Functional and Contextual Classification Concept for Road Network in Thailand: Preliminary Study

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***Abstract*— Roadway classification is a fundamental step in planning and design of road network for the movement of people and goods. It helps classify the roads according to the road hierarchy and determine the proper design (physical characteristics and environmental context) of the roads, as well as the responsibilities of the relevant agencies. However, each country has different road classification systems. Most of traditional systems mainly focus on the road functions, while disregarding environmental and neighboring circumstances. In Thailand, such system results in the overdesign or underdesign of a facility and inappropriate use of roads by all road users. This study presents the concept of road classification system based on both road functions and context setting, and adopt it to the road network in Thailand. The preliminary result showed the disparity of road classes among road function and context settings.**

Index Terms*— *Road classification, Functional classification, Contextual classification, Road network, Road planning

I. INTRODUCTION

THE road is the main and worldwide transportation network that can link the settlements together. Each road has its own characteristics. Specifically, it is designed for certain purposes, provides its own function and service, and is managed by certain authority. Road classification plays a significant role at the early stage of road development process.

Road classification is an approach that systematizes the roads according to the road hierarchy [1]. It helps develop sustainable transportation by determining the proper design including physical characteristics and road environment, and also deciding the relevant authorities for responsibilities.

In Thailand, roads are divided into five categories according to the 2006 Highway Act including motorways (special highways with full control of access), national highways, rural roads, local roads, and concession roads. Furthermore, roads in Thailand are approximately 701,847 kilometers, which are equivalent to the road density of 1.37 km per m^2. They are associated with many authorities including Department of Highways, Department of Rural Roads, Expressway Authority of Thailand, Department of Local Administration, and Bangkok Metropolitan Administrations. The majority of roads are local and municipal roads under Department of Local Administration as shown in Fig. 1. [2]

Under this administrative classification, road networks in Thailand are presented by their functionality similar to other developed countries. The roads are assessed by their mobility and accessibility. However, they are sometimes not fitting with surrounding environment and roadside activities. This can be seen by different conditions; for example, when the high-speed major roads passing through towns or small cities, or when the roads being restricted by neighboring residence.

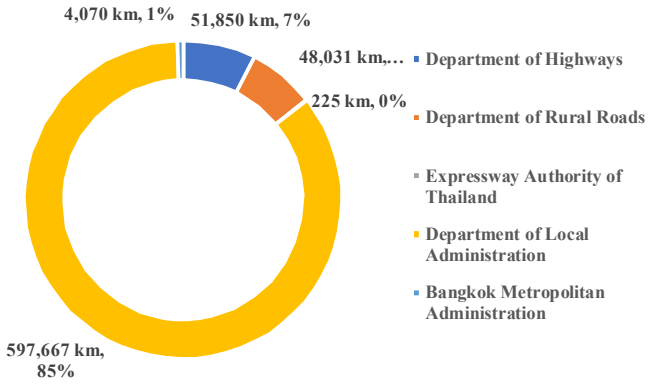

Fig. 1. Percent of road length for Thailand road network by road authorities.

This paper aims to present the concept of functional and contextual road classification system, and to apply it to categorize the segments of road network in Thailand under this classification system.

II. PREVIOUS RESEACHES

The purpose of road transportation system has been changed into a working context that can be more accessible. For instance, local roads that directly connect to arterial roads, result in many alleyways, which cause traffic safety problems and negative impacts to transportation systems. To enhance safety and accountability of the long-term road transportation system, a road classification should be clearly defined and implemented for all road network at an early stage.

The functional classification of the road is to define the role and function of the roads in a road network in order to appropriately serve travel demand. If the functional

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classification is properly done in a planning stage, then the road design will be in a hierarchical manner in many circumstances including its speed, capacity, and relationship to existing and future land use development [3].

The functional classification has been paid more attention in many countries to enable the roads to be effective and safe [4]. For instance, European countries have developed the concept of sustainable road safety systems through the Decade of Action for Road Safety. To implement this concept, each country in Europe takes the functional classification into account in road design and road safety improvement. [5, 6] A number of parameters are used in the road functional classification in Europe [7].

