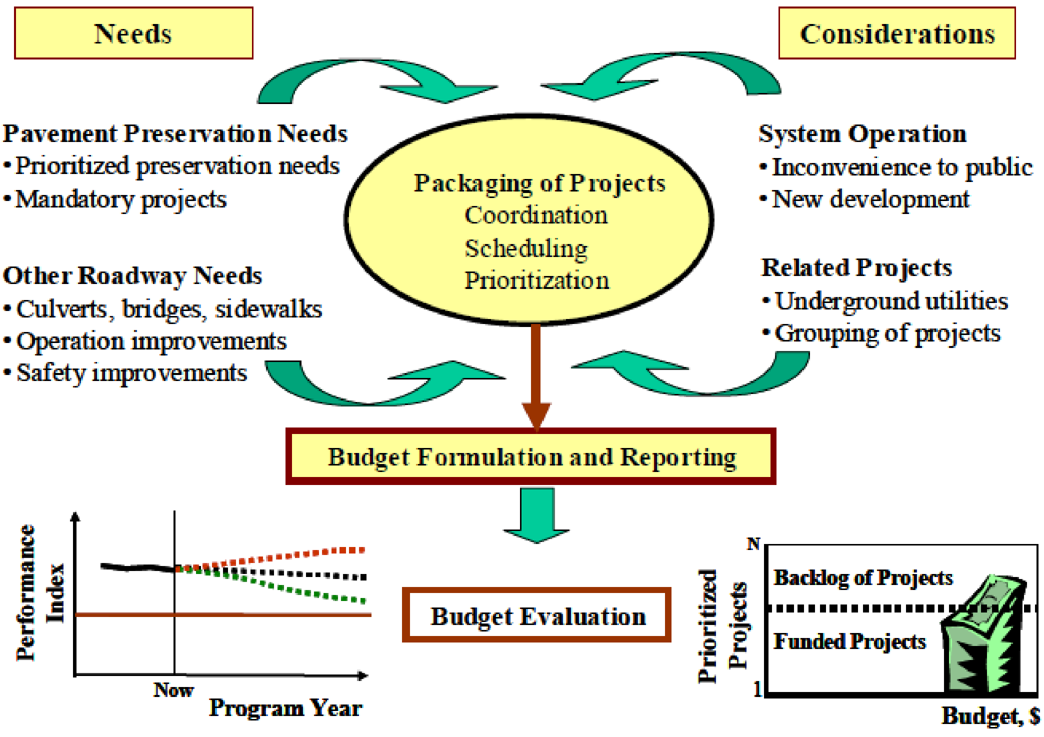

Figure 19 Key budgeting activities

Budgeting builds on the results of planning and prioritization activities – a financial document that determines how the money will be invested in the infrastructure. Budgeting combines technical and financial decision making. The main input to the budgeting process should be the list of documented and prioritized needs and not last year's budget. The primary budgeting activities are schematically illustrated in Figure 5.4.The result of the budget allocation can be quantified and reported using the following means.

- Show the consequences of different budgets in terms of pavement conditions.
- List the specific projects that will not be done because of funding limitations.
- Track the quantity of unfunded needs and the changes in unfunded needs from year to year.
- Monitor network performance trends.

Steps 6 and 7. Project Design and Implementation

The priority planning and budgeting process determines which road sections should receive pavement preservation treatments, the year of preservation, the approximate type of the treatment and the estimated cost of the treatment. Project design determines the actual treatment type and provides additional details required for the construction of the projects such as the layer thickness, type of material and construction methods. It often uses the results of physical tests of the existing pavement materials. The systematic way to approach the design of pavement maintenance and rehabilitation treatment is through life cycle cost analysis (LCCA). LCCA takes into account the cost of the initial constructions as well as all subsequent maintenance and rehabilitation treatments.

The two main decision making concerns during the implementation stage are the selection of construction agents (in-house, contractors) to carry out the work and inspection procedures during construction. In addition to quality control and quality assurance procedures, many municipalities use construction warranties and supervision for construction.

Step 8. Performance Monitoring

Periodic pavement monitoring is important for both individual projects and for the entire pavement network. Regular condition evaluation of all pavement sections in the network can provide a clear indication of the long term trend in the health of the network.

Based on Canadian experience, the main PMS implementation steps and challenges include the following.

- Analysis of system benefits – Management and technical leadership must be convinced that the process will provide benefits to the residents and to the agency.
- Gaining support by council – Acceptance and support by municipal council is vital.
- Getting Management commitment – The implementation of the process takes time and may be labour intensive. The process may change the way in which the pavement preservation business was done and may affect agency staff. Long-term commitment and support by management is required for successful implementation and operation of the process.
- Establishing technical aspects – The process must be technically sound and reflect local conditions,e.g., environment, material availability and constructing industry. Because the process is typically a computer-assisted decision support system, it will require ongoing software support.
- Building long-term commitment – The benefits of the process increase with time and with experience. For example, it takes several years to collect data, obtain pavement performance trends, and calibrate pavement performance models. The availability of good inventory data is necessary to make the process work. The continuing desire to succeed on the part of all principal participants (maintenance personnel, planner, top management) is required.
- Maintaining ongoing support – Identifying and prioritizing needs incurs costs and requires trained personnel.
-

5.5 Findings and discussion

Basically for municipalities with limited access to resources, it is needed to have a model of Pavement Management Systems without requiring use of high technology and costly investment at the initial stage. Although the principles of PMS in every process should be followed, it is realistic to start from providing a good basic process and gradually to develop into more efficient and effective procedure over the time.

Mainly referring to the best practice for Canadian municipalities in preserving road network, the PMS for municipal with limited resources were developed. The proposed PMS shall apply the new set of road condition parameters proposed in chapter 3 as it is customized to local city maintenance practice in Indonesia. Evaluation of PMS practice in Cimahi city and constraints analysis provided evidences for development of the PMS concept. As consequences, a new element ofPMS, so called understanding Original Road Development, has been added to the proposed PMS. The understanding of original road construction/development is an important element because its contribution to the institutional constraints inherited to city road agency on duty. The proposed municipal PMS for Indonesia and its consideration are shown in Figure 20. It includes 8 element processes as described in the following figure and table.

Figure 20 Proposed Municipal PMS for Indonesia

Table 27 Element process of proposed municipal PMS in Indonesia

No	Element process	Description	Evaluation of PMS practices	Comments
1	Original Road Construction	a. Improve information on ledger of road network b. Develop a long term commitment to improve resources in road agency (staff capacity and funding)	- Imbalance: ageing road, large network (266.31km) and deferred maintenance in the past have multiplied the fund and capacity required. - 160 Complaints, 90 responses. - Budget is 2.9 billions IDR/year, no increment.	Current city road agencies were overwhelmed with the maintenance workload and its inherited problems (ageing road, traffic, drainage conditions). It resulted in a reactive maintenance with less planning to the future needs. Information related to original road construction is commonly assumed as part of document of performance monitoring, but due to importance of good track record of each roads and great influence of this information to overall condition, it is necessary to be put in separate elements process of PMS. Well understanding of road conditions in the network shall lead to better preparation of road agencies organization in maintaining its road network. The organization shall be able to measure the maintenance workload and the minimum requirement of resources support.
2	Performance monitoring & Road operation	a. Consistent and routine traffic law enforcement b. Traffic counting c. Routine road and drainage cleaning d. Documenting report of road performance	- Weak control for traffic - Lack of road and drainage cleaning - Littering	Current road operation put less control to traffic and storm water factors. As a result, pavement carried excessive traffic and vulnerable to moisture influences. It is necessary to initiate a continuous effort in monitoring and if possible, controlling the effect of traffic and storm water to the pavement strength. A better coordination with related stakeholder in performance monitoring shall assist road agencies in programming a progressive road maintenance requirement.

