Improvement of Road Layout and Safety in an Urban Environment: Towards a Pedestrian-Friendly Street Corniche of Alexandria as a Case Study

Mohamed Atef Elhamy
College of Engineering and Technology, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt.

ABSTRACT
More than a million people are killed on the world's roads each year. Despite this grim number, some urban transport development policies are looking for increasing automobile use in towns and cities while turning a blind eye towards all forms of public or non-automotive transportation. The aim of this research is to gain better knowledge of how new road layout improvements influence pedestrian safety. It is focused primarily on the analysis of the development project of the Corniche (i.e. coastal path) of Alexandria. New evaluation needs to analyze how this development influence pedestrian safety which is why a methodology has been defined based on several existing approaches: (a) Evaluation of pedestrian safety problems: quantitative approach and qualitative approach; and (b) analyzing of new practices arising from this improvement project. The research demonstrates the need to evaluate road layout improvements that may involve changes in practices that generate new road safety problems, particularly for pedestrians.

1. INTRODUCTION
Traffic accidents are one of the world's largest preventable public health & injury problems. A report published in 2009 by the World Health Organization (WHO) estimated that some 1.2 million people were killed, and between 20 and 50 million suffer non-fatal injuries in traffic collisions on the roads around the world each year. The report illustrated that these collisions were the leading cause of death among

children between 10 and 19 years of age. It also noted that the problem was most severe in developing countries. Over 90% of the world's fatalities on the roads occur in low-income and middle-income countries, which have only 48% of the world's registered vehicles, as shown in Figure 1. Almost half of those who die in road traffic accidents are pedestrians, cyclists or users of motorized two-wheelers - collectively known as "vulnerable road users"- and this proportion is higher in the poorer economies of the world. The WHO report has shown that Egypt is among the highest ten countries in terms of road traffic fatalities [1].

A report published in 2011 by The Central Agency for Public Mobilization and Statistics (CAPMAS) demonstrated that road traffic accidents in Egypt have increased to 25353 by 40.9% between 2010 and 1990, and the number of fatalities has increased to 7640 by 54.9%. It also noted that number of injuries has increased to 39028 by 106.6% in the same period [2], as shown in Table 1 and Figure 2.

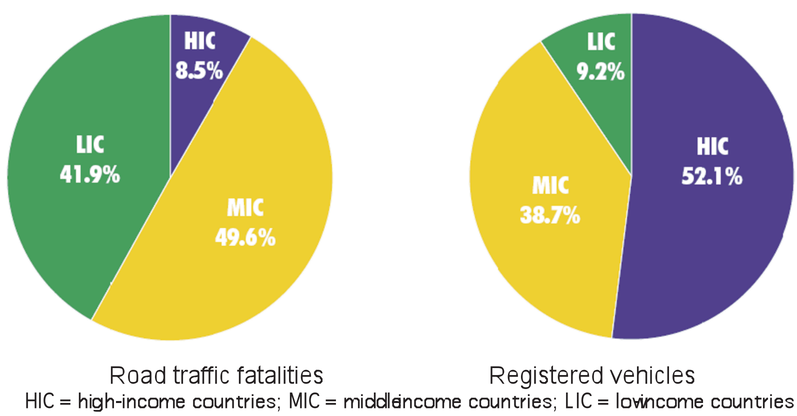


Figure 1. Road traffic fatalities and registered vehicles in the world

Table 1. Motor vehicles accidents and their results in Egypt during the year 2010

Number of registered vehicles	5814385
Number of reported accidents	25353
Reported number of traffic fatalities (70% males, 30% females)	7640
Reported non-fatal road traffic injuries	39028
Estimated road traffic fatalities rate per 100 000 population	32

Accident statistics in Egypt show that pedestrian fatalities account for about 20% of total fatalities in traffic collisions, as shown in Table 2. These statistics clearly showed that pedestrians comprised one of the most vulnerable groups of road users in Egypt. However, pedestrians and other road users have not been explicitly targeted in the National Decade of Action for Road Safety, 2011–2020 (NDARS).

