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To cite this article: M I Ramli *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **235** 012072

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An optimum route analysis of fire rescue according to fire station location (Case study: Residence area in Makassar's central business district)

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Abstract. Fire is a common problem in the last three years in Makassar. Operational Staff of Fire Department Makassar record (January-April) 32 cases of fire disaster in 2015, 44 cases in 2016, and 35 cases in 2017, even on 2018 recently occurs on April and May. The fire disaster is likely to attack in city residences area, in which it is very important especially for fire disaster mitigation. The fire rescue is needed effective route considering the travel time and distance to reach the location of the fire. Determine the route with optimum options will be helpfully the fire rescue to reduce the risk and prevent the situation from getting worse. This research has an objective to give information of optimum route that will use by the fire rescue. The optimum route according to the fire station location using Quantum Geographic Information System (QGIS). The QGIS has required the topology, length, target that finally give the shortest route. The travel time of vehicle also required to the condition of the traffic. Finally, the result of the research shows the optimum route of the fire station rescue to the residence area in the central business district in Makassar.

1. Introduction

The disasters occur when danger or hazard meet with the vulnerability condition, which has low or no capacity to respond or face the danger. The collaboration of these causes the disruption in people lives, such as the destruction of houses, property damage, displacement and even the occurrence of casualties [1]. Fire is one of disaster that often occurs in urban and non-urban areas. Fire disasters in urban areas mainly occur in densely populated areas or in high activity such as commercial [2].

The number of fire fatalities in Makassar has been increasing by years especially in-residence area, figures from Makassar Fire Department show. Among 2011 to the middle years of 2015 at least 825 fire disasters mostly attacked the residence area. Fire disasters are generally caused by short electrical incidents that give high damage to the victims and need a quick response and correctly. The Fire Department needs more information about the optimum route to access the location of disaster soonly. Designated fire routes ensure that the Fire Department can prevent the spread of fire, reduce property and environmental damage, and most importantly, reduce injuries or death. The route choice also attention to the condition of the road network and avoid to the traffic jam when in several cities in the countries are facing traffic congestion problem in a critical level [3].

The technological improvement prepared more service of the online map to find the route from an orign to destination. One of the online service of the map as well known as Open Street Map (OSM). OSM is an open source map based on website and loading maps all over the world, fully developed by

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the volunteer with a survey using the GPS, interpretation map from satellite, and collected the geographic data for free to the user. OSM can download in openstreetmap website. The attribute of data from OSM then used to spatial program Quantum Geographic Information System (QGIS). Basically, the QGIS is a part of Geographical Information System (GIS) based computing system for input, save, manage, and analyze, and reactivate the spatial reference for all purpose that related to planning map [4]. GIS is defined as one of the computer system with an ability to analyze the geographical data such as data entry, data management, and implementation of the result. The output or result as one of the references to the solution related to the geographical problem [5]. The geographical information system is a tool of performance the spatial information on earth, such as city, railway, road network, river, and others [6].

This research is conducted in Makassar and focus on arterial and collector roads, the average velocity, the attribute of roads, and the station of fire rescue. The input data is the start and end point and not considering about the rule, capacity, and traffic. The result is an optimum route, distance from orign (station of fire rescue) to destination point (potential disaster area) residence area of Central Business District (CBD). The information is the fire station area in OSM also the road network attribute then analyzed by QGIS used the optimum route with shortest path tools. Finally, the optimum route from the fire station to rescue area in residential area was found. This study objectives are to preserve an optimum route for fire department according to station location to CBD residence area. The study results are very useful for the Government especially to fire Department in preventing the damage and to reduce the fire disaster in Makassar City.

2. The study methods

2.1 Data collection and preparation

This study using OSM map that downloaded from the website of export.hotosm.org for Makassar area. The map is providing the tools based on region. On the other hand, it is difficult to do from the official website of OSM openstreetmap.org using the export tool. The map from OSM is opened in the hot export website, then use OSM account to log in to get an authorized access. There are four steps in the hot export tool before downloading the OSM map. First, fill the describe (name, description, and project) and search the area. Second, choose a format with shapefile then choose the type of transportation road and building based on necessary data and finally create an export to starting the export process data from OSM. The database from the website is in shape file that ease to open in QGIS.

