The Role of Transportation Engineering in Disaster Management

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Abstract: Various disaster management master plans have been formulated in the international, national and local levels and these plans include transportation aspect particularly in emergency operations plans involving some integration of transportation infrastructure, personnel, and assets in the response phase. Amidst the current occurrence of disasters that plagued the Philippines and the continuing threat of more severe occurrences due to climate change, it will be advantageous for transportation engineering as a field to know specific avenues wherein it could contribute to disaster management. There is a need to establish its role, and conceptualize basic interaction between transportation engineering and disaster management. This study will investigate, explore, and recommend the specific roles that the transportation engineer must play in disaster management for urban areas like Metro Manila.

***Key words*:** disaster management, risk assessment, transportation engineering, emergency operation plans

1. INTRODUCTION

Disaster Management is a discipline that involves preparations for disaster before it occurs, disaster response, and supporting, and rebuilding society[1]. On the other hand, Transportation engineering is a branch of civil engineering that deals the application of technology and scientific principles to the planning, functional design, operation, and management of facilities for any mode of transportation in order to provide for the safe, rapid, comfortable, convenient, economical and environmentally compatible movement of people and goods.[2]

Disasters can happen in many forms and will occur anywhere at any time, often without warning regardless of where the disaster falls. Transportation is critical to evacuation operations in a disaster management, from bringing responders to the scene; transporting the ill and injured up to medical facilities, etc. To achieve an efficient disaster management, transportation must be effectively utilized.

It is important to understand that developing a disaster management is only one step in an extensive process that leads to a successful outcome. Coordination among various public and private agencies and stakeholders is a critical part of developing the plan and is essential to considering all factors specific to a metropolis.

Most disaster management plans do not fully integrate transportation engineering but rather as it is only a part in the logistics and transport process. Therefore there is a need to establish to include transportation agencies and or professionals in the disaster management cycle planning

[1] HaddowButterworth-Heinemann. Amsterdam. ISBN 0-7506-7689-2
[2] Sigua, R. Fundamentals of Traffic Engineering. ISBN978-971-542-552-0

process as key stakeholders since most people and responders use the highways to evacuate whether they are traveling in their own vehicle, or on a bus, or using the roadway to access a train or plane.

In an earthquake impact reduction study in for Metro Manila in 2004[3], involvement of the transportation engineer is implied in the establishment of emergency transportation network. It concerns the designation of primary and secondary network of emergency roads in order to do rescue and relief activities and operation of an emergency road network, which includes institutional and infrastructural arrangements, for emergency road response.

The planning process should aid concerned authorities in bringing the right partners including the right members of the transportation community to the table. There is a still need to establish the role, and conceptualize basic interaction between transportation engineering and disaster management.

The Transportation Research Board of the National Academies Special Report 290 shows that there is scientific consensus confirming global climate change will have significant potential effects on critical transport infrastructure.

In order to address this finding, as well as other potential consequences of natural disasters, transportation and disaster management planners should take a step forward to several new factors taking into account the common grounds when planning for emergency evacuations.

2. METHODOLOGY OF THE STUDY

This study employed the following process to establish the review and research process:

1. Collection of relevant domestic and international evacuation reference materials, plans, policies, journals, industry publications, websites, and other documents.
2. Review and analysis of the documents
3. Compilation of the results of the analysis.

The study included domestic and international documents describing disaster management and other related. The references provide a comprehensive listing of the literature reviewed including its source, title, author, and date.