- Traffic speed—design speed or speed limit
- Trip length—long-distance traffic or local traffic
- Designation status—linking neighborhoods or cities
- Strategic role—connecting different network levels with different urban scales
- Accessibility—primarily for circulation or access
- Administration—by national or local authority
- Network role—forming strategic or local network
- Access control—access controlled or uncontrolled
- Traffic volume—vehicle flows
- Transport mode—presence of vehicles, public transit, pedestrians
- Other urban users—provision for frontage users
- Environment—sensitivity of environment
- Built frontage—presence of frontage
- Road width—width of road

Each country has a classification set sometimes referred to as a road hierarchy, which organizes a set of road type. Understanding the road classification system around the world helps gain an insight into the differences in the road classification, compare the advantages and disadvantages of each system, create better road standards, proper designs, and sustainable road development. Furthermore, the collection of road classification systems around the world presents the similarities of road systems in the neighborhood countries, which may lead to the development of link road networks, business relations, and international communication.

Table I indicates the road classification systems being defined in various countries in Asia, Africa, Australia, Europe, and North America.

Based on the review, it shows that most countries focus on classifying the roads based on their functionalities. A few classification systems consider urban and rural settings, such as UK, Canada, Australia (some states), and South Africa. Moreover, the context settings are roughly classified into urban and rural environments.

III. PROPOSED FUNCTIONAL AND CONTEXTUAL CLASSIFICATION CONCEPT

The concept of road classification since 1984, AASHTO "Green Book" (A Policy on the Geometric Design of Highways and Streets) has considered the functionality of roads with two criteria: accessibility and mobility. Roads are then divided into 4 categories: freeways, arterials, collectors and local roads.

Later, road classification has taken into consideration the development of urban and rural, and the roads are sub-divided into "major" and "minor" roads. However, this road classification system is still inconsistent and not appropriate with road design on the context setting, so the urban and rural areas may not be sufficient for the functional classification of roads in each road type.

TABLE I
ROAD CLASSIFICATION TYPES BY COUNTRY

Country	Functional Classification	Contextual Classification
Asia		
Cambodia [10]	✓	
Indonesia [11]	✓	
Japan [12]	✓	
Malaysia (Federal) [13]	✓	
Malaysia (Other states) [13]	✓	
Myanmar [14]	✓	
Thailand [15]	✓	
Africa		
Kenya [16]	✓	
Nigeria [17]	✓	
South Africa [9]	✓	✓
Australia		
Australia (Western Australia) [18]	✓	
Australia (Victoria) [18]	✓	
Australia (New South Wales) [8]	✓	
Australia (Queensland) [8]	✓	
Australia (Other states) [8]	✓	✓
New Zealand [8]	✓	
Europe		
Belgium (Brussels) [7]	✓	
Belgium (Other Cities) [7]	✓	
Denmark (Copenhagen) [7]	✓	
Denmark (Other Cities) [7]	✓	
Germany [7]	✓	
Greece [7]	✓	
Hungary [7]	✓	
Portugal [7]	✓	

A. Functional Classification

Functional classification is a classification of roads by considering the function of the roadway within its network and the connectivity that the roadway provides among various centers of activity. Network function is defined based on the regional and local importance of the roadway to vehicle movement. Connectivity identifies the types of activity centers and locales that are connected with the particular roadway. The four components of most functionally classified systems are principal arterials, minor arterials, collectors, and local roads.

1) Arterials: Arterials are roads that focuses to travel long distances at high speed without interruption and safety. The road needs to control the traffic flow area

a) Principal Arterials: Principal arterials serve a large percentage of travel between cities and activity centers, which are typically roadways with high traffic volumes and are the frequent route for intercity buses and trucks. Principal Arterials can provide a high degree of mobility and carry a high percentage of travel for long-distance trips including those that go directly through or bypass activity centers.

b) Minor Arterials: Minor arterials provide service for moderate length trips, serve geographic areas that are smaller than the principal arterial roadways, and have higher connectivity to the Principal Arterials. In urban

settings, they interconnect and supplement the Principal Arterial system, connect communities, and may carry many bus routes. In rural settings, they are typically designed to provide higher travel speeds with minimum interference to the trough movement.

2) Collector Roads: Collector roads provide the connection from local roads to the arterial systems. Collectors may be subdivided into major and minor collectors in both the urban and rural areas. A major part of the rural highway system consists of two-lane collector highways. The rural collector routes generally serve travel of primarily intra-county rather than statewide importance and constitute those routes on which predominant travel distances are shorter than on arterial routes. An urban collector is a public facility that includes the entire area within the right of way. The urban collector also serves pedestrian and bicycle traffic and often accommodates public utility facilities within the right of way.