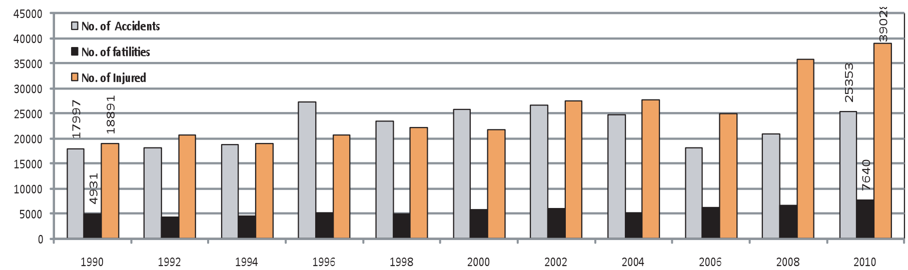


Figure 2. Vehicles Accidents and Its Results in Egypt, 1990 – 2010

Table 2. Fatalities by road user category in Egypt

Fatalities by road user category	Percent.
Percentage of Drivers/ passengers of 4-wheeled vehicles	47.5
Percentage of Pedestrians	20.1
Percentage of Cyclists	1.9
Percentage of Drivers/ passengers of motorized 2- or 3-wheelers	0.1
Percentage of Other or unspecified users	30.4

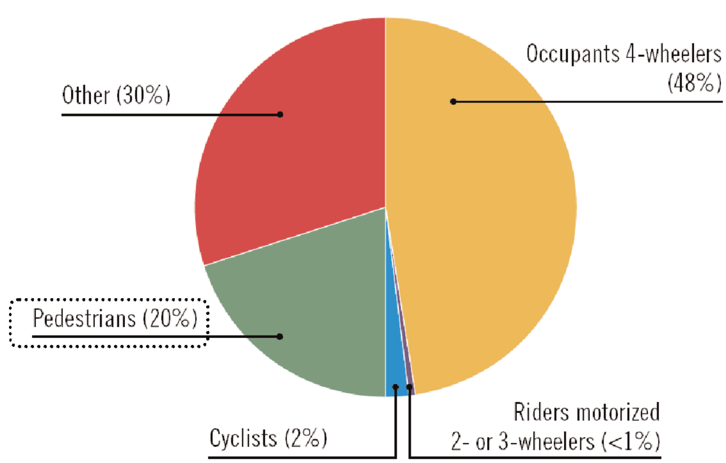


Figure 3. Fatalities by road user category

A recent study estimates the cost of traffic accidents in Egypt for 2008 at around 10 billion Egyptian Pounds (1.6 billion U.S. dollars) with an average cost per accident of 500 thousand Egyptian Pounds ($84 thousand U.S. dollars). Moreover, the study expected a steady increase during the following years [3].

2. THE PRINCIPLE OF PEOPLE FIRST FOR ROAD TRAFFIC SAFETY POLICY

Road traffic is the result of the interaction between humans, vehicles, and environment (road infrastructure, regulation, etc.). In this process, the human is a key (and determining) element, but it is also the weakest link, in terms of both behavior and vulnerability [4].

Vulnerable road users- pedestrians, cyclists and drivers of motorized two-wheelers and their passengers account for almost half of global road traffic fatalities. Pedestrians, in particular, are among the most vulnerable road users. They are involved in more accidents in developing countries than in developed countries. Pedestrians are under additional threat where their needs have not been taken into consideration during the planning of road construction or improvement. In many countries, roads are planned and built to allow motor vehicle to travel faster while insufficient thought is given to the needs of pedestrians which means that these vulnerable road users face increasing risk in using and crossing the roads [5]. It is necessary to further secure the safety of pedestrians, as well as the safety of those especially vulnerable, such as the elderly, the disabled, and children.

3. WHAT MAKES A STREET PEDESTRIAN-FRIENDLY?

A pedestrian-friendly street is interactive, achieving a balance between the various forms of transit: cars, bikes, buses and pedestrians so that it does not favor motorized traffic. These streets tend to share the following physical characteristics:

3.1 Pedestrians Are Effectively Separated From Moving Traffic

Even the ancients knew it was a good idea to separate pedestrians from vehicles roadways. Fruin presents a comprehensive historical perspective of the methods used in the past to limit vehicular intrusion into cities; regulations prohibiting heavy wagons within the central city after dusk; vehicle/ pedestrian separation using stone barriers and metal spikes; and special areas along main thoroughfares where pedestrians could rest [6].