No	Element process	Description	Evaluation of PMS practices	Comments
3	Mandated of Levels of Service	a. Road condition measure b. Set up minimum of LOS using the proposed new set of road conditions parameter	National Minimum Service Standard for road: percentage of length of road in good condition. Classification of Good-Fair-Poor-Very Poor is followed, but no clear measurement.	As part of government entities, city road agencies shall remain use National Minimum Service Standard in reporting the road condition measures. However, agencies have multiple objectives and limited resources in designing maintenance needs. As road users/citizens are the end user of road services, integrating customer oriented improvement into maintenance prioritizing is a resource-efficient method of pursuing road conditions and service goals. The new set of parameter of road conditions developed in the chapter 3 can be a good option for city road agencies in Indonesia because it accommodates Indonesian local situation.
4	Pavement Inventory and Prediction Model	a. Routine inspection of road conditions b. Collection of traffic and rainfall data (coordination with police and relevant agencies) c. Follow up citizen report by conducting a detail inspection	- No scheduled collection - Individual data collection based on citizen complaint - Poor records, the road inventory update once a year - No prediction model	Current agencies do not have an organizational culture to properly document data. Road agencies need to start developing their PMS systems. Historical database and road operation data is an unknown information, thus, the best way to recognize the complexity situation in maintaining the road/drainage network is through monitoring and documenting on the following areas: - behaviorof traffic - pavement conditions and maintenance treatment performance - climate/environment - working restriction - cash flow and other resources Scheduling routine visual inspections, collection of traffic and rainfall data, and review/discussion with citizen may be used as data collection methods. It

No	Element process	Description	Evaluation of PMS practices	Comments
				should be noted that the purpose is not solely to collect the data, but the most important is to build organizational culture that have a high awareness of the future challenges of maintenance. It is also expected that all information/data collected is well documented, so in the future, it can be used to predict performance of road condition for different resource allocation.
5	Identification and Prioritization of Needs	Selection of maintenance treatment strategies based on pavement inventory and prediction model Rank based on weight needs: A. Based on road function 1. Road class B. Based on by discussion among road agency engineers 2. Safety 3. Risk to lose the network 4. Maintain the conditions 5. Aesthetic C. Based on cost	Identification of need depend mainly on citizen complaint related to deteriorated road/drainage. Prioritization is conducted based on engineering judgment and available resources in market.	High dependency to road users/citizens complaints and top management request are not good in the long term for organizational development and reducing maintenance workload. Ensuring that the collected data is used in decision making process is important. In addition to establish a rational process for determining an appropriate design for a specific set of conditions, the data will encourage maintenance personnel to better collect pavement inventory. Prioritizing needs should be able to represent road users need and organizational goals. It is an important decision that needs to be discussed together among stakeholders. If it can be achieved, it shall increase better communication of justification of road maintenance funding.
6	Budgeting	Discussion of rational maintenance proposal driven by pavement inventory data	- Several meetings with relevant agencies - Competition with other budget needs	In order to get adequate funding, discussion with financial agency and/or top management is necessary conduct based on a rational maintenance proposal. The proposal should be developed by collected data and prioritization of needs in the previous process.

No	Element process	Description	Evaluation of PMS practices	Comments
7	Project Design	Put more concern to constructability & needs for water prevention work *(traffic, rain & run-off water, material purchasing, equipment)*	- Design is defined by in-house planning management - Detailing by consultant in package contract (less concern to constructability causes differences between design documents and actual conditions)	Execution of maintenance often faces many disturbance especially because of lack of data and ignorance to the impact during project design process. Therefore during project design, all relevant information of constructability of maintenance work should have been informed to the designer. If it is not provided, designers are responsible to make a request of the information and given sufficient time to investigate the site. This shall reduce additional expense by contractors which is forced to deal with actual condition and completion deadline. This expense should be reduced because it can compensate the maintenance quality.
8	Project Implementation	a. Improving compliance standard for construction especially construction method, superelevation b. Improvement of supervision role	- In-house management - Supervision contract (weak supervision)	Currently, many supervisors are forced to compromise with the actual conditions on site. Basically, supervisor is responsible to bridge the gap between design and actual conditions by giving proper guidance to the contractors. Thus, as long as project design properly considers the relevant actual conditions, supervisor should be fully responsible to assure quality of maintenance works. In regards to supervision contract, compliance standard for construction should incorporate construction method and super-elevation requirement. It is expected that this will put the supervision role in the proper place.

CHAPTER 6 CONCLUSIONS

The main objective of this dissertation is to develop concise pavement management systems (PMS) for municipal road agency with limited resources in Indonesia. In many local cities in Indonesia, various types of resources such as human resources, funds and technology are insufficient. Road management to support the strong social and economic activities is exceedingly poor. Not a few cities are suffering from early deterioration of the paved road. To the author's knowledge, few previous studies discuss the concept of PMS and its implementation method in local government under severe resource constraints. Specific objectives of this study are:

1. To understand association between city road/drainage conditions and municipal pavement management practices
   a. Develop parameters of road conditions based on citizen/road user satisfaction
   b. Formulate a prototype of problem occurrence mechanism of municipal road/drainage maintenance
2. To develop a concise municipal Pavement Management System suitable for city road agency

The data was collected through in-depth interview with relevant city road stakeholders, review on road agency's records, field survey in case studies in Cimahi city, West Java province, Indonesia, and literature reviews in each of topic areas. Although these findings represent the current state of the city road maintenance practice in Cimahi city, West Java province, it can represent overall cities in Indonesia.

Regarding Objective 1.a, a new set of parameters of road performance measures were proposed based on survey of road users/citizens satisfaction and visual road conditions survey. They are:

1. Small volume of pavement distress in scattered area
2. Moving road deterioration
3. Seasonal floods and water pond

4. Rapid decay of newly paved road
5. Disconnected road network

The first four parameters represent the road performance in daily life and the last parameter represents the performance in emergency case such as a big natural disaster.

Regarding Objective 1.b, hypothetical association among three components was proposed: PMS practices, Factors that affect road performance, and Parameters of road conditions. Elements of PMS practices are Original Road Development (ORD), Pavement Monitoring and Operation (PMRO), and Road Maintenance (RM). Factors that affect road performance are Structure, Construction, Traffic, Environment, and Maintenance. Parameters of road conditions are the four parameters in daily life: Small volume of pavement distress in scattered area, Moving road deterioration, Seasonal floods and water pond, and Rapid decay of newly paved road.

Regarding the second objective, each of PMS practices was first analyzed to obtain root constraints of road/drainage maintenance in each dimension of Original Road Development (ORD), Pavement Monitoring and Operation (PMRO), and Road Maintenance (RM), respectively. As a result, it is found that:

- Institutional support for maintenance in initial design and construction,
- Coordination for monitoring & controlling utilization of road network, and
- Coordination and careful management (POAC) of limited resources

are effective to satisfy constraints in each dimension.

The evaluation of the feasibility of the proposed municipal pavement management systems in Indonesia was then conducted through mini forum discussions involving Highway Department and Transportation Agency of Cimahi city. The result showed that basically, Municipal Highway Department (HD) can only control 2 constraints among 14 identified constraints related to problems of Original Road Development (ORD) and Pavement Monitoring and Operation (PMRO). Active participation and coordination from all stakeholders is required to solve problem in those problems. The evaluation also showed that HD is required to emphasize on improving their documentation of road conditions and frequency of routine maintenance as part of the process of proposed pavement management systems. Through better database and inspection of road/drainage conditions, all stakeholders agreed that 24 constraints identified related to Road Maintenance (RM) problem were possibly solved.