3) Local Roads: Local roads account for the largest percentage of roadways in terms of mileage and are typically designed to discourage through traffic. A local road primarily serves as access to a farm, residence, business, or other abutting property. Local roads are typically classified by default; once all other roads have been classified as arterials or collectors, the remainder are local roads.

B. Contextual Classification

Contextual classification is a classification of roads by considering various contexts, including density, land use, and building setback in designing or specifying road types.

Five distinct contexts have been determined to not only represent unique land-use environments, but also identify distinctions that require wholly different geometric design practices in terms of desired operating speeds, mobility/accessibility, demands, and user groups. AASHTO Green Book (2018) presented 5 context categories: rural, rural town, suburban, urban and urban core [1, 21] The context categories are in Table II.

The functional classification and contextual classification system of roadways can be presented in a matrix form for designing roads that depend on speed, mobility, access, and user safety/needs as shown in Fig 2.

Context Setting / Roadway Type	Rural	Rural Town	Suburban	Urban	Urban Core
Principal Arterials					
Minor Arterials					
Collectors					
Local Roads					

Fig. 2. Functional and contextual classification matrix

IV. EXAMPLES OF ROADWAY FUNCTIONAL AND CONTEXTUAL CLASSIFICATIONS

Using the concept of functional and contextual classifications based on their definitions in Section III, the schematic framework of this study is proposed in Fig. 3. The steps of analysis include reviewing the roadway classification systems, defining the measures used to classify roadway types and context settings, developing a classification matrix, collecting relevant data, and performing the classification of segments of road network in Thailand.

In the study, a number of road classification system implemented in both developed and developing countries will be comprehensively reviewed to distinguish the advantages and disadvantages of each classification system. Then, the lists of criteria for roadway functional and contextual classification that properly applied for a road network in Thailand will be determined. The potential criteria used for roadway functional classification are:

- Access control: Access control is the type of control of access and the number of access points along the roadway. Arterials should have limited access points (or full control of access), while local roads should have a number of access points along the road.
- Level of Service: The levels of service are assessed by the efficiency of the road. Roads with high mobility generally have less delay throughout the travel.
- Speed Limit: Speed limits are posted on roads, that relate to the classifications of road. For example, arterial roads have a higher posted speed limit, while local roads have low speed limit.
- Annual Average Daily Traffic (AADT) and Vehicle-Kilometer of Travels (VKT): Each type of road serves different trip characteristics and has different traffic volumes. Arterials serve long-distance trips, and account for greater than half of the daily vehicle kilometers of travel. Collectors account for the next largest percentage of travel. Local roads typically serve low density, dispersed developments with relatively low traffic volume.

TABLE II
CONTEXT CATEGORIES AND PRIMARY FACTORS.

Category	DENSITY	Land Use	Setback
Rural	Lowest (few houses or other structures)	Agricultural, natural resource preservation and outdoor recreation uses with some isolated residential and commercial	Usually large setbacks
Rural Town	Low to medium (single family houses and other single purpose structures)	Primarily commercial uses along a main street (some adjacent single family residential)	On-street parking and sidewalks with predominantly small setbacks
Suburban	Low to medium (single and multi-family structures and multi-story commercial)	Mixed residential neighborhood and commercial clusters (includes town centers, commercial corridors, big box commercial and light industrial)	Varied setbacks and mostly off-street parking
Urban	High (multi-story, low rise structures with designated off-street parking)	Mixed residential and commercial uses, with some intuitional and industrial and prominent destinations	On-street parking and setbacks with mixed setbacks
Urban Core	Highest (multi-story and high-rise structures)	Mixed commercial, residential and institutional uses within and among predominately high-rise structures	