Medieval city planners provided central pedestrian plazas as an open space for the marketplace and the cathedral, as well as a location for festive occasions and recreation. In a number of cities, pedestrians were protected from the elements by galleries, canopies, colonnades, and porticos. The introduction and increased use of motor vehicles in urban areas has made it much more difficult to ensure pedestrian safety and mobility.

In many high-density cities, the sidewalk width has been reduced to facilitate vehicular traffic movement. The potential pedestrian capacity of the sidewalks is further reduced by the intrusion of traffic signals, signposts, telephone booths, bus benches, sewer and other street furniture. Therefore, pedestrian forced to walk out of the pavement. Separation can be provided through the use of sidewalks of suitable width for the expected pedestrian traffic. On-street parking can create a buffer, separating pedestrian on the sidewalk from the motor vehicle traffic on the adjacent roadway. For 60 to 70 km/h, it is recommended that parking be restricted to 15 m from the crosswalk to enhance sight distance [7]. Separation can also be enhanced by incorporating at least

60-cm planting strip in arterial and collector streets' sidewalks [8]. Additional physical barriers could be used to prevent pedestrians crossing in dangerous locations.

3.2 Pedestrians Can Cross the Street Safely and Easily

As a result of increasing use of motor vehicles, most space provided for pedestrians has been sacrificed to provide space for motor vehicle traffic. The wider streets increase the likelihood of pedestrian-vehicle crosswalk conflicts, which increases accident risk. Therefore, the number of lanes should be reduced. Raised medians should be installed on all roads of 4 or more lanes, which can substantially reduce pedestrian, accident risk and also facilitate safe street crossing. Thus, they potentially are the most effective solution to street crossing problems [9].

On the other hand, intersections should be designed to reduce pedestrian crossing distances. Crosswalks should be ample, clearly marked and aligned with sidewalks and pedestrian crosswalk signals should be introduced to facilitate pedestrian crossings. Bridges and underpasses can substantially improve safety for pedestrians needing to cross-busy arterial streets at certain locations. However, they tend to be unpopular with pedestrians due to the additional distance and effort required. Therefore, such facilities must be carefully planned and designed to encourage pedestrians to use the facilities and not continue to cross at street level.

Many of traffic-calming measures such as street closures, speed humps, chicanes (series of alternating curb extensions), traffic curbs, diverters, and others can effectively improve safety for pedestrians and/or traffic as a whole based on reductions in vehicle speeds in neighborhood streets [10].

Enforcement of traffic laws and regulations represents another important element in safe pedestrian activity in a roadway environment. This includes not only the enforcement of pedestrian regulations (e.g., jaywalking, crossing against the signal) but also motorist actions related to pedestrians (e.g., speeding, yielding to pedestrians when turning) [11]. Finally, substantially improved nighttime light that enhances pedestrian safety should be provided.

3.3 The Streets Are Full of Life

Sidewalks and walkways enhance pedestrian safety and mobility. This is a critical component of a pedestrian transportation network in urban and suburban areas. Well-designed paving, street furniture (e.g. benches, seating areas, artwork, etc.), landscaping and lighting make the public sidewalk a place where people want to be. These features create a sense of place on the street and are also important visual traffic calming measures. Furthermore, retail and restaurants thrive on pedestrian-friendly streets providing visual interest for pedestrians. On the other hand, numerous treatments must be existed to address the needs of pedestrians with disabilities, such as textured pavements, audible and vibrating pedestrian signals, larger signs and pedestrian signals, wheelchair ramps, and others [12]. All characteristics should be organized in prototype design standards that are used consistently to encourage pedestrian-friendly streets. Design standards should specify and illustrate sidewalk and crosswalk configurations, materials and detailing, landscaping placement, lighting, street furniture, etc. These characteristics could be achieved through some performance objectives as shown in Figure 5. On the other hand, it is with no doubt that design should consider the cost as an important factor.

Figure 4. Some physical characteristics of Pedestrian-friendly Street.

