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Research Article

A Method of Finding the Best Route and Shortest Route to a Ready Mixed Concrete Plant Through Real Time Tracking System by using GIS and GPS

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Abstract The delay in transportation of ready mix concrete has become a common issue in civil engineering construction industry which wasted millions of rupees. This report is prepared as a part of the research conducted on developing a GIS based tracking system for truck mixers and a system to find the best route in transporting ready mixed concrete. Furthermore, it focuses on determining (VRP) feature in network analysis extension in ArcGIS. A shape files of road network in Colombo area was created using an open street map. The road network was mapped on the open street map shadflies using polylines. For this research, batching plant established in Colombo 14 and three construction sites in Kollupitiya and union place were considered. Relevant coordinates for both batching plant and the construction sites were imported to the map. Before caring out the final simulation, various constraints were assigned to ready mixed plants as well as for the routes such as one way restrictions etc. The traffic flow of the specific routes has been observed in two time frames such as normal peak hours (07:00 hrs. to 20:00hrs) and off peak hrs (20:00hrs to 7:00hrs). The main objective of this research is to developed an optimum delivery plan for truck mixers by using Arc GIS software and provide a guideline to develop this concept to be used in a much larger scale for beneficial of construction industry

Keywords *ArcGIS; ready mixed concrete; tracking system; Network planning*

1. Introduction

Reinforced concrete is being used more often to build structures, meanwhile, the site mixed or ready mixed concrete is being used according to relevant circumstance in Sri Lanka. Nevertheless, site mixed concrete required more man power, time and space than the ready mixed concrete which consume higher cost. Since ready mixed concrete has been mixed up under factory condition the quality of the concrete is trustworthy, therefore ready mixed concrete is recommended for large scale projects. Modern day's ready mixed Concrete has become an essential material integral to construction work and it is essential to supply it on time (Flori M., 2021). But civil engineer who has working in construction sites faces many difficulties in procuring ready mixed concrete, one of the common scenarios would be the delay in procuring ready mixed concrete to a construction site. Since procuring RMC is getting delayed, the contractor would not able to obtain expected quality and also it makes additional abrupt expenditure. Primarily a specific time has been given to deliver concrete from

batching plant to the construction sites. If the concrete couldn't be delivered within the given time period, it may reach its initial setting time and decrease the workability of the concrete (Hershberger, 2015). More often concrete is used for structural elements. If concrete with low slump (low workability) has been used to cast structural elements, it may cause honeycombs, which make the elements week. causing a possibility of failure. Apartment from that those honeycombs formed in a slump, water tank or basement, water may leak through those honeycombs which will take a gratuitous cost to rectify them (Paul Brave, 2018). When procuring of ready mix concrete is delayed, there is a possibility to form construction joints unnecessarily. Since construction joints are known to be weak, cracks may be formed in those areas which affects adversely for the quality of the products. Moreover, if the supply of concrete is delayed, laborers who are allocated to pour concrete will have to wait unexpectedly for a more period of time (Sameeren Kahan, 2018). Nowadays, considering the lack of manpower available a limited number of labors have been allocated to construction activities. Therefore, contractor will have to pay unnecessary overtime for the labors and numerous labor hour will be wasted which would have been devoted for another construction activity. For the contractor it is in dispensable to minimized wastages and offers a competitive rate in the current market. But it is difficult to compete with above unavoidable circumstances (Dozii S.P. and Abou Rizk, 1993). Construction site in urban areas, are only allowed to cast concrete within a given time period because of the traffic and security purposes. If procuring delayed site wouldn't be able to cast within the given period of time and construction site will have to give up casting even through it is incomplete. For that reason, it is responsibility of the batching plant to deliver concrete to the construction site on time. Therefore, delayed truck mixers will be rejected from the construction sites, in such cases batching plant will have to bear the cost which consume.so it is essential to identify the traffic congestions, shorted and best routes between batching plant and construction site to deliver concrete on time. It has become a complicated matter to handle with conventional method such as two-way communication systems. The travel time between the batching plant and the construction sites depends mainly on the traffic condition. For an instance, during morning hours there are massive traffic condition in the High Level road towards Colombo because people are driving toward the city for their occupations but in the evening times it becomes a completely opposite scenario since people are driving out of the city after office hours. Therefor it is not appropriate to follow the shortest route always to deliver ready mixed concrete and truck mixers will have to use two different routes to reach the site from the batching plant and drive back to home to avoid the traffic congestions. If the batching plant is delivering concrete to the construction site along a congested route, they would have to direct truck mixers to the secondary road which may be a longer route but without traffic congestion. If the rain starts suddenly while on the way, driver would have to slow due to the slippery road conditions and the lack of visibility, further more roads might be flooded due to heavy rain (Pushpakumara T.D.C. et al., 2007); it may raise traffic jam on the roads and cause delays in transportation concrete. Similarly, we have witnessed road barriers showed up abruptly around urban area due to security purpose and also because of road renovations. To avoid those circumstances driver would have to use an alternative road because the concrete should be delivered without further delay (Annika and Janas, 2016).