Finally, several well-known guidance for road maintenance and rehabilitation management are examined to find out the principle and the techniques of municipal pavement management systems for maintaining city roads in Indonesia. A concise principle of pavement management systems for municipal road agencies in Indonesia is developed. Documentation of road condition and routine maintenance was incorporated in the proposed PMS. In addition, awareness of size of road network as one of root constraints has led to incorporation of Original Road Construction elements in the proposed PMS. The proposed PMS is also driven by the proposed new set of parameters of road conditions as preference for minimum level of service. Hence, the proposed PMS consists of eight elements as follows: (1) Original Road Construction. (2) Performance monitoring & Road operation (3) Mandated of Levels of Service(4) Pavement Inventory and Prediction Model (5) Identification and Prioritization of Needs (6) Budgeting (7) Project Design (8) Project Implementation.

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Appendices

Appendix 1 Cimahi citizen complaint recapitulation 2014

Appendix 2 Road Condition Survey

Appendix 3 Rebound Hammer Test

Appendix 4 Traffic Counting Survey

Appendix 5 Rainfall data

APPENDIX 1

Cimahi citizen complaint recapitulation 2014

P = Pavement (124 complaints)
D = Drainage (28 complaints)
M = Miscellaneous (16 complaints)

No	Description of works and location	Source	P	D	M
1	Depan SPBU Citeureup air meluap, karena saluran didepan SPBU tsb sempit dan sewaktu normalisasi saluran 2012 tidak dikerjakan	Laporan Kantor Kel. Citeureup		D	
2	Tebing jalan menuju RT.7 RW.5 Kel. Citeureup mengalami longsor, dg ketinggian sekitar 10 m dan lebar 15 m				M
3	Perbaikan Jalan Terusan Sudirman dan drainasenya yg menuju Kampus Unjani	Rektor Unjani	P		
4	Perbaikan Jalan Ibu Sangki RW.013 Kel. Cibeber	Surat Ketua RW. 013	P		
5	Perbaikan Jaling RT. 02 RW. 05 Kel. Cibeber	Surat Ketua RW. 05	P		
6	Perbaikan Jalan di RW. 13 Kel. Pasir Kaliki (Kompleks Cimindi Raya)	Surat Ketua RW. 13	P		
7	Perbaikan Jaling Gg. Alpakah RW. 03 Kel. Citeureup	Warga	P		
8	Pengamanan Pagar Jembatan pintu air RW. 08 Kel. Karang Mekar	Surat Lurah Karang Mekar			M
9	Perbaikan Jalan di RW. 08 KPAD Sriwijaya Kel. Setiamanah. Jl. Sriwijaya VII sekitar 125 m; Jl. Sriwijaya IX sekitar 150 m; Jl. Sriwijaya XII sekitar 150 m	Surat Ketua RW. 08	P		
10.	Dibuatkan bak control persis pada pertemuan got saluran air hujan (di tikungan jalan rorojonggrang raya ke cibaligo)	Surat dari Andreas Suparno, di koord deg Kimrum		D	

No	Description of works and location	Source	P	D	M
11	Perbaikan Jalan Sambi sari I sekitar 225 m dan Jalan Sambi sari II sekitar 225 m	Dulur uing	P		
12	Trotoar di Jln Citeureup, dari SPBU sampai dg bengkel cat mobil tergerus banjir	Pesduk			M
13	Usulan median jalan di cisangkan dibongkar saja, karena membuat jalan jadi sempi dan banyak terjadi kecelakaan	Pesduk			M
14	Perbaikan Jaling di RW 28 Kel. Cipageran	Pesduk	P		
15	Perbaikan jalan dan gorong2 di RW 18 RT 5 Kel. Cibeureum dan RW 34 RT 4 Kel. Melong	Aep Dewan	P	D	
16	Perbaikan Jaling RT 01 Gg Mesjid, RT 02 Gg Cempaka RW 11 Kel. Melong	H. Redi	P		
17	Perbaikan Jaling di Gg Karno RT 6 RW 8 Kel. Leuwigajah (Depan rumah Asep Jaya)	Rita Dewan	P		
18	Perbaikan Jalan RW 19 Cileuweung Cipageran	Achmad Gunawan	P		
19.	Jalan sudah rusak di RT 5 RW 14 Kel Setiamanah	Vera	P		
20	Perbaikan jalan Rd. Saleh Unjani	Wakil Walikota	P		
21	Perbaikan Jaling RW 15 dan RW 16 Kel. Cibabat	Alvian	P		
22	Perbaikan jalan alternative di Kav. Bukit Sangkuriang RT 02 RW 06 Anggaraja Cipageran (tempatnya LSM Solusi)	Dani Bastaman	P		
23	Perbaikan GG Cipeer RT 05 RW 01 Citeureup dan Terusan Ranca Belut Kp. Tegal Kawung RT 01 RW 08 Cipageran	Agus Dewan	P		
24	Perbaikan jalan Kalasan 1 sampai dengan Kalasan Raya	Pesduk	P		
25	Perbaikan Jalan Melong Asih	Pesduk	P		
26	Perbaikan Jalan Roket Raya (200 m) dan drainase jalan kiri/kanan nya di RT 01 RW 20 Kel. Cipageran	Achmad Zulkarnaen	P		

No	Description of works and location	Source	P	D	M
27	Sisa Perbaikan Jalan Melong Green perlu diperbaiki lagi	Pesduk	P		
28	Perbaikan jalan Kol Masturi, dari Pasar Atas sampai dg Perempatan Citeureup	Pesduk	P		
29	Perbaikan jalan Sriwijaya II, VI, VII, VIII, IX, XIII	Tika Dewan	P		
30	Penyempitan saluran di depan alfamart (Boeing Raya/Melong Green)	Pesduk		D	
31	Perbaikan Jalan H. Ashari Kp Ciawitali Blk Indomart	Weli	P		
32	Perbaikan Jalan Joyodikromo	H. Nafsun/Robin	P		
33	Perbaikan Jaling Kp. Lembur Sawah, perbatasan RW 12 – RW 16 Kel. Utama	Robin	P		
34	Perbaikan Jaling Kp. Hujung Kulon RW 05 Sebelah SMKN 1 Cimahi Kel. Utama	Robin	P		
35	Perbaikan Jaling Kp. Saradang RT 02 RW 03 Kel. Leuwigajah	Robin	P		
36	Perbaikan jembatan Lembur Sentosa (Kali Cihujung) Kp. Lembur sawah RW 12 dan Kp Hujung Kidul RW 07 Kel. Utama	Robin			M
37	Perbaikan Jaling RW 13 Cigugur Tengah	Eko Dewan	P		
38	Saluran pake gravel jadi banjir di RW 19 Cigugur Tengah (Perlu koord dg Kimrum)	Eko Dewan		D	
39	Perbaikan Jaling Haur Koneng Citeureup	Ustaman	P		
40.	Perbaikan Jaling RW. 6 Kel. Cibeureum	Nafsun	P		
41	Perbaikan Saluran di RW 16 Kel. Cigugur (TPS)	Mahpuri		D	
42	Perbaikan Jaling Foker I (90 x 4 m)	Staf Bapeda	P		
43	Perbaikan Gorong2 RW. 14 Baros			D	
44	Pembangunan/Perbaikan Gorong2 Kebon Rumput ke arah Unjani	Mahpuri		D	
45	Perbaikan Jaling Purnawirawan	Wakil Walikota	P		
46	Perbaikan Jaling Kalasan 5	Edi Kanedi	P		