3. CROSS-LINKING TRANSPORTATION AND DISASTER MANAGEMENT

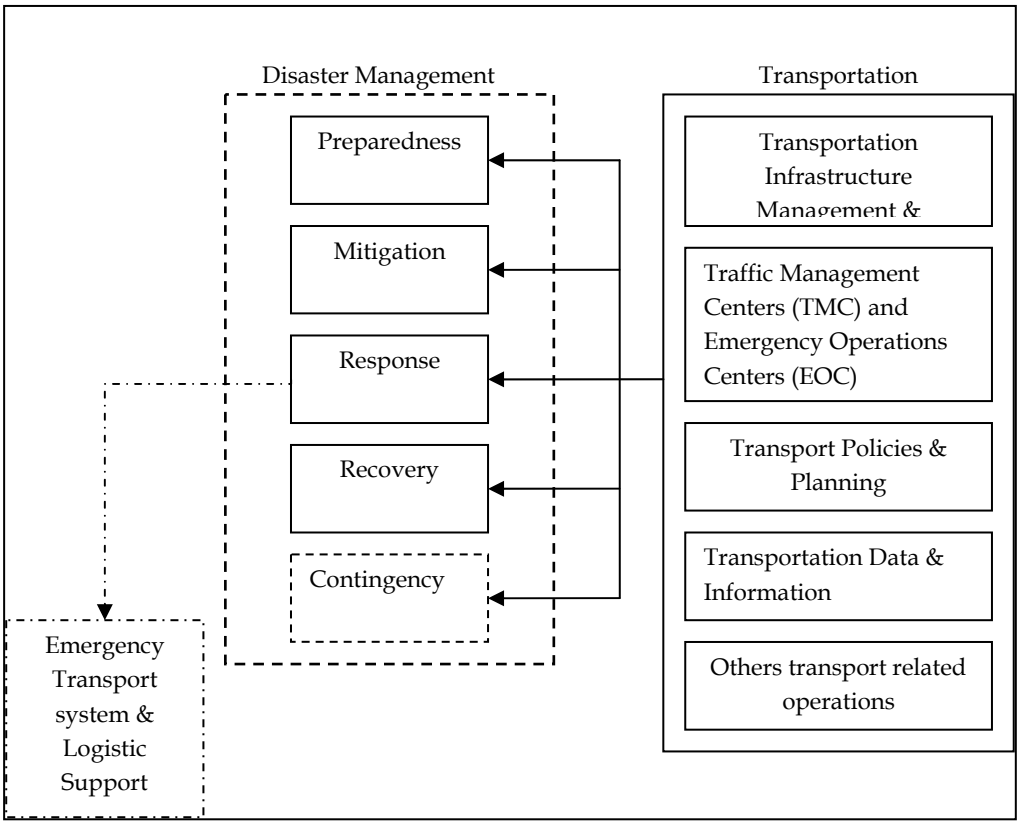
When disaster event has occurred, transportation agencies, working with local official and emergency management agencies, focus on two traditional, principal objectives: First, Minimize the time it takes to get an adequate force of emergency responders to the scene where they can help victims, provide assessments, and control access. Second, to maximize the proportion of the population moved away from the hazardous area without being subjected to other risks (e.g., traffic accidents; prolonged exposure to the danger). Once an event has occurred and the initial response has been completed, the transportation community can play an important role in the impacted community's return to normalcy. Table 1 shows Factors relating transportation operations to disaster evacuation.

[3] MMEIRS Final Report Volume 1 Executive Summary, March 2004

Table 1. Factors relating transportation operations to disaster evacuation

EVACUATION DECISION CONSIDERATIONS
Establishment of Condition and availability of evacuation routes
Determining lead time for evacuation
Determination of vulnerable transportation infrastructure
Selection of staging areas that may include transportation facilities
Coordination of traffic control devices needed in response
Establishment of plans if shutting down highway work zones, non-essential commercial vehicle traffic including oversize loads, hazardous materials, etc. are needed
Implementation of contraflow, if necessary
Identification of evacuation route plans, including the routes that are designated for ingress/egress traffic

The need to establish baseline data necessary to cross-link transportation and evacuation planning are also eminent. The process of identifying and incorporating transportation data and analysis to throughout the disaster management plans are lacking and the understanding and experience among disaster officials and emergency planners in transport operation is not clear. Thus, information focused specifically on cross linking transportation and evacuation planning at a local level is essential. As shown in the Figure below, transportation systems are involved in each disaster management cycle.