Objective	Pedestrian Facility Design	Roadway Design	Intersection Design	Traffic Calming	Traffic Management	Signals and Signs	Other Measures
Reduce speed of motor vehicle		• Add shoulder • Road narrowing • Reduce number of lanes	• Modem roundabouts	• Curb extension • Choker • Chicane • Speed humps • Speed table • Raised pedestrian crossing • Raised intersection • Woonerf • Paving treatments		• Adjust signal timing for motor vehicle	• Speed monitoring motor trailer
Improve sight distance visibility for motor vehicles and pedestrian	• Crosswalk enhancements • Roadway lighting • Move poles at street comers	• Add shoulders		• Curb extension • Speed table • Raised crossing • Raised intersection • Paving treatments		• Sign improvement	
Reduce volume of motor vehicles		• Reduce number of lanes		• Woonerf	• Diverters • Mill. Sneer closure • Partial street closure • Pedestrian street		
Reduce exposure for pedestrians	• Bridges / underpasses.	• Road narrowing • Reduce number of lanes • Raised median • crossing island		• Curb extension • Choker • Pedestrian crossing island		• Pedestrian signal timing • Accessible pedestrian signal	
Improve pedestrian access and mobility	• Sidewalk /walkway • Curb ramps • Crosswalk enhancements • Transit stop treatments • Bridges / underpasses	• Raised median		• Choker • Pedestrian crossing island		• Traffic signal • Signal enhancement • Accessible pedestrian signal • Ped. signal timing	
Encourage walking by improving aesthetics	• Street furniture • Roadway lighting • Landscaping options	• Raised median		• Gateway • Landscaping • Paving treatments			• Identify neighborhood
Improve compliance with traffic laws			• Red-light cameras	• Traffic calming			• Speed monitoring trailer • Pedestrian/ driver education • Police enforcement
Eliminate behaviors that lead to crashes			• Red-light cameras	• Traffic calming		• Pedestrian signal timing	• Pedestrian/ driver education • Police enforcement

Figure 5. Matrix of potential performance objectives and measures for pedestrian-friendly streets

4. CORNICHE OF ALEXANDRIA AS A CASE STUDY

Alexandria, with a population of 4.1 million, is the chief port and the second-largest city in Egypt after Cairo. The city lies on the Mediterranean Sea at the western edge of the Nile Delta. Founded by Alexander the Great in 331 BC, Alexandria became the capital of Greco-Roman Egypt. However, ancient Alexandria was in a decline until the 19th century when it took a new role as a focus for Egypt's commercial and naval expansion [13].

Alexandria was organized around a gridiron plan, keeping with the Hellenistic tradition. The city is considered as a model of linear cities where the city extends along the seacoast. In such cities the main traffic extends longitudinally as major arteries parallel to the direction of the coast with perpendicular cross secondary roads. In Alexandria, there are two major arteries: Horria Avenue and The Corniche (a French word means the waterfront road).

4.1 Historical Background of the Corniche

Corniche of Alexandria is a waterfront promenade; a major street which runs along the Eastern Harbour. The Italian Egyptian architect Pietro Avoscani designed it in 1870 [14], [15]. The road in the eastern port area was developed during the period from 1905 to 1907 then it was extended to the suburb of Ramleh by year 1911. As a result of this extension, recreation centers were moved from Mahmudiyah Lake to the new waterfront [16]. During the nineteen twenties and thirties, the road was extended to Montaza palace, the eastern end of the Corniche. After several years, and as a result of over crowdedness, Alexandria's Corniche has been developed by extremely widening it. The project started in 1998 and continued until 2006, at distance between Montaza Palae and Selsela (Figures 6 & 7). The project was completed in six phases and included adding lanes to the Corniche Street along the Mediterranean waterfront, pedestrian and cycling paths, seating areas and recreational areas. Now Alexandria's Corniche is about 20 km long and about 30 meters wide on average.