No	Description of works and location	Source	P	D	M
47	Perbaikan Jalan Kb. Jeruk Cibeureum	Sunarto	P		
48	Perbaikan lanjutan Jalan H. Haris	Cecep Dewan	P		
49.	Perbaikan Jaling Makmur RT 01, 03 dan 04 RW 14 Cibeber	Rita Dewan	P		
50	Perbaikan Jaling RT 01 RW 13 (Jl. Suka indah IX) Padasuka	Rita Dewan	P		
51	Perbaikan Jaling RT 08 RW 06 Cibogo Leuwigajah	Rita Dewan	P		
52	Perbaikan Jaling RT 06, 07 RW 03 Leuwigajah	Warga	P		
53	Perbaikan Jaling Nusa Hijau RW 18 Citeureup	Rini Dewan	P		
54	Perbaikan Jaling RW 05 Cipageuran	Rini Dewan	P		
55	Perbaikan Jaling RW 26 Kel. Melong	IWK	P		
56	Perbaikan Jalan Sewu 3	Pesduk	P		
57	Perbaikan Jaling Bobojong RW 15 Cipageuran tembus ke PCI	Pesduk	P		
58	Perbaikan Jaling GG Pancuran RT 01 RW 11	Pesduk	P		
59	Perbaikan Jaling Singkurmulya RT 05, 06 Paskal	Cecep Dewan	P		
60	Perbaikan Jaling Kp Nyalindung RT 05 RW 05 Citeureup	Cecep Dewan	P		
61	Perbaikan Jaling dekat Mesjid LDII Jl. Raya Cibabat Gg Karya Bakti 6 dalam Kel. Cigugur Tengah	Cecep Dewan	P		
62	Perbaikan Jaling RT 5 RW 18 Cibabat	Dedi Kuswendi	P		
63	Perbaikan Jaling RT 4 RW 4 Kel. Cibabat	Dedi Kuswendi	P		
64	Perbaikan Jaling RT 01, 02 RW 01 Pondok Mas Indah	Tono	P		
65	Perbaikan Jaling Blok Hegarmanah	IWK	P		
66	Perbaikan Jalan RW 29 Rancabentang Kel. Cibeureum		P		
67	Pembuatan drainase jalan Taman Adiraga Kb. Rumput			D	

No	Description of works and location	Source	P	D	M
68	Normalisasi Saluran Jalan akses tol baros (Depan PDIP) 180 m'	Denta		D	
69	Penataan U Turn Bawah Fly Over Cimindi				M
70	Perbaikan Jaling Sukamaju Nyontrol RT 01 RW 02 Cigugur Tengah		P		
71	Guna Keselamatan pejalan kaki di jalan Lurah (Blk SMPN 1), agar dibuatkan pembetonan bahu jalan (P= 48 m, L=1.80 – 3.20 m)	RW 03 Karang Mekar	P		
72	Perbaikan Jaling RT 02 RW 11 Cigugur Tengah (Blk Taman Mutiara)	Warga	P		
73	Perbaikan Jaling RT 02 RW 05 Kel Cibeber	Lurah Cibeber	P		
74	Perbaikan Jaling RT. 01, 02, 03 RW. 02 Kel. Citeureup	Ketua RW 02	P		
75	Perbaikan drainase jalan RT 06 RW 07 Leuwigajah (P=400 m, L=1 m dan kedalaman 2 m)	Ketua RW 07		D	
76	Perbaikan Jaling Lurah masuknya dari dari no. 65 Karang Mekar Regency	Cecep Dewan	P		
77	Perbaikan Jaling Belakang Pasar Rancabentang RW 23	H. Hidayat	P		
78	Perbaikan Jaling Sangkuriang Barat 1 RT 04 RW 20 Kel. Cipageuran	Rita Dewan	P		
79	Rabat Beton Jaling RT 04 RW 19 Cibogo Leuwigajah	Aspirasi Dewan '13	P		
80	Perbaikan Jaling RW 06 Cigugur Tengah	Aspirasi Dewan '13	P		
81	Perbaikan Jaling RT 02 RW 09 Kel. Melong	Aspirasi Dewan '13	P		
82	Perbaikan Jaling RW 17 Cimindi	Aspirasi Dewan '13	P		
83	Perbaikan Jaling RT 01 RW 09 Cibeber	Aspirasi Dewan '13	P		
84	Perbaikan Jalan dan Gorong2 RT 05 RW 05 Cibeureum	Aspirasi Dewan '13	P	D	
85	Pengaspalan Jalan Perumahan Pharmindo RT 03 RW 25 Melong	Aspirasi Dewan '13	P		

No	Description of works and location	Source	P	D	M
86	Perbaikan Jaling RW 17 Cibabat	Aspirasi Dewan '13	P		
87	Perbaikan Jaling RT 06 RW 08 Cipageran	Aspirasi Dewan '13	P		
88	Perbaikan Jaling RT 01 RW 19 Cigugur Tengah	Aspirasi Dewan '13	P		
89	Perbaikan Jaling RT 01 RW 09 Padasuka	Aspirasi Dewan '13	P		
90	Perbaikan Jaling RT 02, 04 RW 15 Padasuka	Aspirasi Dewan '13	P		
	Jaling 4 x 4 m dan kedalaman 1 m amblas di RT 04 RW 06 Cigugur Tengah	Laporan Bencana	P	D	
91	Perbaikan jaling RT 5, 6 RW 04 Kel Cibabat	Warga	P		
92	RW 21 Kel Cipageran (Masuknya dari Perumahan Cipageran Asri) Drainase jalan diusahakan minta lahan dari warga	Yohanes/Warga		D	
93	Perbaikan jalan dekat Jembatan Pemkot (Yohanes)	RUTIN saja	P		
94	Perbaikan Jalan Industri (Beton)	Rutin Saja	P		
95	Crosing di Pasir kaliki	Tugas Made		D	
96	Perb Jaling Mukodar III, Tengah, Raya	Warga	P		
97	Perbaikan Jembatan Cibodas (Sebelah PT. SAFTA JAYA) Masuk RW. 03 Melong	Forum Peduli/Hendra	P		
98	Pembuatan Crosing di Dekat Jembatan Blok Nyontrol (RW. 03 Kle. Melong)	Forum Peduli/Hendra		D	
99	Peninggian Jembatan Kecil di RT 02 RW 02 Melong	Forum Peduli/Hendra			M
100	Pembongkaran Kabel PLN di Jembatan Mancong RW.01 Melong	Forum Peduli			M
101	Perbaikan Jaling RT.3 RW.5 Kel. Karang Mekar (Masuk dari Bank NISP Gatot Subroto)	Aris Purnomo	P		
102	Perbaikan Jalan Terusan Jend. Sudirman yang menuju lokasi kompleks stkip siliwangi, stai siliwangi, unjani dan stikes ahmad yani	Ketua STKIP Siliwangi	P		
103	Perbaikan jalan di belakang Mako Satdik Susjur Ba/Ta Pusdikif Jln Gatot subroto	Dansatdik Susjur Ba/Ta	P		

No	Description of works and location	Source	P	D	M
104	Perbaikan Jaling Kompl. Pilar Mas RT.8 RW.3 Kel. Utam (500 m)	Lurah Utama	P		
105	Perb. Jaling RT. 1, 2 RW 4 Kel. Utama berbatasan dg RW. 10 Baros (700 m)	Lurah Utama	P		
106	Perbaikan jaling Trowulan V	Edi Kanedi Dewan	P		
107	Minta pembuatan/perbaikan saluran sebagai penggelontoran di sebelah kali cimahi (dekat Baso Curug) Cibodas RT 2 RW 11/ daerah H. Nafsun	Yaya Sunarya Dishub		D	
108	Perbaikan Jembatan di perbatasan RW 9 dan RW 14 Kel Setiamanah	Vera Kel Setiamanah			M
109	Di area pertigaan Tagog Amir machmud ada sumbatan air	Pesduk		D	
110	Mohon perbaikan gorong2 dan pembatas jalan di turunan belokan dari arah sangkuriang-veteran (sering kecelakaan)	Pesduk		D	M
111	Perbaikan jaling kompleks Padasuka RT 2, 3 RW 13	Lilis Dewan (diprioritaskan)	P		
112	Perbaikan jembatan RT 4 RW 20 Kel. Padasuka (bade Urug)	Lilis Dewan			M
113	Perbaikan gg di RT 7 RW 20 Kel Padasuka	Lilis Dewan	P		
114	Perbaikan jalan di dalam komplek Microwave RW 12 Kalidam Kel. Karang Mekar (1000 x 3 m)	Surat RW 12	P		
115	P2WKSS 2014 di RW 08 Kel. Cibeureum (Rancabentang)		P		
116	RT. 01 RW. 19 Babakan Cipageran (Sisa Tahun 2013 yg belum dikerjakan 2.5 x 300 m)	Achmad Gunawan	P		
117	Jaling RT. 3 RW 13 Abdul Halim Cigugur, merupakan sisa pekerjaan Hibah (di Keceng Bobi)		P		
118	Perbaikan jalan di Kompleks Batalyon Armed	Surat dari Danyon	P		