In the NARC workshop report sponsored by FHWA[4], basic data elements or sets that should be considered in the creation of a general baseline for cross-linking transportation and evacuation planning, including:

- Possible hazards/risk assessment;
- Demographics and Population Characteristics (through local surveys);
- Vehicle availability/primary method of transportation
- Age
- Disability status and type
- Residential, Daytime or Tourist/Non-permanent
- Population Evacuation Behavior (through local surveys);
- Land Use Assessment;
- Community Assets and Critical Facilities (i.e. schools, universities, transit, hospitals, street maps, utility lines etc.);
- Shelter Capabilities;
- Commuter Shed flows (work-to-home travel patterns);
- Topography;
- Evacuation routes;
- Traffic flow and control
- Estimates of vehicle movements
- Fuel management/available supply; and,
- Relevant and consistent terminologies.

Additional topics raised but not fully addressed by current research or NARC workshops includes:

- Regional threat assessment;
- Vulnerability analyses of regional transportation infrastructure;
- Multi-modal evacuation planning;
- Modeling & simulation;
- Emergency transit operations planning;
- Training & tabletop simulation exercises;
- Public outreach efforts and best practices;
- Logistics support to local and national responders;
- Support of special facilities & special needs population search and rescue operations;
- Cost effective recovery investment strategy development;
- Transportation infrastructure damage assessment;
- Broadband and its Role in Regional Transportation-Evacuation Planning, Response and Recovery – Urban, Suburban and Rural; and,
- Social Networking and its Role in Transportation-Evacuation Planning.

The use of modeling and analysis tools in transportation engineering can provide disaster management planners with a means to apply different disaster-related scenarios to an event, thereby providing the opportunity to develop alternative means to evacuate.

4. INVOLVEMENT OF TRANSPORTATION IN DISASTER MANAGEMENT

In the Study for Earthquake Impact Reduction for Metropolitan Manila in the Republic of the Philippines (MMEIRS), the structure of Disaster Management Plan for Metro Manila is shown in Figure 1. where in most of transportation involvement are seen in the improvement of disaster

[4] Streamlining cross-linking transportation and evacuation planning: A Resource Guide, NARC and FHWA

response capability. Among the 105 identified priority action plans in the master plan, 40 of them are selected as high priority action plans in accordance with the overall basic strategies to improve the existing situation. Table 2 shows the list of high priority action plans. Note that most of transportation aspects are included in concept number two: building basic capacity for relief and recovery.

However, in an event of response scenario, transportation agencies and professionals can take steps to maximize the roadway system's capacity before the evacuation begins such as suspending toll collection, suspending highway construction and opening as many lanes under construction that can be done safely, securing roadway construction sites, clearing roadways of debris, and other such pre-evacuation activities. It is important to monitor the conditions of the roadway (e.g., for debris or flooding) so that evacuees can be prepared and re-routed if necessary. In addition, incidents such as vehicle crashes may occur and will need to be responded to and cleared quickly to avoid hindering the evacuation.

Thus, transportation officials can work with traditional disaster planners or operations staff to support emergency operations activities, transportation organizations can supply information, personnel, equipment, and supplies on the scene to aid in an evacuation, including those that:

- make decisions
- generate, collect, and/or analyze information
- design strategic, operational, and contingency plans
- manage operations and resources for the response
- Execute emergency (including evacuation) orders and response operations.