2. Objectives

Introduce the uses of GIS+ GPS systems to ready mixed concrete plants.

- Highlight the vacuum in using modern technology and encouraging the authorities to pursue it.
- To find the optimum route between the construction site and the plant in transporting ready mixed concrete.

Considering the traffic conditions, road conditions and the distance, a decision could be made in selecting the optimum route. So that the plant managers can save time and money which was supposed to be wasted and the construction site may receive good quality concrete in time.

- Develop a vehicle tracking system to locate a vehicle at any given instance in order to take remedial action.

If mixer drivers stopped by some where unnecessarily, plant managers will detect it in his computer. Then he can immediately inquire the driver or immediately visit his location in order to find the reason. Sometimes a truck mixer driver may meet with an accident or lose track while on the way to site at late night, he might not be able to communicate with the plant or he might not be able to explain where exactly he is; in such cases, plant manager can track his whereabouts using GPS coordinates and find a solution.

3. Literature Review

Considering routes, congestions, traffic incidents and weather, which differs the fastest route from the shortest route, author developed a system to find an optimal route using ArcGIS (Devarasetty, 2010). The optimal route was defined as the route which minimizes the travel time between any two given point and maximizes the cost associated with the travel. Standard deviation of the speed along each route was assumed. The using road network data and standard deviations, optimal route were calculated. Both travel time and reliability of the roads were used to define their respective cost attributes. Using standard deviation of the speeds, it's difficult to identify the sudden stops or sudden accelerations. For an example, in a roundabout or a junction with traffic lights, vehicles stopped for a while and suddenly accelerate. So it is appropriate use constrains for those junctions and obtain the standard deviation of the speeds, in between junctions.

School bus routing and scheduling are among the major problems because school bus transportation needs to be safe, reliable and efficient. Using GIS+GPS systems Nayati M.A.K (2008) developed a GIS based student transport management system, to transport students in an economical and convenient manner. Furthermore, author tried to demonstrate the major problem occurred in school bus routing and scheduling such as, how to minimize transportation cost, time, total number of buses in transportation and how to design student pick up and drop off point. Hence, the research was to find answers to all above questions in safe, reliable and efficient manner. Same time author has tried to improve the transportation security of school transportation management system.

Lack of proper planning and management in student transporting systems, causes traffic congestions on the roads which wastes millions for the fuel and priceless working hours of the people who are crossing by those areas. Also students can save lot of free time at home because they can reach home early without being exhausted. So it may helpful to their studies and ironically this helps to make educated students in the future. Even though the author considered a high school situated in Hyderabad, it perfectly suited for the Sri Lanka as well. It is true that, rise of the number of vehicle registered and the unplanned transportation systems cause these priceless wastages mostly. As a solution transportation system has been developed using GIS and Automated Vehicle Location. So then it's easy to allocate necessary bus routes considering traffic conditions and the road conditions. Also some parents don't let their children go to school by school buses, because of lack of security. With Automated Vehicle Location systems, it is easy to find out the vehicle location using GPS in urgency such as sudden change of weather condition or traffic condition. So those parents may feel free to send children by school buses and it may help to reduce the number of vehicles on the road. Furthermore, author has introduced a zoning system in student transporting system. Students who live around the same area can be allocated to a one route. So they can reach home earlier than travelling around incompetently.

Similarly zoning system proposed by the author can be used in ready mixed transporting systems as well. Batching plant managers can divide the concrete supplying area by town wise or district wise. So if concrete has been ordered to a new construction site where they don't know the GPS coordinates, still it is possible identify which zone it belongs to and predict the costs that will consume.

With the growth of demand for ready mixed concrete, it is difficult to procure in high quality using traditional, two way voices based communication and experience driven management. From this research Lu M., Shen X., Lam H.C., Chen W. developed solution which helps to compete with the market and satisfy the demand in escalating scale and complexity.

Using this system, he intends to;

1. Identify the real time location while truck mixers on the move in between construction site and the batching plant.
2. Obtain the time taken to procure and use them to quality control and also management strategies.
3. Raise the communication method between truck mixer driver and the control Centre.

As discussed above, it is essential to supply concrete in time. Basically overdue procuring RMC directly affect the quality of the concrete. It may reduce the workability of the concrete and may cause water leakages in the joints and honeycombs which can cause structural hazard.

Author intends to resolve above problems by developing an automated, reliable real time monitoring platfo1·1n for RMC. As a conclusion author has optimized the main five stages in procuring RMC which are,

1) Loading concrete in to the truck mixer at the batching plant.
2) Truck mixer travel to the site.
3) Waiting till unload the concrete on site.
4) Unloading using particular method.
5) Return back to the batching plant.

So then it is easy to identify delays and take immediate actions to overcome them.
In Srilanka, it is quite complicated than Hong Kong, though real time tracking system has been essential for past few years but it has become a reality with these GIS+GPS tracking system.

4. Methodology

Develop a system whereby the best and shortest route between a construction site and plant may be determined (since the shortest route might not always be the best route due to traffic and road conditions),

Employing a real time tracking system on the truck mixers by using ARC GIS, Visual Basic and Java programming systems.