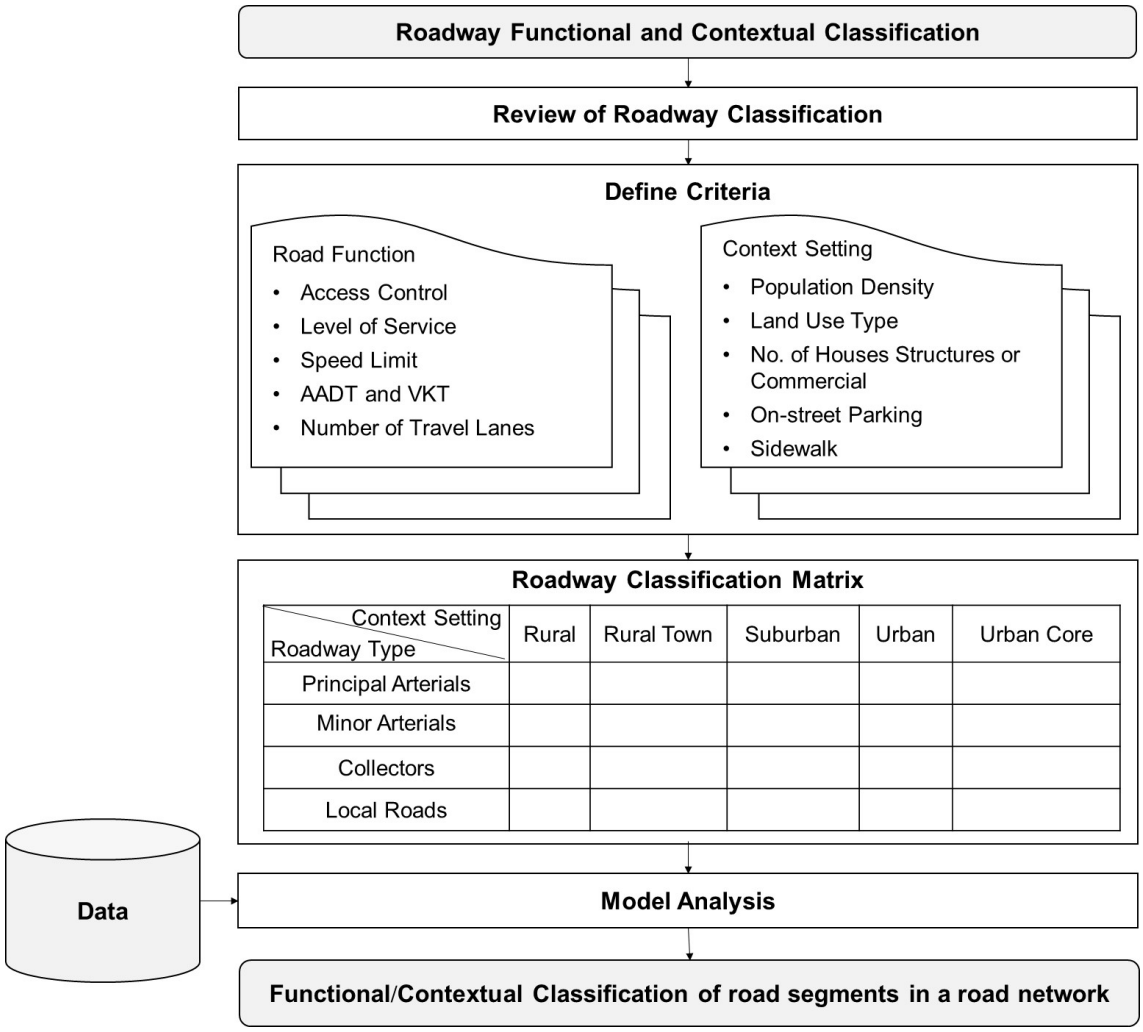


Fig. 3. Proposed model framework and contextual classification matrix

- Number of Travel Lanes: Roads are designed and constructed according to their function and forecasted travel demand. Arterial roads will be designed with multiple travel lanes to provide high capacity, while local roads need fewer number of travel lanes to provide low capacity.

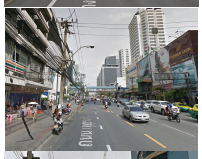
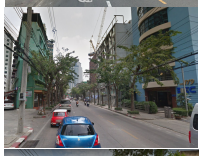
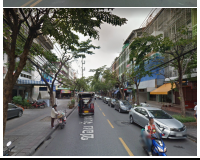
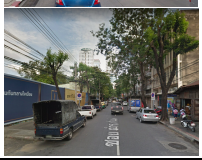
The potential criteria used for roadway contextual classification are:

- Population Density: Population density is one of the most frequently used parameters to identify urban and rural areas. For example, urban areas are the areas with high population density (greater than 5,000 population per km^2), while rural areas are those with low density.
- Land Use Type: The land use along the roads can help indicate the context setting of roads. It presents the type of population settlement and activities along the roads. Rural areas are those agriculture, natural resource, and some isolated residential areas. Urban areas are those commercial, residential, and institutional uses with low-rise or high-rise structures.
- No. of Houses Structures or Commercial: The density of house structures or commercial indicates the amount and types of activities along the roads. It can be another representative of the area type.
- On-street Parking: On-street parking implies the area type and roadside activities along the roadways. The number of on-street parking on urban roads is higher than that on rural roads.
- Sidewalk: Sidewalks typically represent the presence of pedestrians or non-motorized road users and area type along the roadways.

