Positive Impact of El Azhar Road Tunnels on Transport energy, Environment and Tourism in Fatimid Cairo.

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Abstract: The Fatimid Cairo was built one thousand ago by El Moez Li-Dinellah to be the capital of Islamic Egypt. It has many historic Islamic buildings and monuments and it is a very attractive area for tourists and traders as they can find the most famous antique markets in Khan El Khalily and many other places. The main route in the area is El Azhar street which passing through it. The ministry of transport built a two level steel bridge along the street to solve the problems of transport and traffic congestion in seventies of the last century. The bridge and the very crowded street caused a bad appearance of the historic buildings in addition to the high rate of energy lost in transport, air and noise pollutions which affect badly on the residents and tourists. To avoid these negative impacts, the ministry of transport and National Authority for tunnels constructed two road tunnels under El Azhar street. This paper contains the main features of the transportation means in the Fatimid Cairo before and after building of the tunnels. Comparisons and analysis will be carried to clarify the advantages of the tunnels and their positive impact on saving energy and reducing rates of air and noise pollutions as the result of the higher ventilation chimneys and preventing on surface traffic.

1. Fatimid Cairo Description

1.1 Establishment of Fatimid Cairo

When the Fatimid region (969 – 1171) settled in Cairo under the leadership of El Moez Li-Dinellah it was called "Cairo of El Moez" because Fatimid people decorated its four suburbs with luxurious buildings, delightful spots and gardens. It was the settlement of rulers and princes where they built about 360 historic Islamic buildings. Al Azhar Mosque was established in 972 in porticoes style shortly after the founding of Cairo itself, and located in the center of an area teaming with the most beautiful Islamic monuments from 10^{th} century [1]. Architecturally, the mosque is a palimpsest of all styles and influences that have passed through Egypt.

Today the university built around the mosque is the most prestigious of Muslims school, and its students are highly esteemed for their traditional training. In addition to the religious studies, modern schools of medicine, science and foreign languages have also been added. Nowadays, the ministry of culture renewals all these ancient buildings which are lying in the area from north of Gamaleya to Bab El Wazir in the south and from Salah Salem road at the east to Portsaid street at the west. Fatimid Cairo Zone is shown in the map illustrated in Figure 1.

1.2 Natural Environment

It is 35.5 ^{o}c of the average high temperature and 21.0 ^{o}c of the average low temperature in summer and it is 18.5 ^{o}c and 7.1 ^{o}c in winter. Moreover, the precipitation in Cairo is little and also the rainfall in winter is about 24.3 mm in average. Greater Cairo has a population of 17 millions, with area of 7000 ha. The growth rate of population in last 13 years was 13 % which shows average rate of 1.3% per year [2].

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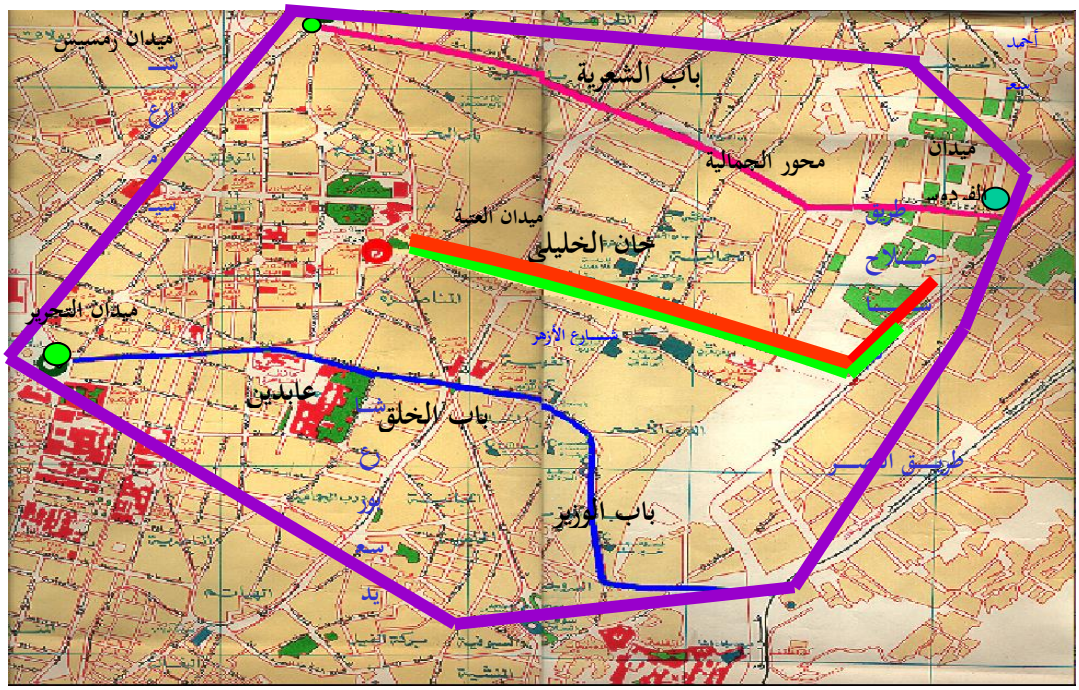