Transportation professionals can also provide a wealth of information to support evacuation planning such as traffic counts, roadway capacity, planned highway construction, maps, and other such data necessary to develop a good plan and can access a wide variety of tools to facilitate the evacuations along roadways. Some Key Roles of Transportation Professionals/Officials may include:

- Collect analyze and report traffic information
- Provide evacuation route plans
- Conduct traffic incident management with first responders and local law enforcement.
- Order and provide traffic operations resources to support evacuation and other movement coordination operations
- Provide information to Traffic Management Centers (TMC) and Emergency Operations Centers (EOC)

Table 2. List of High Priority Action Plans

Concept 1 : Enhance legal framework and institutional capacity for disaster management	**Concept 3 : Strengthen community preparedness for the earthquake**
Strategy 1: Enhance legal basis for disaster management	**Strategy 1: Enhance self reliant and mutual help for efficient risk management capacity**
RMS-3: Strengthen legal basis for disaster management at the national level by updating/replacing PD1566	CRI-1: Knowledge development about earthquake hazards and vulnerabilities
RMS-3: Strengthen legal basis at the local level by adopting model city/municipal ordinance	CRI-1: Enhance the community governance and linkage with LGUs
Strategy 2: Strengthen institutional capacity for mitigation, preparedness and response	CRI-1: Enhance potential emergency management capacities
RMS-4: Promote the reorganization and revitalization of city/municipal and barangay Disaster Coordinating Councils	CRI-1: Enhance the administrative system supporting community activities
RMS-4: Promote local government mitigation planning through implementation of the Earthquake Mitigation Handbook and the Earthquake Mitigation and Response Checklists – Local Planning Guide	**Strategy 2: Inculcate a disaster mitigation culture in future generations**
RMS-4: Conduct training needs assessment and develop capacity building programs for local and barangay DCCs	CRI-2: Enhance school risk management capacity
RMS-6: Encourage local emergency response planning through use of the Earthquake Mitigation and Response Checklists—Local Planning Guide	CRI-2: Inculcate a disaster mitigation culture in future generations
RMS-6 /RMS-16: Encourage adoption and utilization of Emergency Response Pocket Guide and Guide for Managing Information by agencies and LGUs	**Concept 4 : Reduce dangers of residential buildings**
Strategy 3: Strengthen inter-institutional coordination	**Strategy 1: Strengthen buildings against earthquake**
RMS-5: Strengthen MMDCC by updating its structure and organizing and implementing a MMDCC Work Plan	USI-1: Promote subdivision development procedures
RMS-5: Encourage inter-local cooperation through zonation of LGUs and Mutual Aid Agreements	USI-3: Promote disaster resistant urban development/ re-development
Concept 2 : Build Basic Capacity for Relief and Recovery	USI-3: Enforce and develop laws and regulations related to urban planning and building code
Strategy 1: Enhance emergency health and medical response system	USI-4: Research and development on strengthening buildings
RMS-11: Enhance organizational response capacities	USI-4: Promote construction and improvement for earthquake resistant buildings
RMS-11: Improve government hospital capacities	**Strategy 2: Avoid fire outbreaks from residential buildings**
RMS-11: Enhance logistics and medical supplies	USI-2: Tie down and stabilize propane cylinders against earthquake shaking
Strategy 2: Establish emergency transportation system	USI-2: Promote replacement to unbreakable (plastic-bottled) gasoline vending
RMS-12: Establish emergency road network	**Strategy 3: Promote research and technology development on earthquake impact**
RMS-12: Secure road between Batangas Port to Metropolitan Manila south region	R&D-1: Evaluate activity of the valley fault system
RMS-12: Convert one portion of Manila port to earthquake resistant construction	**Concept 5 : Enhance National System Resistant to Earthquake**
RMS-12: Secure road between Subic port/ Clark field to Metropolitan Manila North region	**Strategy 1: Protect stability of national government function**
RMS-12: Construct Laguna de bay northern shore unloading facility	NSD-1: Enhance continuity of national government function with the President's office
RMS-12: Secure Ninoy Aquino airport function	NSD-1: Promote urban reform around the nationally important facilities
Strategy 3: Secure water	**Strategy 2: Protect stability of socio-economic system**
RMS-10: Secure the large scaled water source for drinking	NSD-2: Enhance emergency measures by businesses
RMS-10: Formulate emergency supply system of water, (food, and other necessities)	NSD-2: Enhance safety of online financial services
-	NSD-2: Enhance disaster finance system