No	Description of works and location	Source	P	D	M
	IV jalan Gatot Subroto	Armed			
119	Penghubung jalan antara jalan gandaatmaja dengan Tut wuri	Pesduk	P		
120	Semula RT. 1, 2 RW 11 Melong menjadi RT. 2, 4 RW 11 Gg. Cempaka dan Gg. Turi Kel. Melong	H. Redi (Harus Dikerjakan)			M
121	Perbaikan jaling rt. 3, 4 rw. 4 dan rt. 2 rw 3 paskal	Warga/hilal	P		
122	Jangan lupa usulan dari hilal haraf di akomodir				M
123	Jangan Lupa Saluran drainase babakan loa/Rancabali	IWK		D	
124	Perbaikan Gorong2 jalan di Simpang Jati-Pemkot			D	
125	Pusdikhub	Komandan			M
126	Perbaikan jaling Baros Indah Rw. 3	IT	P		
127	Perbaikan jaling abdul sukur bawah di RT. 04 RW 07 Kel. Padasuka (Sekitar daerah Ranca belut)	Warga	P		
128	Perbaikan kompleks RT. 3, 4 RW. 4 Kel. Pasir Kaliki	Warga	P		
129	Perbaikan jaling Puri Cipageran Indah	Pesduk	P		
130	Rencana Perbaikan Terusan Sudirman, tambahkan dg Trotoar	Itoc	P		
131	Perbaikan Jalan di RW. 07 Paskal	Warga	P		
132	Perbaikan Gorong gorong di RW. 18 Kel Cipageran	Warga		D	
133	Perbaikan Gorong gorong di Jalan Kerkof No. 112 RT. 02 RW. 20 Kihapit, karena sering banjir	Pesduk		D	
134	Puri Cipageran I blok H 1 RT. 007 RW. O24 sering kebanjiran	Pesduk		D	
135	Babakan negla RT 06 RW 03 Kel Cimahi (154 x 4 m)	085795050620/Lilis Dewan	P		
136	Jalan Taman Lingkar RT.6 RW.26 Cipageran	Heri (Lurah Cigugur)	P		

No	Description of works and location	Source	P	D	M
137	Gg. H, Sujai Cihanjuang Minta di Hotmix, krn sdh rusak	Hendra Abi	P		
138	Perbaikan (Rabat Beton) Jl. Anggrek RT 1/14 Ke. Cibeber 3 x 125m, dan di RT 4/14 Kel. Cibeber 3 x 40 m	Rita Dewan, Di ABT di Kerjakan	P		
139	Komp Nata Endah Cihanjuang	Asep AP			M
140	Perbaikan Jalan Kearah Alm Bu Teti Kompleks PEMDA Padasuka	Karwa	P		
141	Jalan menuju SMA Pasundan di jln Terusan (Depan Kec. Cimahi Tengah) 4 x 160 m	Abah Utay	P		
142	Minta diperbaiki depan/sebelah rumah Pa dudu (Kompleks Cimindi Raya Blok V No. 5 RT.001 RW 04 Pasir Kaliki)	IT	P		
143	Perbaikan Jaling di RT 1 RW 3 Kel. Utama (dekat The Edge) ± 120 m		P		
144	Jalan ke unjani Cibeber minta diperbaiki untuk Sholat Ied	RW	P		
145	Perbaikan jalan kearah rusun Cigugur	Ison	P		
146	Perbaikan Jaling di RW. 12 Kelurahan Leuwigajah	Aida	P		
147	Perbaikan Jaling di Blok C (RT. 03,04,05 RW. 17)	Anto Dewan	P		
148	Perbaikan Jaling di Gg. Cemara Kel. Melong	H. Redi	P		
149	Drainase Jalan RW. 10 Cibaligo / Martasik Cipageran	Agun		D	
150	Perbaikan Jaling di RW. 19 Cileuweung Cipageran, kearah babakan	Agun	P		
151	Perbaikan jaling Foker Tengah IV. Foker IV jalan utama perbatasan dg RW. 06 dan RW. 23	Ketua RW. 23 Melong	P		
	Foker Tengah perbatasan RT 03 dan RT 04				
	Jalan Dakota Selatan perbatasan RT. 01, 04, 05 dan 06				

No	Description of works and location	Source	P	D	M
152	Pengaspalan Jaling di RT. 08 RW. 09 Leuwigajah (200 m')	Lurah dan Warga	P		
153	Perbaikan jalan di RW. 17 Setiamanah/depan M. Al Kautsar (100 m')	Ekbang Setiamanah	P		
154	Perbaikan Jalan di RW. 11 Setiamanah (daerah Pasopati) 100 m'	Ekbang Setiamanah	P		
155	Perbaikan jalan di RW 6,7, 12 Pojok Selatan dg Beton	Ekbang Setiamanah	P		
156	Trotoar jalan Pojok Utara - Selatan	Ekbang Setiamanah			M
157	Perbaikan Jaling (RW01, RT/RW01/02, RW02, 03, 04, 05, 12, 13, 16)	Lurah Utama	P		
158	Perbaikan drainase jalan Ibu Ganirah dan jalan Unjani RW. 02 Kel Cibeber (250 m')	Lurah Cibeber		D	
159	Perbaikan drainase jalan Kerkoff di RW. 08 Kramat Jati			D	
160	Perbaikan jaling RT 3 dan 5 RW. 04 Cibabat	Dedi K	P		
161	Perbaikan Jaling di Jalan Lestari RW. 19 Perumahan Pemda Kel. Padasuka	Ace Hernawan	P		
162	Perbaikan Jaling di RW. 20 (antara RT.06 dan 07) Kel. Padasuka	Ketua RW.20	P		
163	Mohon perbaikan/ membesaran buis beton di jalan Nasional sebrang BCA			D	

APPENDIX 2

Road Condition Survey

1. Data collection

Road condition survey was conducted using windshield survey or visual inspection rating (VSR) method. Low costs, speed of delivery of data, and avoidance of expensive measuring devices are significant advantages of this method (Hartgen and Shufon 1983).The windshield survey or visual inspection rating (VSR) method was performed by the researchers using a car, driving at the speed limit, but frequently driving at a slower speed on the shoulders along the distressed locations. Frequent stops were made near locations where severe distresses were witnessed. Drainage features at and/or near these locations were inspected to determine of improper drainage was a contributing factor to the distress. In addition, several photographs of the distresses pavements were taken at these locations.Some of the information collected during the conditions survey included:

- Visual evaluation of the pavement surface by windshield survey.
- Photographs of existing pavement conditions,
- Visual assessment and photographs of the drainage conditions, vertical alignment and soil conditions.

2. Result

Video and excel documents.