4.1. Methodologies Flow Chart

4.2. Description of Methodologies

Ready mixed concrete plant in the middle of the Colombo, obviously getting orders more than hundred meter cubes per day. Therefore, they face lots of difficulties to plan truck mixers because they have to provide an efficient service with good quality in the competitive market. Probably most of the truck batching plants doesn't have more than enough truck mixers. So then it's really necessary to plan what they have. Road condition, traffic condition and the other reasons are mostly a hazard to the manager of the batching plant. It's a great help if the manager can accurately predict the time taken.

So ArcGIS vehicle route problem solver can find a solution for all these problems.

a. Select the "New vehicle routing problem" in "Network Analyst" extension tool bar
b. Then “Vehicle Route Problem” window will appear.

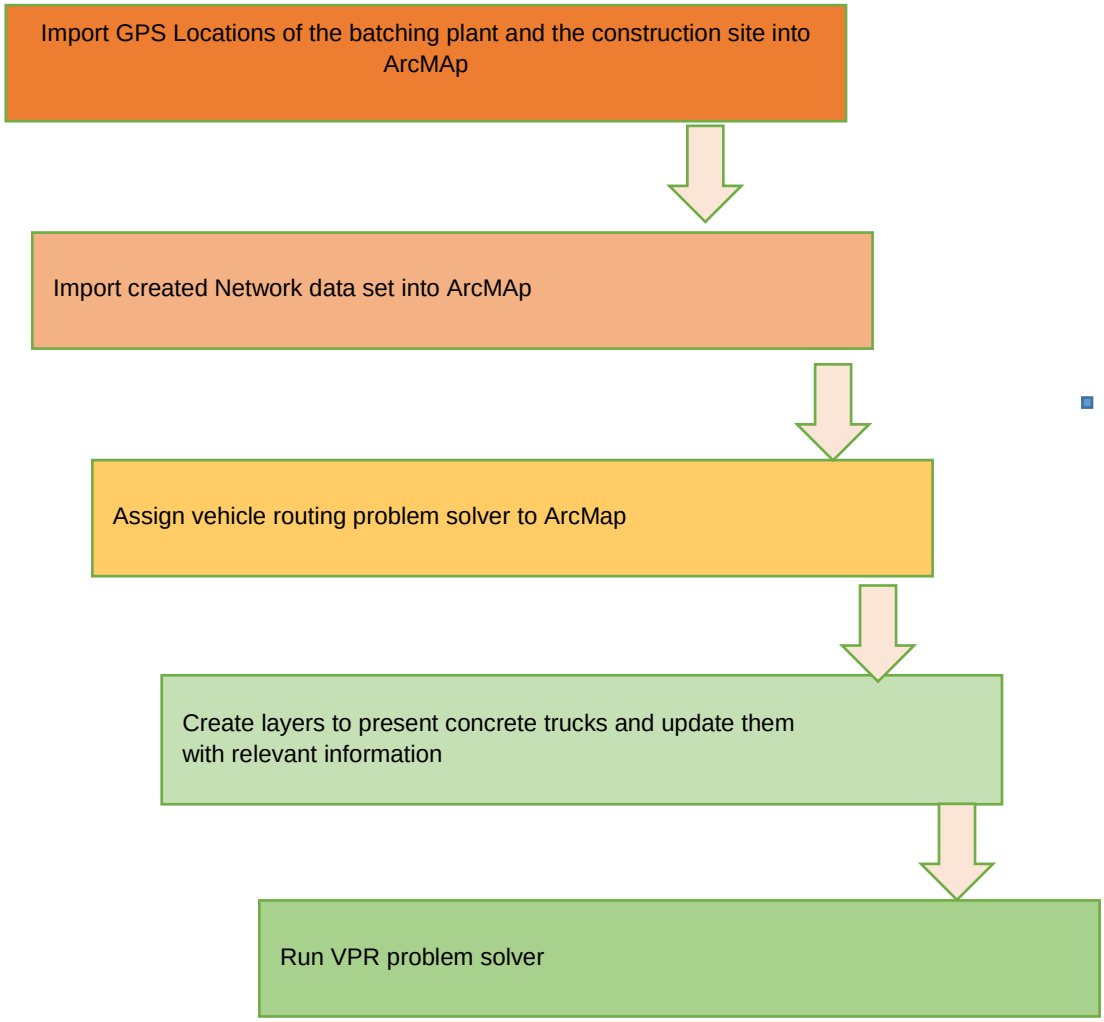

Figure 1: *Flow Chart*

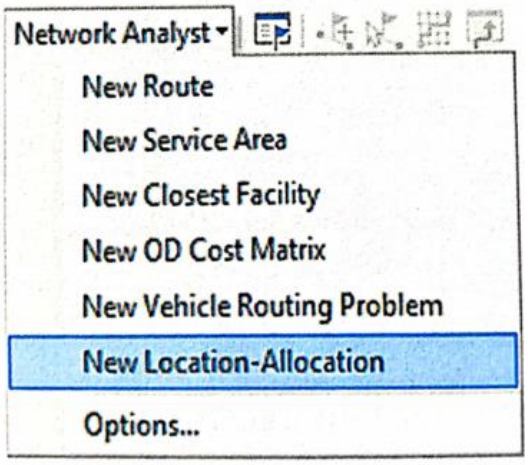

Figure 2: *Opening vehicle routing problem solver in Network Analyst extension*

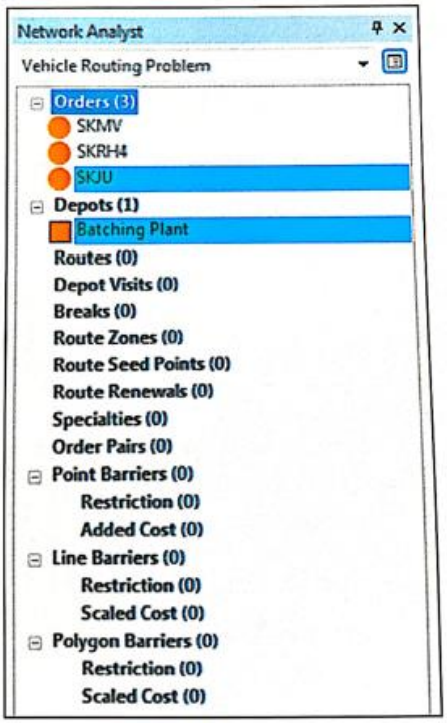

Figure 3: *Vehicle Routing classes*

Definitions of above classes as follows

Orders This class stands for the construction site and it stores ordered concrete volume of each site

Depots This class stands for the batching plant.it implies the place where the route going to start and to finish in.