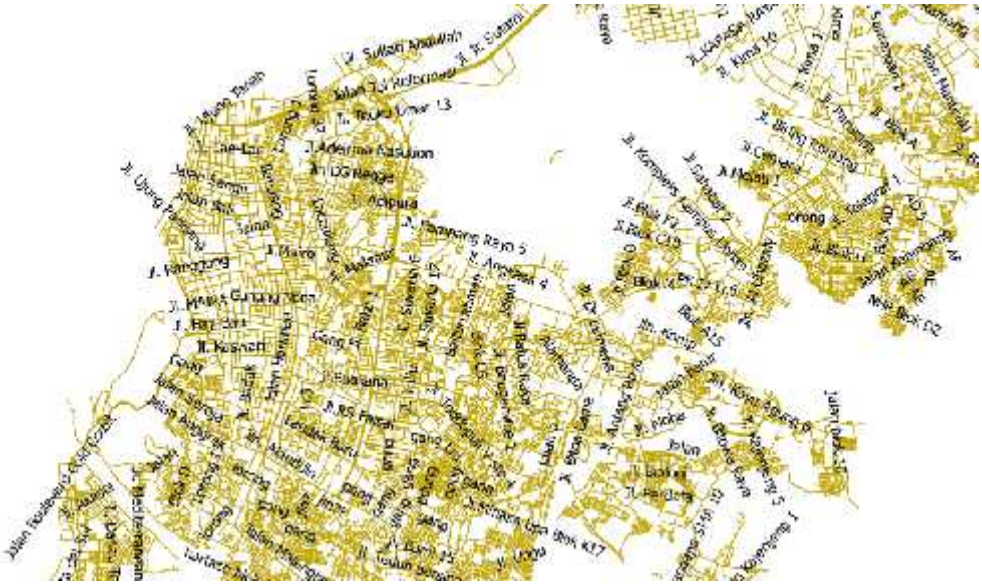

Figure 1. The OSM Map in QGIS

The available map in OSM is plotted to QGIS consists of the length and the classification of the road and used to analyze the optimum route. The Indonesia highway classification rule no. 38 (2004) divide the road according to function with arterial, collector, and local [7]. According to the classification, the velocity of the vehicle (free flow speed) also determined in rule no. 34 (2006) for arterial roads 70 – 120 km/h and 60 – 90 km/h of collector roads [8]. Further, the nearest station would help each other to minimized the disaster and selected three stations to encounter the fire in CBD residence area. The coordinate of the fire stations is available on OSM and google map then pointed in QGIS as the start and finish of fire rescue route. The following figure is showing the location of the fire station with a red point and the blue point is the disaster area in Makassar map from google map facilities.

Figure 2. The Fire Station Location and Disaster Area

The Makassar map in figure 2 shows the fire station location with number and x code for disaster location of residential area. The coordinate of fire stations and disaster area plotting in QGIS. Then, we prepare data for analysis activity in the program using the *plugin* facilities of QGIS.

2.2 The simulation program

This study develops a simulation program of route analysis on QGIS using *road graph* function to find the optimum route of disaster location. Road graph plugin is a C++ plugin for QGIS that calculates the shortest path between two points on any polyline layer and plots this path over the road network. The features calculate the path, as well as the length and travel time, optimizes by length or by travel time, and exports path to a vector layer [9]. The entire road network is captured by using the open layers plugin. The possible road networks were digitized by using Quantum GIS and analysis is carried out by using Road graph plugin and shortest path is calculated by shortest path analysis. The attribute of each road contains information roadway geometric and its characteristics in QGIS according to OSM map. The road graph has to be configured, therefore the analysis was carried out by giving an approximate speed limit as 30 km/h for all possible scenarios as an average speed of the vehicle in arterial and collector roads.

3. Result and Discussion

3.1 The optimum route of fire station

The simulation shows the optimum route from fire stations to the disaster area. The optimum route as the shortest path is computed within the available road network of the study area from the fire station

to the disaster area in Makassar CBD residence area in figure 3, 4, and 5 respectively. The figure describes the starting point of the fire station through the road network according to road graph analysis in QGIS to the fire disaster location. The route only through the arterial and collector road in the road network with the red line. The potential area of disaster is marked with the blue circle that showed the total residence area surround the CBD. The optimum route would guidance the fire rescue to through the road with optimum distance and time.