ROAD CONDITION SURVEY

Date : November 2014

Street : Mahar Martanegara street

TIME	KM	ROAD SURFACE			VIDEO MIN	ROAD CONDITION SUMMARY	Drainage	Pothole	Uneven	Crack	Rutting	Shoulder	Slope	SCORE		
							5	4	4	4	4	4	4			
								B	C	D	E	L	K			
		Type	Condt.	Width (m)		Odometer	M	Pothole F	Soft G	Erosion H	Rutting I	Uneven J	Slope K	(max 29)		
9:27		A	G	8	9:14	2+800	1	1	1	1	1	1	2	8		
		A	G	8	8:55	2+700	1	1	1	1	1	1	2	8		
		A	G	8	8:35	2+600	1	1	1	1	1	1	2	8		
		A	G	5	8:13	2+500	4	1	1	1	1	3	2	13	Drainage	
		A	G	5	7:50	2+400	5	1	1	1	1	3	2	14	Drainage	
		A	G	5	7:32	2+300	5	1	1	1	1	3	2	14	Drainage	
		A	G	5	7:19	2+200	3	1	1	1	1	3	2	12		
		A	G	5	7:01	2+100	3	1	1	1	1	2	2	11		
		A	F	6	6:50	2+000	4	1	1	2	1	2	2	13	Drainage	Repair
		A	F	6	6:30	1+900	2	2	2	3	1	2	2	14	Drainage	Rehab
		A	F	6	6:13	1+800	3	2	2	3	1	1	2	14	Drainage	Rehab
		C	G	6	5:30	1+700	3	1	2	1	1	2	2	12		
		A	P	6	5:06	1+600	3	1	2	2	1	2	2	13	Drainage	Rehab
		A	P	6	4:51	1+500	5	4	2	2	1	4	2	20	Drainage	Rehab
		A	P	6	4:30	1+400	5	2	2	2	1	4	2	18	Drainage	Rehab
		C	G	6	4:08	1+300	4	1	2	2	1	3	2	15	Drainage	Repair
		C	G	6	3:52	1+200	3	1	2	2	1	2	2	13	Drainage	Repair
		C	G	6	3:45	1+100	2	1	1	1	1	3	2	11		
		C	G	6	3:32	1+000	2	1	1	2	1	2	2	11		
		A	G	5	3:14	0+900	2	1	1	1	1	2	2	10		
		A	G	5	3:08	0+800	2	1	1	1	1	2	2	10		
		A	G	5	2:58	0+700	2	1	2	1	1	3	2	12		Repair
		A	G	6	2:48	0+600	3	1	2	1	1	3	2	13	Drainage	Repair
		A	G	6	2:36	0+500	4	1	1	1	1	3	2	13	Drainage	
		A	G	6	2:10	0+400	3	1	2	1	1	2	2	12		
		A	G	6	1:54	0+300	2	1	2	1	1	2	2	11		
		A	G	6	1:25	0+200	2	2	1	1	1	2	2	11		
		A	G	6	1:07	0+100	3	1	1	1	1	2	2	11		
9:17		A	F	6	0:26	0+000	2	2	3	1	1	2	2	13	Drainage	Repair

TYPE OF SURFACE : A: Asphalt, C: Concrete, R:Rocks, G: Gravel, S:Soil

PAVEMENT CONDITION : G: Good, F:Fair, P: Poor, VP:Very Poor

SURFACE CONDITION OF PAVED Rd : G: dense texture, F: open texture, P: rough and exfoliate, VP: crack and exfoliate

SHOULDER FOR PAVED ROAD : 1. good shape and slope, 2. poor super-elevation, 3. high/low <10 cm, debris/garbage, 4. >10 cm or no road shoulder

SUPERELEVATION/CS-SLOPE : 1. 4%-2%, 2. 2%-flat, 3. flat but uneven, 4. no shape

DRAINAGE : 0: none, unrequired, 1: good, 2: fair (cleaning is required), 3: poor (small repair is required), 4: heavy damage, 5: none, but required

LEVEL OF PAVEMENT DISTRESS (% OF AREA)

TYPE OF DISTRESS	PAVED ROAD			
	1	2	3	4
	GOOD	FAIR	POOR	VERY POOR
B. Pothole	0-1	1-5	5-15	>15
C. Uneven surface	0-5	5-10	10-50	>50
D. Crack	0-3	3-12	12-25	>25
E. Rutting	0-3	3-5	5-25	>25

TYPE OF DISTRESS	UNPAVED ROAD			
	1	2	3	4
	GOOD	FAIR	POOR	VERY POOR
F. Potholes	0-3	3-10	10-25	>25
G. Soft spot	0-3	3-10	10-25	>25
H. Surface erosion	0-3	3-10	10-25	>25
I. Rutting	0-5	5-15	15-50	>50
J. Uneven surface	0-3	3-10	10-50	>50

ROAD CONDITION SURVEY

Date : November 2014
Street : Kerkof street

TIME	KM	ROAD SURFACE			VIDEO MIN	ROAD CONDITION SUMMARY Odometer	Drainage M	Pothole B	Uneven C	Crack D	Rutting E	Shoulder L	Slope K	SCORE (max 29)		
		Type	Condt.	Width (m)			5	Pothole F (4)	Soft G (4)	Erosion H (4)	Rutting I (4)	Uneven J (4)	Slope K (4)			
		A	VP	5	10:29	3+500	5	4	4	4	1	4	2	24	Drainage	Reconst
		A	VP	5	9:50	3+400	5	4	4	4	1	4	2	24	Drainage	Reconst
		A	VP	5	9:35	3+300	5	4	4	4	1	4	2	24	Drainage	Reconst
		A	VP	5	9:22	3+200	5	4	4	4	1	4	2	24	Drainage	Reconst
		A	VP	5	9:02	3+100	5	4	4	4	1	4	2	24	Drainage	Reconst
		C	G	5	8:54	3+000	2	1	3	2	1	3	2	14		Reconst
		C	G	5	8:35	2+900	2	1	1	2	1	3	2	12		
		C	G	5	8:22	2+800	2	1	1	2	1	3	2	12		
		C	F	5	7:58	2+700	2	1	2	3	1	3	2	14		Repair
		C	G	5	7:30	2+600	2	1	1	2	1	2	3	12		
		C	G	5	7:18	2+500	2	1	2	2	1	2	2	12		
		C	G	5	7:00	2+400	2	1	2	2	1	2	2	12		
		C	G	5	6:47	2+300	2	1	2	2	1	2	2	12		
		C	G	5	6:30	2+200	3	1	2	2	1	2	2	13	Drainage	Repair
		C	G	5	6:09	2+100	3	1	2	2	1	2	2	13	Drainage	Repair
		C	VP	5	5:40	2+000	4	4	4	4	1	4	2	23	Drainage	Reconst
		C	VP	5	5:23	1+900	4	4	4	4	1	4	2	23	Drainage	Reconst
		C	P	5	4:55	1+800	3	2	3	3	1	3	2	17	Drainage	Reconst
		C	P	5	4:40	1+700	3	2	3	2	1	3	2	16	Drainage	Reconst
		C	F	5	4:20	1+600	4	2	2	2	1	2	2	15	Drainage	Reconst
		C	P	5	4:03	1+500	4	3	3	2	1	2	2	17	Drainage	Reconst
		C	P	5	3:51	1+400	4	2	4	4	1	3	2	20	Drainage	Reconst
		C	P	5	3:31	1+300	4	2	3	3	1	3	2	18	Drainage	Reconst
		C	F	5	3:23	1+200	2	1	3	2	1	2	2	13		Repair
		C	F	5	3:10	1+100	2	1	3	2	1	2	2	13		Repair
		C	F	5	2:50	1+000	2	1	2	2	1	2	2	12		
		C	F	5	2:39	0+900	2	1	2	2	1	2	2	12		
		C	F	5	2:20	0+800	2	2	2	2	1	2	2	13		Rehab
		C	F	5	2:08	0+700	2	1	2	2	1	2	2	12		
		C	F	5	1:55	0+600	2	3	2	2	1	2	2	14		Rehab
		C	G	5	1:39	0+500	3	1	1	2	1	2	2	12		
		C	G	5	1:22	0+400	3	1	1	2	1	0	2	10		
		C	F	5	0:56	0+300	3	1	1	2	1	0	2	10		
		C	F	5	0:46	0+200	3	1	1	2	1	0	2	10		
		A	F	5	0:20	0+100	4	2	2	2	1	4	2	17	Drainage	Repair
9:40		A	G	5	0:05	0+000	4	1	1	1	1	4	2	14	Drainage	Repair