Figure1: Fatimid Cairo zone

1.3 Tourism and Marketing

In the heart of the Fatimid Cairo Khan El Khalili was built by Emir Djaharks El Khalili in 1382 [1]. Together with the Al-Muski and Al Azhar markets to the west, they comprise one of Cairo`s most important shopping areas. But more than that, they represent the market tradition which established Cairo as a major center of trade, and at the khan, a lot of tourists and foreign merchants are found along the year. As shown in Table 1, the number of tourists visited Egypt is in increase [3].

1.4 Urban Transport in Fatimid Cairo

Due to the economic development, population has concentrated in the city leading to high increasing in transport demand. The public transport system of the city is composed of buses, minibuses and microbuses. Also, motor cars have rapidly increased and a chronic traffic jam has often occurred at major junctions in recent years. Such increase of traffic volume has not only brought air and noise pollution, but also obstruction of economic activities and expansions.

Table 1: Number of tourists visited Egypt in 2004 -2005

Region	2005	2004	Change
Middle East	1224573	1084410	12.93
Africa	203481	184667	10.19
America	218681	193614	12.95
Europe	4528115	4376572	3.46
East Asia	296824	261225	13.63
Total	6471674	6100488	6.08

2. Problem Definition

2.1 Assessment of traffic characteristics in Fatimid Cairo

Studies which had been carried out in seventies of the last century agreed that the main solution to meet the requirements of urban transport inside Fatimid Cairo is to build a steel bridge of two levels in order to connect El Darrassa in the east of El Azhar street with the city center of Cairo, in addition to keeping the on ground surface traffic [4].

The bridge was built in the beginning of eighties passing through El Azhar street, and it transfers the traffic flow which is coming from Salah Salem Road to El Opera Square and also in the opposite direction. Figure 2 shows a photo of El Azhar bridge clarifying the worst sight seeing of it. In-movement licensed vehicles through Cairo in the end of year 1991 are shown in Table 2 [4].

Table 2: Licensed Vehicles through Cairo in year of 1991

Type of vehicles		**No. of Vehicles**
Private cars		515402
Taxi		63445
Buses	**Public**	5116
	Private	5080
	Tourism	4717
	School	1387
Lorry and Truck		104098
Motor cycles		98327
Others		66163
Total		863735

It is also illustrated in the study which carried out in 1998 that no. of trips in the city is 14.1 million trip and vehicle speeds for different transport modes used in Cairo in the study year is 15.9 km/h for buses, 17.4km/h for minibuses, and 20 km/h for private cars. Average delay time and noise level recorded in El Azhar street was 30 minutes and 80 to 85 decibels respectively [4].