Figure 6. Phases of Alexandria's Corniche development project

Figure 7. Phases of Alexandria's Corniche development project

4.2 Methodology

Road safety evaluation in literature often consists in taking stock of the number of road accidents before and after the improvement. This method, however, does not make it possible to determine the influence of the improvement. That is why a methodology has been defined based on several existing approaches with the following major principles: (a) evaluation of pedestrian safety problems: quantitative approach [17] and also qualitative approach, e.g. as used for traffic calming measures [18], and (b) evaluation of new practices arising from the improvement [19]. The developed methodology is based on six stages: (a) Researching the goals of the improvement; (b) a detailed analysis of the road layout; (c) a detailed analysis of the site environment (land use, practices, type of users, etc.). (This is often based on field observations and questionnaires); (d) defining the study area: the improved road only or the entire area of influence. (Road safety evaluations often deal with the improved area. Nevertheless, in some cases, the studied area is extended to the improvement's area of influence, which takes the various alternate routes into account); (e) Taking stock of the number of road accidents before and after the improvement. (Access to accident data is necessary to evaluate a project for pedestrian safety); and (f) A detailed analysis of accidents reports to identify accident scenarios before and after the improvement. This stage is based on official reports. Accident data should be available and reliable. In many countries, especially in the developed world, data may come from various sources, including police, insurance, ambulance, and hospital records. The situation, however, is different in developing countries, where it is very difficult to access the data as a result of lack of data, filing issues, authorization to consult data, etc. [20]. In these countries, the police accident data are not collected with a view to providing research information but for the purposes of litigations [21]. Therefore, such data do not have detailed information to carry out in-depth research. Similar to other developing countries, there is an enormous lack of detailed accident data in Egypt. The main source of local accident data is the ambulance. Interviews with road designers, users of the road improvement, municipal technical services, shopkeepers, etc. helps compensate for the lack of data (particularly for the period before the improvement).

4.2.1 Researching the goals of the improvement

According to The Arab Contractors, Osman A. Osman & co., the project aimed at increasing the road width through a total length of 17 km, including all new asphalt concrete works, renewing and upgrading the underground utilities (gas, electric, storm drains and traffic signals networks), sidewalks and pedestrian underpasses, in addition to shore protection activities.

4.2.2 A detailed analysis of the road layout

For analyzing The Corniche layout, it was divided into five sectors having the same characters, as shown in Figure 8.

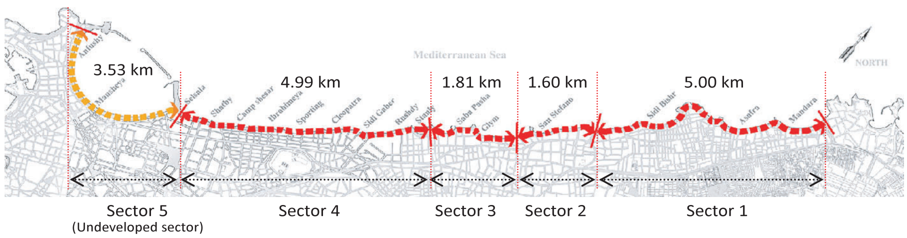


Figure 8. Five sectors of analysis

The analysis involves: (a) Pedestrian crossing distance: Crossing distances vary through the project sectors, as shown in Table 3. It reaches more than 40 m in some turns. Therefore, it separates the neighborhood from its coast; (b) Pedestrian underpasses, crosswalks and crosswalk signals: There are 13 underpasses along the Corniche. The underpasses distances do not equally diverge. Furthermore, the distances between the underpasses do not fit the capabilities of human mobility, causing the pedestrians to frequently cross the wide road "at their own risk" which increases accident rate. According to a questionnaire designed to daily users of the Corniche, 72.4% of the respondents prefer to use underpasses when they were available. 27.6% do not prefer to use underpasses or use it intermittently due to far distance, insecure feeling, laziness due to lack of escalators, and lack of cleanliness (answers ranked in order of importance). With regard to crosswalks and crosswalk signals, there are two new crosswalk signals along the Corniche. Crosswalks are clearly marked but crossing distance is excessively long and signals are not automatic; (c) Traffic calming and speed humps: In many places along the Corniche, cats-eye grids are used as traffic calming. However, they do not force motorists to slow down because they can easily be by-passed. It should be noted that there is not any speed hump installed along the Corniche; (d) Speed limitation: Low speed limits are not rigorously enforced. Moreover, some motorists do not know the speed limit on the road (which is 60 km/h). According to the questionnaire, 79.5% of the respondents know the speed limit. 20.5% of the respondents do not know the legal speed limit. However, only 4% of the respondents respect the speed limit while 96 % do not respect it. The questionnaire illustrates that 19.7% of the respondents drive at 100 km/h and faster; (e) Sidewalks: As a result of the development project, the old sidewalk adjacent to the shore was widened to 5 m. Furthermore, a new promenade was established along the sidewalk in the region from Sidi Gaber to Shatby, as well as from Louran to Glym. The questionnaire showed a positive indication from pedestrians using this side broad promenade. However, in some regions, shopkeepers use the opposite sidewalk as an extension to their shops which forces pedestrians to walk out of the pavement. This may lead to new types of road safety problems; (f) On-street parking: There is no place designed for on-street parking. There are only places for buses waiting in front of bus stops. However, public car parks are gathered in specific places along the Corniche, as shown in Figure 10. They accommodate a limited number of cars and are always crowded; (g) Physical barriers: Metal fences were used in the middle of the road in some places to prevent pedestrian from crossing the street from one side to the other. Needless to say, this fence is not a proper solution for decreasing pedestrian accidents; (h) Landscaping and street furniture: The promenade was furnished by providing clusters of sitting areas. A number of palm trees were planted in these sitting areas. However, long distances of the promenade seem to be unfriendly; (i) Lighting: The Corniche was supplied by satisfactory lighting. However, lighting in some places need to be enhanced especially in Sidi Gaber; and (j) Entertainment activities: Clusters of services and activities were provided through the development project. A number of social clubs and restaurants were established along the Corniche. Moreover, active water related activities significantly increased.