Routes This class stands for the path where the truck mixer supposes to travel along from the batching plant to construction site when transporting concrete. Each construction it has its own route which is different from the other.

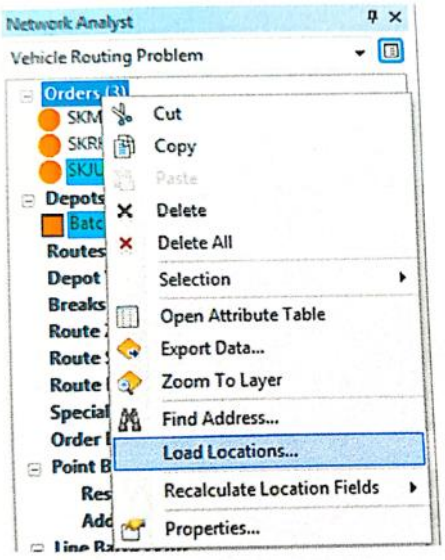

Figure 4: *Adding construction site locations*

As per the figure above, right click on the "Orders" class in "Vehicle Routing Problem" tool bar, and click on the "Load Locations' to load the coordinates of relevant construction sites.

Then right click on the "Depots" class in "Vehicle Routing Problem" tool bar, and then click on the Load locations' to load the coordinates of the batching plant. Route is a line feature so there is two ways of creating a route.

a. Import route feature from and existing vehicle routing problem.
b. By right clicking on the "Route class in "Vehicle Routing Problem" tool bar and click on the “Add Item" to create a new route.

In the research I have to create a route by using “Add item”

Figure 5: *Creating a Route*

Attribute of "Properties - Routes" dialog box should be filled with the suitable values of the route and site name.

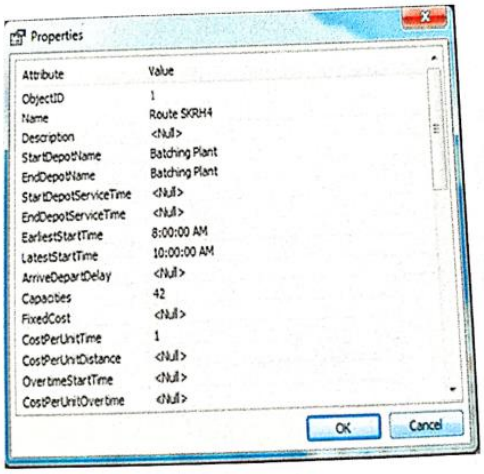

Figure 6: *Properties of Routes*

GPS coordinates of the construction sites were tabled in an excel sheet and imported them in to ArcMap. Open street map was converted to Kandawa coordinate system .