Figure 2: Bad sight seeing of El Azhar steel bridge

2.2 Causes of Traffic pollution and Increasing of Fuel Consumption

Pollution and negative impact due to traffic in urban areas is divided into three common types as follows:

1- Air pollution
2- Noise pollution
3- Bad sight – seeing
4- Increasing of Fuel Consumption
5- Solid Waste

2.2.1 Air pollution

Traffic in urban areas is the main producer of air pollution and has negative impact on air quality. Hydrocarbons and nitrogen oxides come from a great variety of industrial and combustion processes. A previous study carried out in USA clarified that the share of vehicles in emissions of nitrogen and hydrocarbons is 71% and 70% respectively. Also, increasing in air pollutants ratios is directly depending on traffic volume, traffic density and vehicle speed. It is illustrated in Figure 3 that vehicle speed has two opposite effects as the increase in vehicle speed needs an increase in the required motor power, resulting in higher fuel combustion and fumes.
On the other hand, increasing in vehicle speed reduces trip time, thus it reduces the volume of fumes. Incomplete combustion is most likely to occur at low air to fuel ratios in the engine. These conditions are common during vehicle starting when air supply is restricted, when cars are not tuned properly, and at altitude, where thin air effectively reduces the amount of oxygen available for combustion [5].

Nationwide, two thirds of carbon monoxide emissions come from transportation sources, with the largest contribution coming from highway motor vehicles. In urban areas, the motor vehicle contribution to carbon monoxide pollution can exceed 80%. Also, ozone is formed in the atmosphere through a complex set of chemical reactions involving hydrocarbons, oxides of nitrogen, and sun light. Ozone is a severe irritant as it is responsible for the choking, coughing, and stinging eyes associated with smog [6].

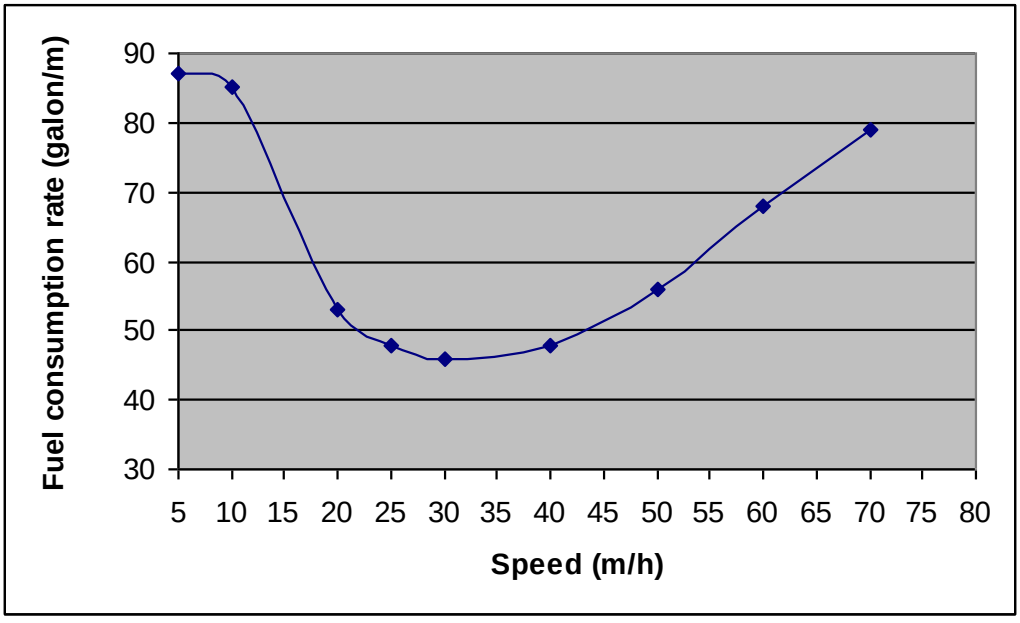

Figure 3: Effect of private car speed on fuel consumption rate

2.2.2 Noise pollution

Sources of traffic noise includes: system of vehicle exhaust, friction between vehicle tyres and pavement surface, and motor voice. Figure 4 shows the direct effect of vehicle speed and traffic density on noise levels emitted from private cars. People who are exposed to high noise levels for short discontinuous periods may lose part of their hearing for some period, but those who are expose to high noise levels for long continuous periods may lose part or all hearing abilities. Headache, stress and nervous instability may happen to the human body during the period of hearing loss [6] .