All data associated with road segments in a road network will be collected. These data include road attributes, traffic data, and spatial data related to land use and neighboring environment along the roadways. The model analysis will be performed through spatial analysis and traffic analysis to identify the class of the road segments in a road network.

Table III shows the preliminary results of this study. It presents the examples of road segment under different functional and contextual classes. Although there is no detailed analysis, this table helps visualize the distinction among road classes.

TABLE III
EXAMPLES OF ROAD SECTIONS BY FUNCTIONAL AND CONTEXTUAL CLASSIFICATION.

Roadway Type	Context Setting				
	Rural	Rural Town	Suburban	Urban	Urban Core
Principal Arterials					
Minor Arterials					
Collectors					
Local					

The examples of road segments in each class are discussed as follows.

A. Rural Minor Arterial

Fig. 4 shows the example of minor arterial roadways within rural environment. This type of road has many travel lanes with high speed limit, has few access points with controlled access, e.g. signal- or stop-controlled intersections, and serves high traffic volume. The land use types along this roadway are agriculture and isolated residential area. The density of population and house structures and commercial is relatively low. Moreover, neither on-street parking nor sidewalk is available.

Fig. 4. Example of rural minor arterials

B. Rural-Town Collector

Fig. 5 shows the example of collector roadways within rural-town environment. This type of road has a few travel lanes with low-to-medium speed limit due to a higher number of access points. The land use types along this roadway are different from typical rural roadway. They can be commercial or single-family residence area. The population density is medium and the density of house structure and commercial is low-to-medium. The on-street parking is possible, but sidewalk is somewhat limited.

Fig. 5. Example of rural-town collector

C. Urban Collector

Fig. 6 shows the example of collector roadways within urban environment. Similar to a rural-town collector in Example II, this type of road has a few travel lanes with low-to-medium speed limit. The land use types along this roadway are commercial and residence area with multi-story buildings. The density of population and commercial is relatively high. The on-street parking and sidewalk is present.

Fig. 6. Example of urban collector

Table IV compares the elements among three road segment examples with respect to road functionality and context setting.

TABLE IV
EXAMPLES OF ELEMENTS FOR ROADWAY CLASSIFICATION

Element	Examples of Roadway Class		
	Rural Minor Arterials	Rural Town Collectors	Urban Collectors
Road Functionality			
Access control	Few / Controlled	Medium / Uncontrolled or Controlled	Medium / Uncontrolled or Controlled
Level of service	High	Medium	Low-Medium
Speed limit	High	Low-Medium	Low-Medium
AADT and VKT	High	Medium	Medium-High
Number of lanes	More	Medium	Medium
Context Setting			
Population density	Low	Low	High
Land use type	Agriculture/ Isolated residence	Commercial/ Single family	Multi-story, low-rise building
House/commercial	Lowest	Low-Medium	High
On-street parking	None	Yes	Yes
Sidewalk	None	Sidewalk with	Yes

V. CONCLUSIONS AND RECOMMENDATION

This study presents the concept of road classification system that integrates the functional and contextual elements to classify the segments of road network. Functional classification determines the hierarchy status and the road services within the network, whereas context classification provides guidance regarding the design of roads that are suitable for the characteristics of the surrounding environment. By definition, this study presents the examples of road sections associated with each class. It shows that the expanded functional and contextual classification system is plausible to apply to road network in Thailand. Further, the preliminary result can help planners, engineers and designers recognize the needs to consider the context settings in road classification.

Further studies should be conducted to systemically and systematically classify the road network. The entire road network (as a system) should be classified with single classification system. The systematic framework should be deliberately proposed for functional and contextual classification. In addition, clear definition, logical criteria, and justifiable methodology are required.

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