Source: MMEIRS (2004)

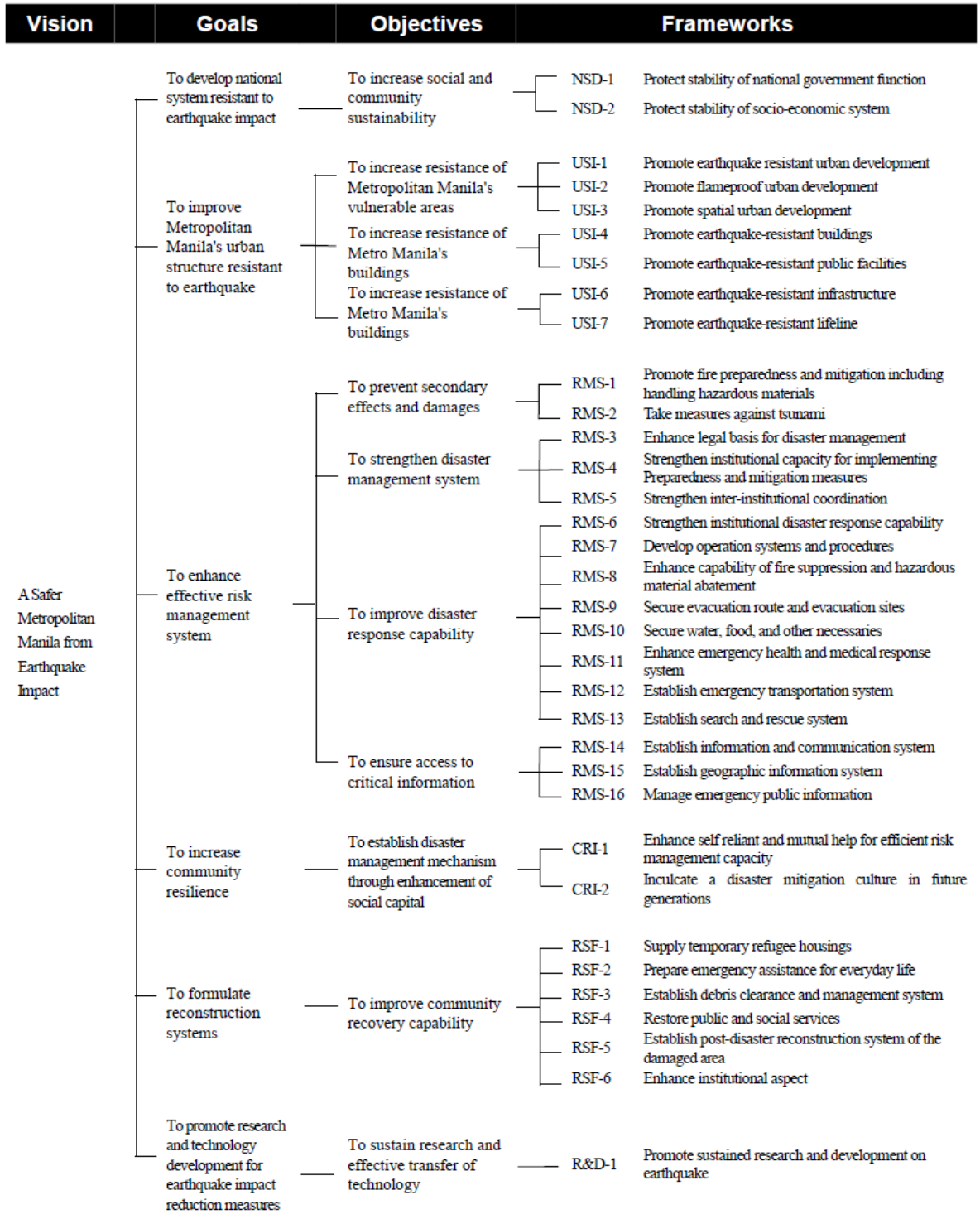


Figure 1. Structure of the Disaster Management Plan for Metropolitan Manila

Source: MMEIRS (2004)