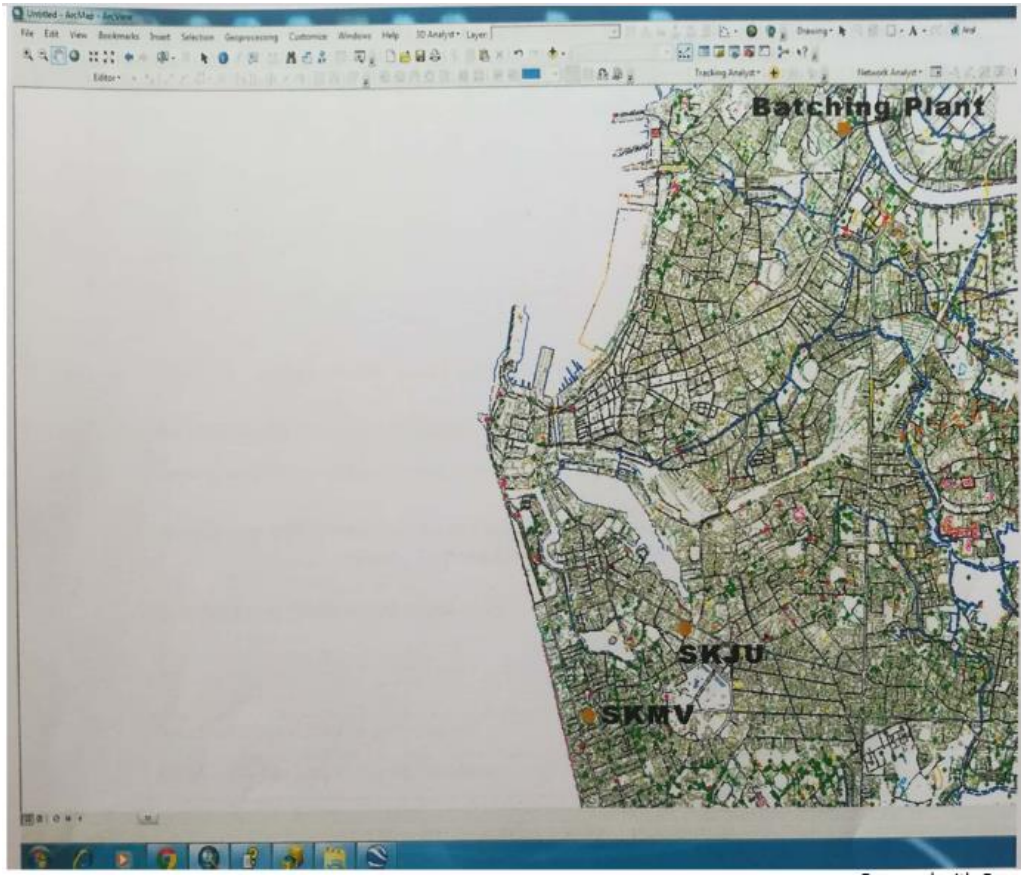

Figure 7: *GPS locations of construction sites and the batching plant on OSM*

5. Date for Study

A field survey has been carried out to collect the GPS coordinate of the batching plant and construction sites by using a PS receiver. Coordinates of each construction site and the batching plant were as follows.

Table 1: *Surveyed GPS Coordinates of batching plant and the construction sites*

Location	Name Of The Location	North	East
01	Batching Pant	0769391	375770
02	SKMV	0764171	373048
03	SKJU	0765025	373967

Average speed has been calculated by multiplying maximum speed of the truck several constrains as mentioned below.

Average speed = Maximum X constrain for the X constrain for the X constrain for the
speed road condition traffic condition load

Assumed maximum speed of the truck= 40 km/h

Table 2: *Constrains for road conditions*

Road which has two or more lanes.	0.90
Road wish has less than one two lanes.	0.70

Table 3: *Constrains for traffic conditions*

No of lanes / Time period	Less than two lanes	Two or more lanes
0700 hrs	0.75	0.50
1200 hrs	0.90	0.75
2200 hrs	0.90	0.90

Table 4: *Constrains for loading*

Loaded Truck	0.80
Unloaded Truck	1.00

After calculating average speed, travel times between nodes are calculated and delay fur each node is added to the total travel time. All the roundabouts are divided in to two categories as roundabout with color lights and without color lights. Therefore, assumed delays for the roundabouts will be as mentioned below,

Table 5: *Delays for the Junctions.*

Time / Period / Roundabout type	07000 hrs	1200 hrs	2200 hrs
With colour lights	2.50mins	2.00mins	0.75mins
Without colour lights	1.50mins	1.50mins	0.50mins

After final simulations, best respected to the traffic flow were as follows,

Table 6: *Best routes between Batching plant and construction sites*

Start	Finish	Best route (Route number)		
		0700 hrs	1200hrs	2200hrs
Batching plant	SKJU site	Route 01	Route 01	Route 01
SKJU site	Batching plant	Route 01	Route 01	Route 01
Batching plant	SKJU site	Route 02	Route 02	Route 01
SKMV site	Batching plant	Route 02	Route 02	Route 01

6. Analyses and Discussion of Results

After solving the “vehicle Routing Problem solver” in “Network Analyst” extension, routes are automatically categorized in “Vehicle Routing Problem “tool bar. Two construction sites have been considered in this research. Once coordinates of construction sites are imported to the map, we can identify the routes which are available (Devarasetty, 2010). Basically shortest route will be shown (Bagli et al., 2011) and before decide using the shortest route it is necessitate to consider about the traffic condition, road condition and whether conditions. Therefore, considering the travel time according to the traffic flow and the delays in junctions, average speed has been calculated and imported to road network. Hence, if sudden barriers showed up, truck mixer driver can contact the batching plant and ask for a guide. Then plant management can see the all other routes on the map and they will be able to guide them in most economical and fastest way considering travel times between nodes. It may reduce unnecessary delays due as discussed in introduction. So then the batching plant will be able to provide better and quality service. Furthermore, batching plant will be

able categorize the map by considering the distance and relevant constrains, in to specific areas. Once the concrete is ordered, they can offer an accurate rate in seconds by looking at that category (Nayati M., 2008). By the real time tracking system, location of the truck mixer will be shown on the display in every ten seconds. (M Lu, X Shen, W. Chen, 2006). If the truck has been stopped unnecessarily, plant can inquire the reason. Using this system batching will have the capability to take down follows Instead of filling a receipt traditionally.