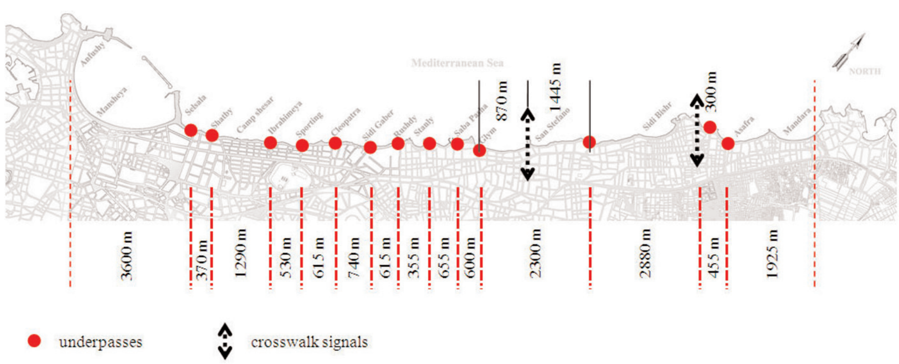
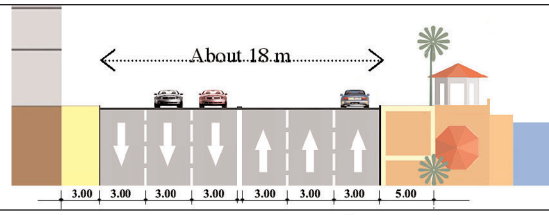
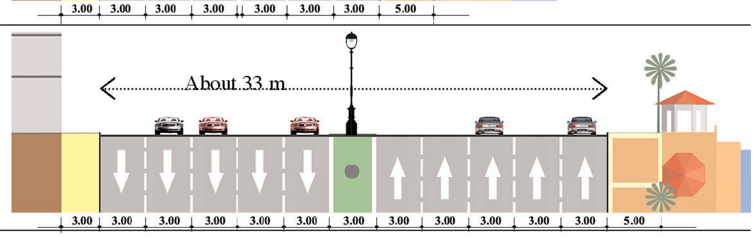
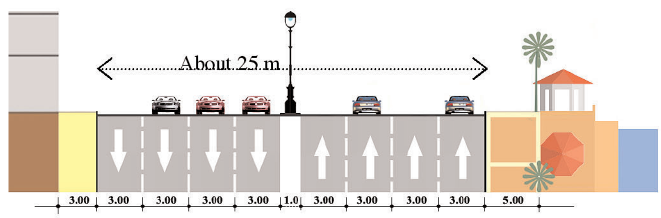
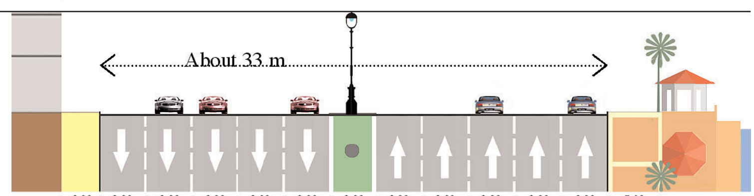
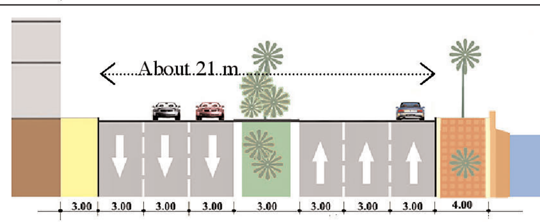
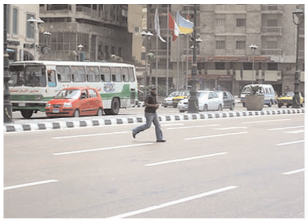