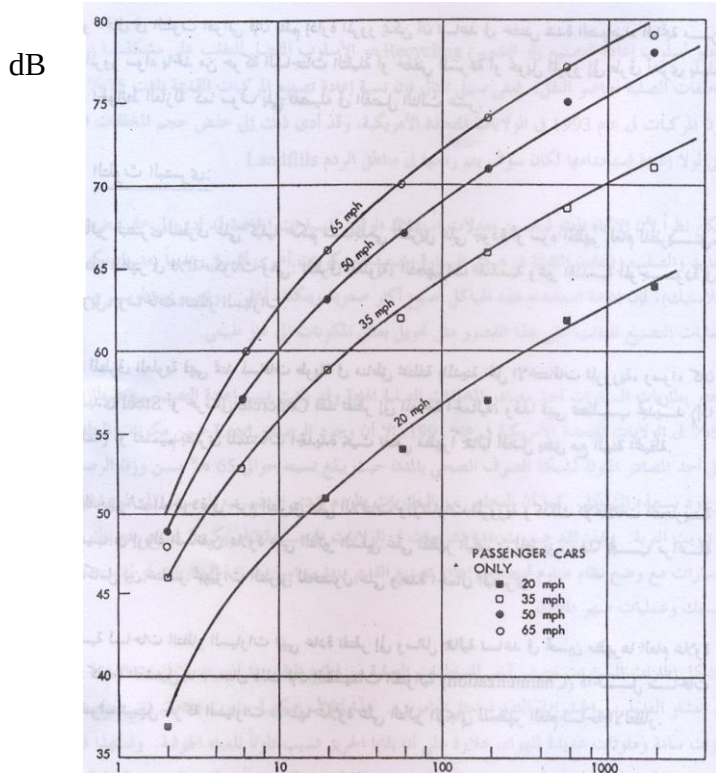

Figure 4: Noise levels generated from traffic movement

The Egyptian law No.4 for environmental protection of 1994 limits the maximum value of noise level in the street to 50 dB(A) during daytime, and 40 dB(A) at night-time. German specifications give standard noise levels as shown in Table 3 [7].

2.2.3 Bad sight - seeing

Appearance of road depends on three components, elevated structures (viaducts and bridges), road geometries, mobilizations in the right of way and parking areas. Steel and concrete bridges cause prohibition of sight seeing and reaching sun light to the on surface ground, especially at the case of narrow streets.

Table3 Standard Noise Levels by VDI 2719

Type of Room	Lp dB(A)
Bedrooms at Night • Residential Areas • Other Areas	 35 to 40 40 to 45
Living Rooms at Daytime • Residential Areas • Other Areas	 40 to 45 45 to 50
Communication & Workrooms at daytime • Classrooms • Offices for several persons • Open plan and service halls	 40 to 50 45 to 55 50 to 60

2.2..4 Increasing of Fuel Consumption

Main causes of increasing the rate of fuel consumption of traffic are overcoming the rolling resistance and overcoming the mechanical loss during movement and Idling. Idling rate of fuel consumption is 650 gallon per 1000 vehicle-hour. Volume of consumed fuel in a trip of length (D) and time (T) can be given by the following model[8].

F = K1* D + K2 * T where,

K1 = rate of fuel consumption to overcome the rolling resistance.

K2 = rate of fuel consumption to overcome the mechanical loss during movement and idling.

Vehicle type affects on values of **K1** and **K2** as given in Table 4 [8].