Figure 3. The optimum route of fire station 1

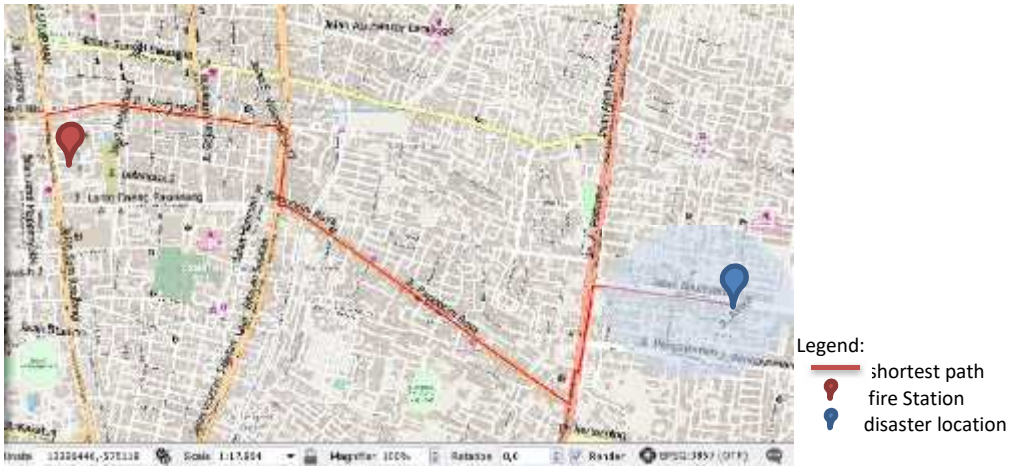

Figure 4. The optimum route of fire station 2

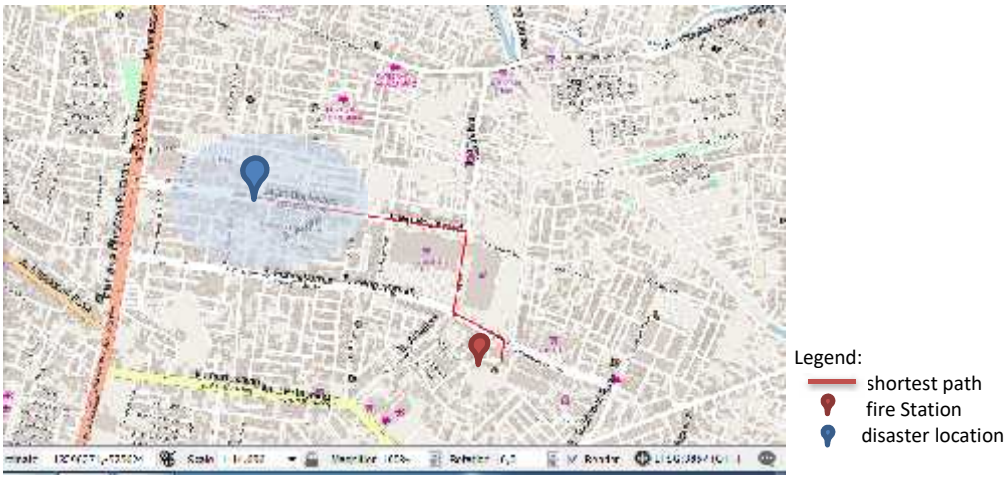

Figure 5. The optimum route of fire station 3

3.2 The length and time of fire station to disaster area

The total distance from fire station 1 is about 4.25118 km and the time taken to reach the place is computed as 0.141706 hours which is equal to 14.1706 minutes, for the fire station 2 the shortest path is 5.76988 km the time taken to reach is about 0.192329 hours which is equal to 19.2329 minutes, and for the fire station 3 the shortest path is 1.33622 km the time taken to reach is about 0.0445405 hours which is equal to 4.45405 minutes shows in figure 6. This study is also can be used for alternative solution by recognizing the route between the two known address, by linking the entire data base of address.

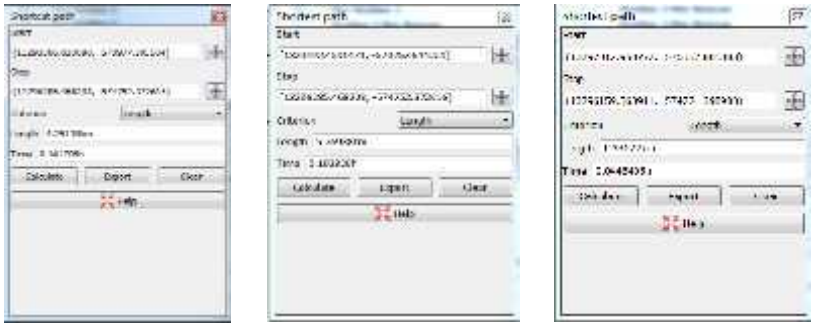

Figure 6. Length and time of fire station to disaster area

3.3 The optimum route of fire station

The total length road network for stations are different according to the location. Therefore, the analysis was carried out by giving an approximate speed limit as 30 km/h. The shortest path computed the optimum route of each station to the disaster area within the available road network of the study area. The table 1 below shows the summary of the optimum route through the road network, length, and time.

Table 1. The optimum route of fire stations on road network

Fire Station	Route	Length (km)	Time (minutes)
1	Ratulangi – Mongingsidi - Rappocini – Pettarani - Boulevard	4.25	14.17
2	Sunu – Mesjid Raya – Urip Sumoharjo – A.P Pettarani - Boulevard	5.76	19.32
3	Pengayoman – Adhyaksa - Boulevard	1.33	4.45

4. Conclusion

The optimum route of fire rescue according to fire station to the disaster area in CBD residence has been created by using Quantum GIS. The total length of from fire station to the disaster area of station 1 is about 4.25 km and 14.17 minutes through Ratulangi – Mongingsidi – Rappocini – Pettarani – Boulevard (disaster area), the fire station 2 is about 5.76 km and 19.32 minutes through Sunu – Mesjid Raya – Urip Sumoharjo – A.P Pettarani – Boulevard, and the fire station 3 is about 1.33 km and 4.45 minutes through Pengayoman – Adhyaksa - Boulevard. Quantum GIS is providing the available data source to support in decision making. This study is expected to give useful information for the management of fire rescue department also for the further study of fire disaster management.

Acknowledgment

We would like to thanks and appreciation of the Transportation Laboratory of Civil Engineering Department of Hasanuddin University, which support the tools and together analyzing. Without their cooperation, this paper would not be possible to be arranged.

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