TYPE OF SURFACE : A: Asphalt, C: Concrete, R:Rocks, G: Gravel, S:Soil
PAVEMENT CONDITION : G: Good, F:Fair, P: Poor, VP:Very Poor
SURFACE CONDITION OF PAVED Rd : G: dense texture, F: open texture, P: rough and exfoliate, VP: crack and exfoliate
SHOULDER FOR PAVED ROAD : 1. good shape and slope, 2. poor super-elevation, 3. high/low <10 cm, debris/garbage, 4. >10 cm or no road shoulder
SUPERELEVATION/CS-SLOPE : 1. 4%-2%, 2. 2%-flat, 3. flat but uneven, 4. no shape
DRAINAGE : 0: none, unrequired, 1: good, 2: fair (cleaning is required), 3: poor (small repair is required), 4: heavy damage, 5: none, but required

LEVEL OF PAVEMENT DISTRESS (% OF AREA)

TYPE OF DISTRESS	PAVED ROAD 1	2	3	4
	GOOD	FAIR	POOR	VERY POOR
B. Pothole	0-1	1-5	5-15	>15
C. Uneven surface	0-5	5-10	10-50	>50
D. Crack	0-3	3-12	12-25	>25
E. Rutting	0-3	3-5	5-25	>25

TYPE OF DISTRESS	UNPAVED ROAD 1	2	3	4
	GOOD	FAIR	POOR	VERY POOR
F. Potholes	0-3	3-10	10-25	>25
G. Soft spot	0-3	3-10	10-25	>25
H. Surface erosion	0-3	3-10	10-25	>25
I. Rutting	0-5	5-15	15-50	>50
J. Uneven surface	0-3	3-10	10-50	>50

APPENDIX 3

Rebound Hammer Test

Data collection

The tests were performed in one day, 12 December 2014. The procedure for this testing is based on ASTM C805, “Standard Test Method for Rebound Number of Hardened Concrete”.

1) The instrument was calibrated.
2) All members and points of a concrete structure selected for testing were prepared in smooth and dry condition.
3) The instrument was hold firmly so that the plunger is perpendicular to the test surface.
4) The instrument was gradually pushed toward the test surface until the hammer impacts.
5) After impact, pressure on the instrument was maintained and, if necessary, thebutton on the side of the instrument was depressed to lock the plunger in its retracted position.
6) The rebound number on the scale to the nearest whole number the rebound number was read and recorded.
7) Six to ten readings from each test area were taken. No two impact tests were closer together than 25 mm (1 in).
8) The impression made on the surface after impact was examined, and if the impact were crushes or breaks through a near-surface air void, the reading was disregarded and another reading was taken.
9) Readings differing from the average of ten readings by more than six units was discarded and the average of the remaining readings was determined. If more than two readings differ from the average by six units, the entire set of readings was discarded and rebound numbers at ten new locations within the test area was determined.
10) Rebound number were converted to cube compression strength based on the conversion table or graphic.

Result

Report No : 1
Location : Mahar Martanegara street (direction to Cimindi Market)
Testing Date : 12 December 2014

	Angle position								
	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°
Location / Test No.	0	1	2	3	4	5	6	7	8
1	30	34	32	30	31	31	28	32	26
2	35	36	34	31	34	33	30	30	28
3	33	35	33	33	30	30	31	30	28
4	33	35	33	33	30	30	32	31	29
5	34	34	33	32	32	30	33	31	30
6	32	33	34	33	32	30	30	30	27
7	34	34	32	30	33	32	30	28	30
8	34	34	32	32	30	32	28	30	27
9	33	33	33	31	32	30	30	28	27
10	33	34	32	30	32	31	30	28	26
Minimum value	30	33	32	30	30	30	28	28	26
Maximum value	35	36	34	33	34	33	33	32	30
Average value	33.1	34.2	32.8	31.5	31.6	30.9	30.2	29.8	27.8

Report No : 2
Location : Mahar Martanegara street (direction to Baros Toll Gate)
Testing Date : 12 December 2014

	Angle position								
	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°
Location / Test No.	0	1	2	3	4	5	6	7	8
1	28	32	33	32	33	32	29	28	31
2	31	30	34	33	30	34	28	28	29
3	30	30	32	30	30	30	30	30	29
4	30	28	30	29	30	30	33	30	31
5	32	32	31	29	29	33	31	32	32
6	31	30	30	30	32	32	28	32	30
7	29	32	29	30	32	31	31	30	29
8	31	30	30	35	30	31	30	31	30
9	30	30	29	33	32	33	30	29	28
10	31	31	30	34	29	32	31	30	30
Minimum value	28	28	29	29	29	30	28	28	28
Maximum value	32	32	34	35	33	34	33	32	32
Average value	30.3	30.5	30.8	31.5	30.7	31.8	30.1	30	29.9

Report No : 3
Location : Mahar Martanegara street (direction to Baros Toll Gate)
Testing Date : 12 December 2014

	Angle position								
	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°
Location / Test No.	0	1	2	3	4	5	6	7	8
1	41	38	42	43	40	38	41	41	39
2	38	36	39	43	37	37	38	39	40
3	40	40	43	38	39	37	39	39	42
4	37	39	37	41	42	40	42	43	40
5	39	37	41	43	40	39	40	40	39
6	42	40	41	40	37	40	40	39	40
7	38	40	37	39	38	39	39	41	40
8	37	42	39	39	40	41	40	41	40
9	39	37	37	40	39	40	38	43	42
10	42	38	41	40	37	40	39	42	41
Minimum value	37	36	37	38	37	37	38	39	39
Maximum value	42	42	43	43	42	41	42	43	42
Average value	39.3	38.7	39.7	40.6	38.9	39.1	39.6	40.8	40.3

Report No : 4
Location : Mahar Martanegara street (direction to Leuwigajah Roundabout)
Testing Date : 12 December 2014

	Angle position								
	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°
Location / Test No.	0	1	2	3	4	5	6	7	8
1	41	36	36	43	36	36	42	38	40
2	39	40	37	43	36	37	40	39	41
3	41	38	40	39	37	38	40	37	39
4	38	38	41	42	38	40	39	39	38
5	42	38	41	42	40	38	38	39	42
6	42	41	40	40	40	38	39	40	40
7	42	39	44	44	36	40	39	40	40
8	40	41	36	44	36	38	38	39	41
9	38	38	39	39	39	40	40	40	43
10	39	37	38	43	43	39	40	37	40
Minimum value	38	36	36	39	36	36	38	37	38
Maximum value	42	41	44	44	43	40	42	40	43
Average value	40.2	38.6	39.2	41.9	38.1	38.4	39.5	38.8	40.4

Report No : 5
Location : Kerkof street (direction to Leuwigajah Roundabout)
Testing Date : 12 December 2014