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Table 4: Values of **K1** and **K2**

Type of vehicles	**K1** (mm litre /km)	**K2** (mm litre /km)
Standard car	111.59	1.045
High class car	121.8	1.084
Small car	90.30	0.44
Minibus	100.91	0.40

3. Analysis of Traffic characteristics in Fatimid Cairo

It is given in item 2 that maximum speed for private car in a trip through El Azhar Street is 20 km/h only and delay time is 30 minute, so by substitution in the equation given in the previous item, the volume of consumed fuel for a standard car through El Azhar street in year 1998 at the delay time can be calculated as follows:

F1 = 111.59 * 2.650 + 1.045 * 30 * 60
= 2176.71 mm litre

The required consumed fuel for traveling through El Azhar street in average speed of 20 km/h can also be calculated as follows:

F2 = 111.59 * 2.650 + 1.045 * (2.65/20) * 60 *60
= 794.18 mm litre

The total fuel = 2176.71 + 794.18
= 2970.89 mm litre

If it is considered that the allowable speed is 60 km/h, the fuel required for the same trip can be calculated as follows:
F =111.59 * 2.650 + 1.045 * (2.65/60) * 60 * 60
= 461.87 mm litre
Loss of fuel for one car = 2970.89 - 461.87 = 2509.02 mm litre

In addition to the loss of consumed fuel, it causes emissions of pollutants such as hydrocarbons, ozone and nitrogen oxides depending on the number of speed reductions and returning from. Also, noise levels have been assessed as 70 to 80 dB, which is more than the standard levels. Bad Appearance is also noticed in the tourist area due to the two levels elevated steel bridge as explained before and shown in Figure 2.

Based on several studies and the summarized analysis in the previous item, transport problems were identified in Fatimid Cairo are summarized as follows:

1- Congestion roads caused by large number of vehicles due to high demand for transport service in peak hours.
2- Crowded modes of transport especially on public sector for some routes passing through crowded districts due to insufficient supply against high demand.
3- Low degree of efficiency and comfort on some public modes.
4- Unnecessary fuel consumption caused by low speed traveling, and due to speed reduction and return from.
5- Long trip and delay times.
6- Air and noise pollutions.
7- Bad Appearance.

3. Necessity of El Azhar Road Tunnels

Within the framework of a revival and development plan for the glorious tourist area, the project of El Azhar road tunnels has been proposed. The main objectives of this project are:
1- Providing a safe and efficient underground transport mean.
2- Creating a vehicular free surface for tourism and pedestrian purposes.
3- Reduction of air and noise pollutions on the ground surface of Fatimid Cairo.
4- Enhancement of appearance by removal of the elevated bridge.

To achieve the above mentioned objectives the ministry of transport and National Authority for Tunnels decided to construct two tunnels under El Azhar street. The north tunnel transfers the traffic flow from Salah Salem road to El Opera square and the south tunnel for the opposite direction as shown in Figure 5.