- Plant departure time.
- Site arrivals time.
- Site departure time.
- Plant arrivals time.

So it may solve all the conflicts between the plant and the drivers. Even the drivers are encouraged to drive quickly because they know that they are inspected secretly. In a sudden break down or an accident, even the driver unable to explain the exact location, batching plant can identify the location and reach him as soon as possible even if construction site complaint about delays, batching plant would be answer them with evidence. Therefore, he can provide a more efficient, height quality service, which beats the competitive market. Similarly, construction site can plan his construction project well and accomplish his goals expected and under expected budget. Apart from that is possible to utilize these applications to supply management organizations such a currier and logistic, traffic planners, fire brigades, security forces, airline organizations and other transportation organizations. So they can identify the problem accrued during the process and attend to find solutions in an instant. As a result, they can offer an excellent service for their clients in fiercely competitive markets and optimize the time and money wastes-due.

Assigned routes from batching plant to above mentioned construction site will be as follows,

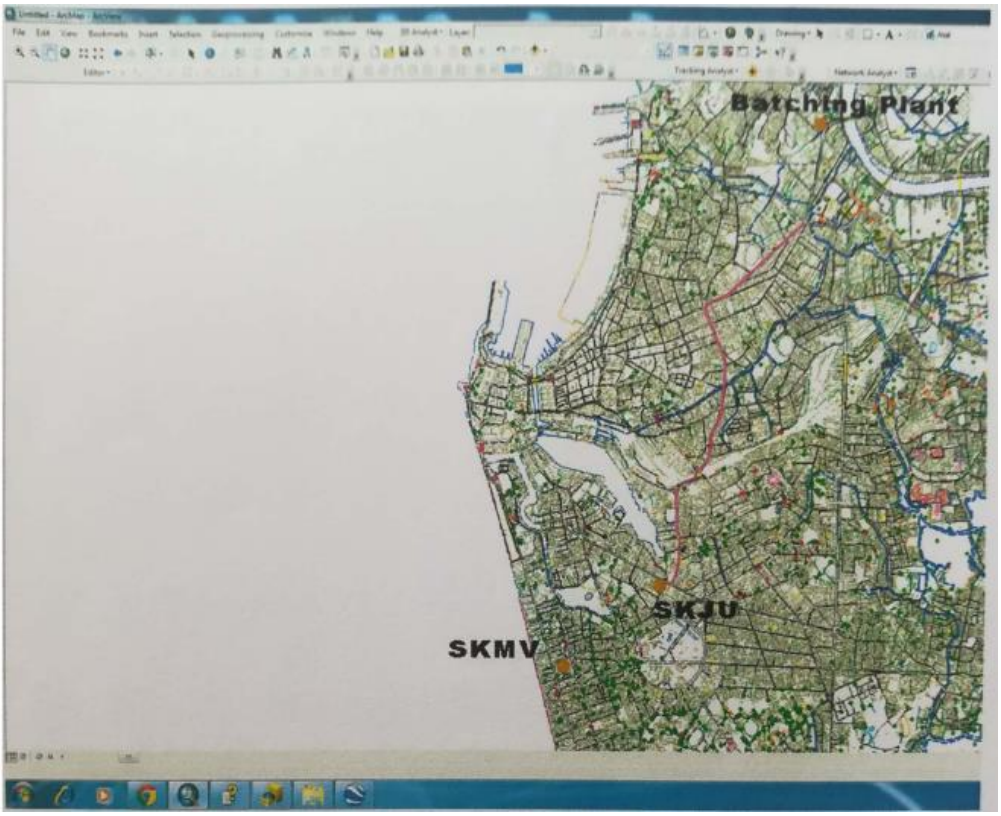

Figure 8: *Best route from batching plant to SKJU in all time*

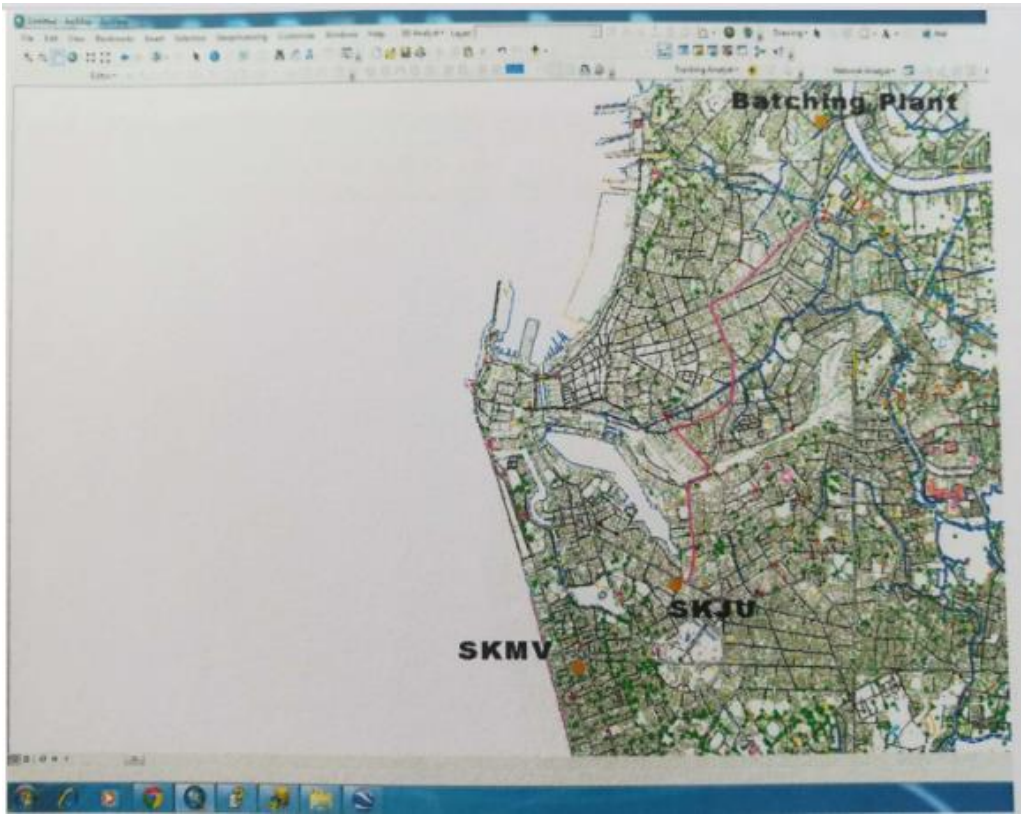

Figure 9: *Best route from SK.JU to Batching plant in all time*

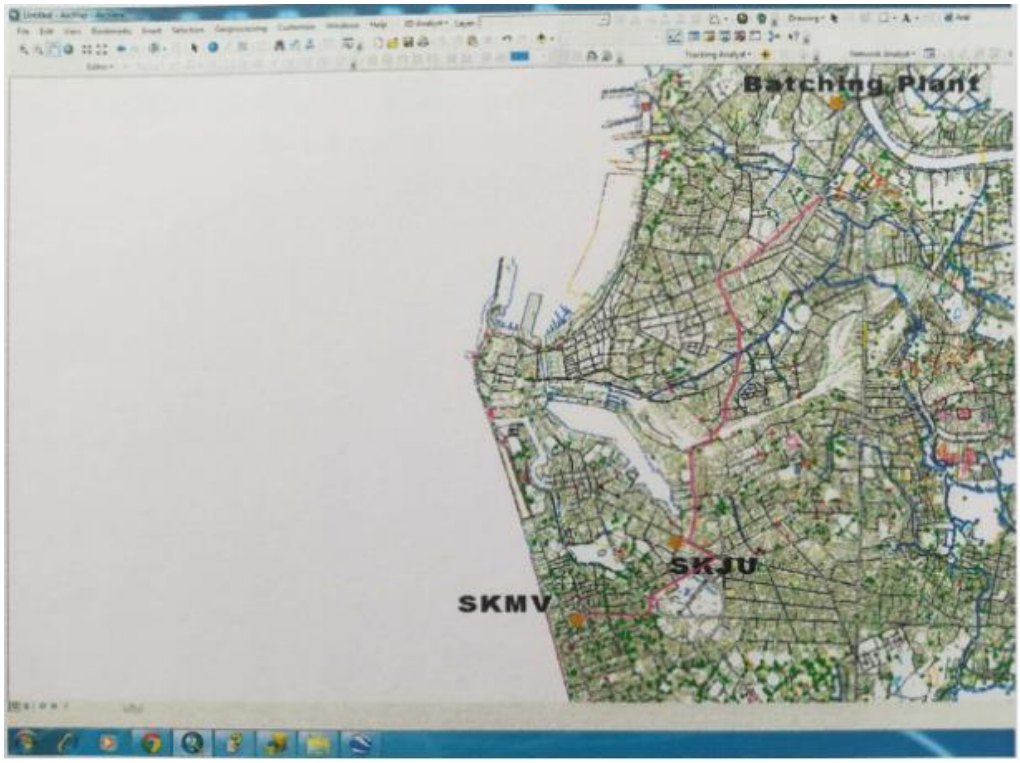

Figure 10: *Best route from Batching plant to SK.MV site and SK.MV site to Batching plant at 0700 hrs & 1200 hrs*