	Angle position								
	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°
Location / Test No.	0	1	2	3	4	5	6	7	8
1	42	36	38	36	38	36	35	35	40
2	42	38	38	37	42	36	36	35	40
3	40	36	36	37	39	37	36	35	40
4	43	36	36	37	39	38	40	36	39
5	38	40	36	36	40	38	40	37	39
6	43	37	34	36	39	38	41	35	38
7	38	37	38	39	41	37	38	36	37
8	38	36	34	39	40	37	38	38	38
9	38	39	36	37	37	36	39	38	39
10	43	38	37	39	37	37	40	37	38
Minimum value	38	36	34	36	37	36	35	35	37
Maximum value	43	40	38	39	42	38	41	38	40
Average value	40.5	37.3	36.3	37.3	39.2	37	38.3	36.2	38.8

Report No : 6
Location : Kerkof street (direction to Batujajar)
Testing Date : 12 December 2014

	Angle position								
	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°
Location / Test No.	0	1	2	3	4	5	6	7	8
1	37	37	39	41	36	42	36	35	36
2	37	37	43	38	37	40	37	37	37
3	40	40	40	39	35	38	37	38	38
4	36	43	41	40	36	38	36	39	39
5	41	39	41	37	38	38	40	40	38
6	41	39	42	38	40	37	37	40	38
7	37	39	43	40	37	40	38	42	40
8	40	40	40	37	41	42	37	39	39
9	41	36	41	37	38	38	37	38	38
10	41	36	42	42	37	38	37	39	37
Minimum value	36	36	39	37	35	37	36	35	36
Maximum value	41	43	43	42	41	42	40	42	40
Average value	39.1	38.6	41.2	38.9	37.5	39.1	37.2	38.7	38

Summary

Name of street	No.	Rebound number			Cube Compressive Strength (kg/cm2)	
		Min	Max	Average	Range	Min
Mahar Martanegara st.	1	26	36	31	297 ± 62.85	234.15
	2	28	35	31	297 ± 62.85	234.15
	3	36	43	40	453 ± 70.65	382.35
	4	36	44	39	435 ± 69.75	365.25
Kerkof st.	5	34	43	38	417 ± 68.85	348.15
	6	35	43	39	435 ± 69.75	365.25

APPENDIX 4

Traffic Counting Survey

Data collection

Traffic Data survey and projections thereof of traffic volumes arebasic requirements for planning of road development and managementschemes.Data used in this calculation were collected through manual traffic counting at three observed streets. Manual traffic counting was used because no device had been installed in those three observed street.

Four days sixteen hours counts were conducted on the street. Specific location in each street was determined on site. For each direction, 1-2 persons were set up for classifying and counting the vehicles as they pass. Based on the pre-observation on site, manual traffic flow count was categorized by a visual assessment of the vehicle size, as follows:

- Passenger cars
- Motor cycle
- Heavy vehicle single axle
- Heavy vehicle double axles or more

Annual Average Daily Traffic (ADT) calculation methods

Example:

4-days 16 hours traffic flow =Σ (m * E)

=Σ(passenger cars*1)+Σ(motorcycle*0.4)+Σ(Heavy vehicle*1.3)

=3140*1 + 6000*0.5 + 2000*1.3 + 200*1.3

=9000 vehicles

Note. E (passenger cars equivalent) is a conversion factor for non-passenger cars based on Indonesia Highway Capacity Manual 1997 for 4 lanes and 2 ways undivided, traffic flow less than 3700 vehicle/hour.

Using a 95% confidence limit for the 24-hour traffic flow with 5% tolerance, then16 hours traffic flow is 95% of 24-hour traffic flow, therefore:

4-days 24 hour traffic flow = 9000/0.95 = 9474 vehicles

Average Daily Traffic (ADT) = 9474/4 = 2369 vehicles/day.

As for the Annual Average Daily Traffic (AADT), the derived Day Traffic is converted as follows:

AADT = 2369 x conversion factor

= 2369 x 1.115 (considering medium scenario)

= 2641 vehicles.

Result

Mahar Martanegara street (in front of Bulog office)

Name of street			Mahar martanegara street			
Day		Time	Number of vehicles			
			Motor - cycle	Passenger cars	Heavy vehicles	
					Single axle	Double axle or more
Monday	18-May-15	07:00 - 23:00 (16 hours)	38764	7634	1732	6593
Tuesday	19-May-15		38400	7520	1662	6880
Wednesda	20-May-15		39523	8653	1643	7120
Thursday	21-May-15		36876	7456	1701	6903
Total (vehicle)			153563	31263	6738	27496
Total (pcu)			**76782**	31263	8759	35745
Percentage			**50%**	20%	6%	23%
Total (pcu)			152549			
ADT			40144			
AADT			**44761**			

Kerkof street (in front of Pertamina)

Name of street			Kerkof street			
Day		Time	Number of vehicles			
			Motor - cycle	Passenger cars	Heavy vehicles	
					Single axle	**Double axle or more**
Monday	18-May-15	07:00 - 23:00 (16 hours)	18765	6543	1567	13541
Tuesday	19-May-15		19200	7250	1600	13760
Wednesda	20-May-15		20174	6745	1564	13245
Thursday	21-May-15		18432	8732	1763	14129
Total (vehicle)			76571	29270	6494	54675
Total (pcu)			38286	29270	8442	**71078**
Percentage			26%	20%	6%	**48%**
Total (pcu)			147075			
ADT			38704			
AADT			**43155**			

Summary

Name of street	AADT (vehicles)	% truck	
		Single axle	Double axle or more
Mahar martanegara street	44761	6%	23%
Kerkof street	43155	6%	48%

APPENDIX 5

Rainfall data

		Date of measurement																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Rainfall (mm/month)	Days of rain in a month	Max	Min	Average
2012	June																						25										25	1	25	25	25
	July												35							95	55												185	3	95	35	62
	August							Tool is under repairment																													
	September						30				40							70		50	55												245	5	70	30	49
	October		5		190	115	30	160		5						20		40	5	15	15	15		20						60	125	5	825	16	190	5	52
	November	5	40	180	80				80				65	115	40	60	5	60	195	140	100	140	175	40	15	65	35	65	60	80	40		1880	24	195	5	78
	December	10	10	20	110	85	50	35	10		5	35	5	7.5	40	25	35	80	65	20	120	45	75	25	10	15	35	20	35	15	85	65	1192.5	30	120	5	40
2013	January	75		40	30	35	15	135	110	10		20	25	15	40	35	10	55		50	50		90	10		65		30	60	70	35	25	1135	25	135	10	45
	February			20	100	90	130	20	70	25	95		30	95	160	20			55	65			62	8			30						1075	17	160	8	63
	March	12	18	50	160			20	30			23	22						10	39	35					50	35	5	40				549	15	160	5	37
	April	185	100	9	86	175	175	220	62	38		50	58		8	115	2			44	120		75	7	82	24	3			4			1642	22	220	2	75
	May	8	83		17	15		100	29	65	87	180			4		15	51	8	104	5	32	39	100		15	5		10		105		1077	22	180	4	49
	June	5							80		10	165	95	45	70											3							473	8	165	3	59
	July			77	170				9	15	73		10			30					53		55						10				502	10	170	9	50
	August							Tool is under repairment																													
	September							Tool is under repairment																													
	October							Tool is under repairment																													
	November							Tool is under repairment																													
	December																		145	120	10	120	70							10	155	25	655	8	155	10	82
2014	January	20			10			100	195	185	165	115	45	10			10	145	80	55		20	95	60		5		5	55	45		25	1445	21	195	5	69
	February		70																														70	2			35
	March																																72	2			36
	April																																33	1			33
	May																																29	1			29
	June							Tool is under repairment																													
	July							Tool is under repairment																													
	August																																70	2			35
	September																																150	2			75
	October																																345	8			43
	November											50	84	53								18	29	85	55		9		85	93	7	90	658	12			55
	December																																575	10			58