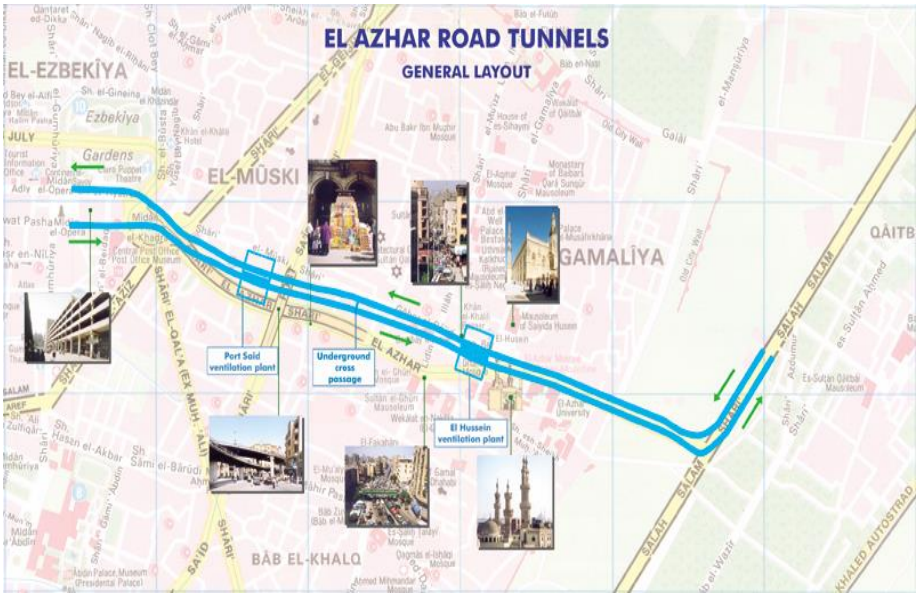

Figure 5: General layout of El Azhar road tunnels

3.1 Tunnel Cross Section

The bored tunnel cross section was constructed using two bentonite slurry tunnel boring machines. Each of them was of 9.44 m in diameter and 66 m long to follow the designed alignment, where each tunnel should have two traffic lanes per direction as shown in Figure 6 [9].

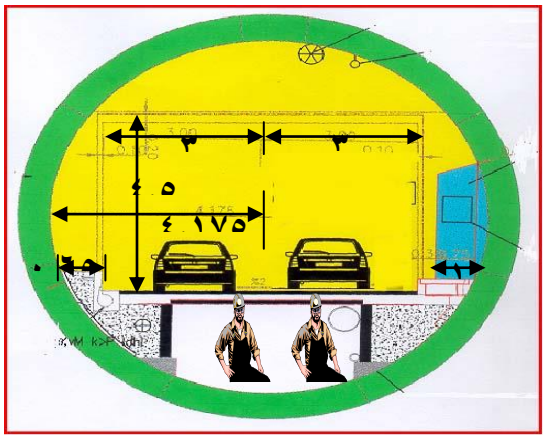

Figure 6: El Azhar tunnel cross section

3.2 Ventilation System

The project contains 4 ventilation stations, where they are working for the two tunnels in 4 different locations. Every one contains fans for drawing and entering pure air and other fans for exhausting air. The ventilation chimneys were architecturally built with the same style of the surrounding historic buildings, and they are higher than the adjacent building, as shown in Figures 7 and 8.

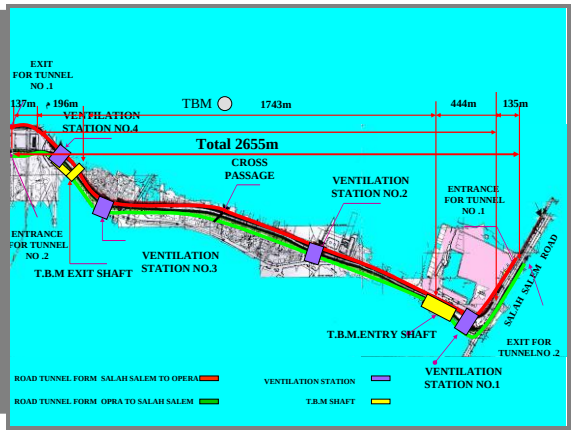

Figure7: Islamic style of ventilation chimneys. Figure 8: Locations of ventilation stations

The two tunnels are also equipped with air quality monitoring instruments to chick the degree of noxious fumes and alarms which will alert the operators to any problems with the ventilation equipment.

4. Conclusion

It is concluded from the precious analysis that construction of El Azhar road tunnels contributes in solving many transport and traffic bad effects, thus it helps in protecting and keeping the historic buildings in Fatimid Cairo. The positive impact of building the tunnels can be summarized as follows:

1- Reduction of the trip time to 4 minutes instead of more than half an hour.
2- Reduction of fuel consumption of passing cars by about 84%.
3- Reduction of accident rates and traffic jams.
4- The tunnels contribute in reducing air and noise pollutions by about 60% in case of removing the steel bridge.
5- Offering a vehicular free surface for tourism and pedestrians purposes, thus better appearance of the historic buildings will be achieved.

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