Transportation experts can provide ideas in planning, transit, traffic engineering, highway construction, and maintenance, for example, maintenance personnel or contractors can provide supplies for rest areas or assist with debris removal, and construction staff or contractors can assist with securing work zones or repairing roadway damage. It can also provide assistance to ITS resources, timing traffic signals, and providing traffic control devices such as cones, barriers, and signs, to assist in directing traffic during the evacuation. Transport Planners can identify routes that have a high probability and feasibility of use considering their survivability, ease of restoration, functional service, and strategic location.

Planners will also analyze potential bottlenecks, barriers, scheduled work zones, and other potential problems in advance to determine an evacuation route. Control points can be planned, ensuring sufficient staging capacity for emergency services, crossovers and turnarounds for contra-flow, and ingress to affected areas.

Transportation professionals will determine highway capacity or the number of vehicles that can pass a certain point on the highway in a specified period of time under prevailing road and traffic conditions under emergency situations and will also determine the amount of time needed to evacuate an area. This can be done by creating spatial and temporal distribution models, plan for traffic incidents, and take into account human nature. For example, many people may be away from their homes and need to commute against traffic to reach home and gather their families and belongings before they begin to evacuate. Conversely, ”shadow evacuations” occur when people decide to evacuate prior to notification or choose to evacuate even when they are not in harm’s way.

5. BEST PRACTICES OF TRANSPORTATION OPERATIONS IN DISASTER MANAGEMENT

There of numerous best practices of transportation operation in disaster management are present in various countries, these includes but not limited to the following:

Intelligent Transportation Systems (ITS)

a. Use of Transportation Management Centers for Emergency Operations
b. Use of Traffic Cameras for Critical Infrastructure Use of Closed Circuit Television (CCTV) to Monitor Freight Rail Movement
c. Automatic Vehicle Location (AVL) Systems
d. Condition Acquisition and Reporting System (CARS)

Emergency Operations Center Practices

a. Virtual Emergency Operations Center
b. Response Information Management System (RIMS)
c. Incident Response Protocols

Emergency Traffic Management and Evacuation

a. School System Evacuation Plans
b. Active Medical Surveillance System

Intelligence Sharing and Infrastructure Protection Systems

a. Information Sharing and Analysis Centers (ISACs)
b. Evacuation Traffic Information System (ETIS)

Policy

a. Protection of Vulnerability Assessment Information

b. Critical Infrastructure Protection

6. FINDINGS, ANALYSIS AND RECOMMENDATIONS

This paper presents various specific avenues of the roles of transportation professionals to disaster management. It is also found that the role of transportation is limited to logistics and transport support process in the entire disaster management cycle and most disaster management plans do not fully integrate transportation design and process. The process of identifying and incorporating transportation data and analysis throughout the disaster management plans are lacking and the understanding and experience among disaster officials and emergency planners in transport operation is not that intensive.

Transportation engineers and planners has the capability to minimize the time it takes to get an adequate force of emergency responders to the scene where they can help victims, provide assessments, and control access and maximize the proportion of the population moved away from the hazardous area without being subjected to other risks such as traffic accidents. It can also provide assistance to ITS resources, timing traffic signals, and providing traffic control devices such as cones, barriers, and signs, to assist in directing traffic during the evacuation. Transport Planners can identify routes that have a high probability and feasibility of use considering their survivability, ease of restoration, functional service, and strategic location.

It is recommended to establish and include transportation agencies and or professionals in the disaster management cycle planning process as key stakeholders. Private and government authorities in charge of disaster management planning should also consider various transportation design criteria and technical operations regarding the utilization of transportation infrastructure for disaster management.

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