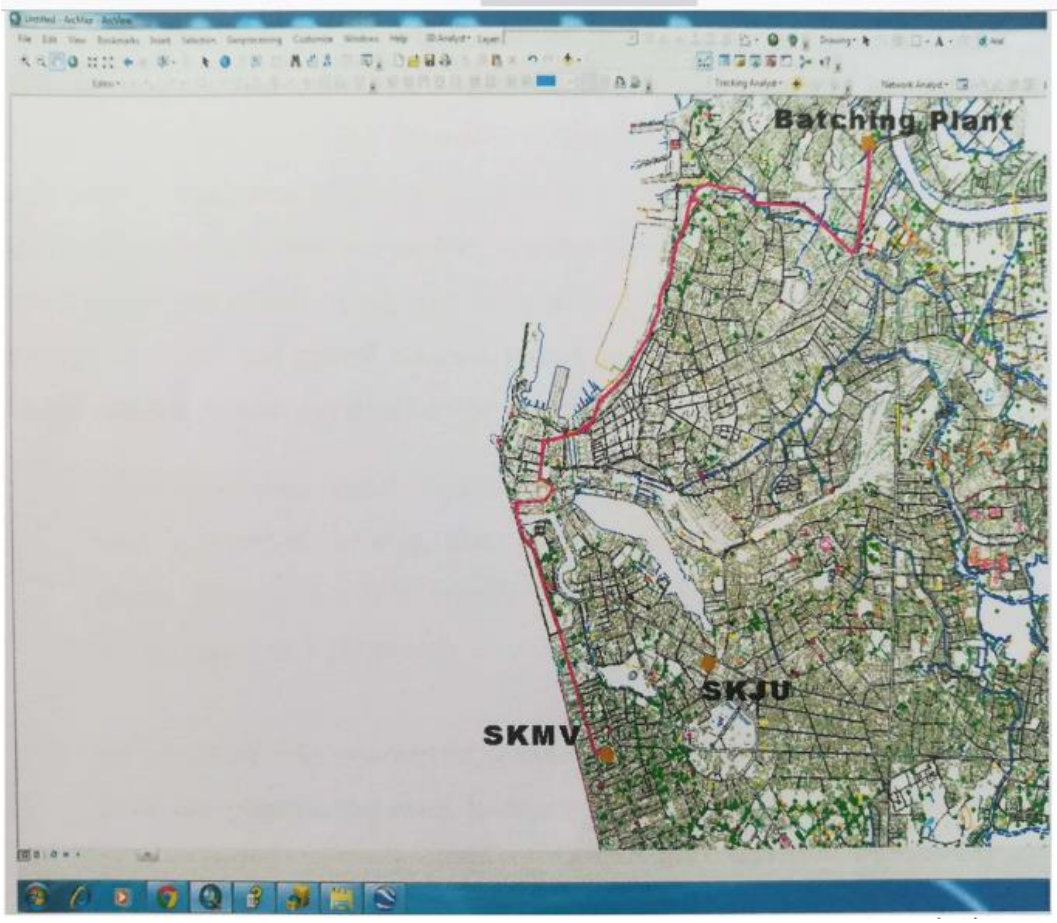

Figure 11: *Best route from Batching plant to SKMV site and SKMV site to Batching* plant at 2200 hrs

Conclusion

"Vehicle Routing Problem Solver" in Network Analyst" extension and "Tracking Analyst" extension are highly demanded extensions of ArcGIS in logistic industry and supply management industry. These applications are hugely involved in developing GIS based real time tracking the best route finding system. By developing above mentioned system, using ArcGIS to a concrete ready mixed plant, the pant manger can track and control the truck easily while he is in an office. The advantages of such a system may be enumerated a follows.

Since the average speed respected to traffic flow and delays in nodes have been imported to the map, plant manager can identify the best route in an instant. Hence, he will be capable of procuring concrete to the construction site on time with high quality.

He would be able to ascertain whether a truck mixer is following the given route and pinpoint the exact locations where stops are made by the drivers Unnecessary.

He would be able to determine the exact location of the truck mixer at any given point in time by using GPS coordinates. Plant manager can easily identify misleads doing by the truck mixers and reach them in an urgency.

With such a system in place, a supplier could help project managers adhere to a given budget and construction program and literally help save millions in rupees and thousands of unnecessary labor hours.

At the beginning of this research, it was quite difficult to find out the digitized map of the Colombo city. So then I used AutoCAD road network map which is converted to a shape file. Road network map I found was drawn under different coordinate system from the Kandawala coordinate system. Then it was resolved by importing Kandawala coordinate system to the road network map. Furthermore, if traffics data in all these routes were not easily available. Therefore, some assumptions were taken accordingly. For this research, network data set was created only for two construction sites. In further development or in application it is necessary to obtain exact constrains for the junctions and average speed respected to the traffic flow which required traffic details of past years. Then it takes only seconds to find the best route and time taken to travel.

Recommendation for Future Works

- A detailed network data set should be created including 'Historical traffic conditions and road conditions.
- Above systems could be introduced and developed in to broader areas. Especially in textile industry, emergency services such as fire rescue and ambulance services etc.

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