Figure 9. Walk distances between pedestrian underpasses and crosswalk signals.

Figure 10. Places of car parks along the Corniche and estimate number of capacity.

Table 3. Main characteristics of the road sectors (pedestrian crossing distance)

Sector No.	Neighborhoods	Length Km.	Typical Section in the road
1	Mandara Asafra Sidi Bishr	5.00	
2	San Stefano	1.60	
3	Glym Saba Pasha	1.81	
4	From Stanly to Shatby	4.99	
5	Selsela Mansheya Anfushy	3.53	


Lack of underpasses and crosswalks


Use of cats-eye as a traffic calming


Use sidewalks as a restaurants extension


Lack of car parks and on-street parking


Physical barriers to prevent road crossing


Unfriendly sidewalks

Figure 11. A number of Cornice's problems

4.2.3 Analysis of site environment

According to the Alexandria 2050 vision Strategy, the land use map illustrates that the majority of the uses along the Corniche are residential-commercial use. At the area extending from the Qaitbey fortress to Shatby area, buildings by the seashore are devoted to restaurants, clubs and a marina. The east side's seashore buildings are summarized by light structured cabinets, areas of private cabins, restaurants and a hotel, while the seashore itself is either privatized or access to certain parts of the beach is restricted by tickets. These activities encourage pedestrians to frequently move between the two sides of the road that may lead to increase road safety problems.

4.2.4 Defining of the study area

Through the preceding study, it is clear that the study area is the improved road only. The development of the Corniche positively influences the alternative routes where traffic is significantly decreased.

4.2.5 Taking count of the number of road accidents before and after the improvement.

The main source of Corniche accident data is the Alexandria's Ambulance Facility (AAF). As a result to the enormous lack of detailed accident data, there are no accidents data collected from the Corniche before 2002.

The data demonstrates that total number of accidents occurred along the Corniche has increased by 86.2% from 623 in 2002 to 1160 in 2010. With regard to vulnerable road users, the total number of fatalities increased to 314 in nine years, while the total number of injuries increased to 11609 during the same period. Furthermore, the data illustrates that the percentage of vulnerable males exceeds that of females and the percentage of vulnerable adults exceeds that of children.

Table 4. Accidents data of the Corniche according to AAF (2011)

	year									Total	Percent.
	2002	2003	2004	2005	2006	2007	2008	2009	2010		
Total number of accidents	623	789	1039	1334	1007	1196	1272	1301	1160	9721	
Total number of fatalities	17	18	20	29	29	39	50	61	51	314	2.6%
Total number of injuries	722	917	1277	1541	1213	1452	1516	1506	1465	11609	97.4%
Gender (male)	500	659	880	1034	782	995	1073	1039	1041	8003	67.1%
Gender (female)	239	276	417	536	460	496	493	528	475	3920	32.9%
Age (less than 15 y.)	69	73	94	222	87	108	87	85	104	929	7.8%
Age (more than 15 y.)	670	862	1203	1348	1155	1383	1479	1482	1412	10994	92.2%

Table 5. Detailed data of the Corniche according to (AAF)

		Number of Accidents													
Sec.	Area	2002	03	04	05	06	07	08	09	10	Total	Total of the Sec.	Length Km.	Accidents /Km.	width m.
	Mandara	18	13	31	31	23	26	20	33	24	219				
1	Asafra	29	37	52	82	62	47	43	47	76	475				
	Sidi Bishr	100	100	146	184	161	148	235	266	191	1531	2225	5	445.0	18
2	San Stefano	54	78	89	115	85	108	172	152	115	968	968	1.6	605.0	33
3	Glym	44	99	118	124	74	73	60	80	98	770				
	Saba Pasha	2	0	13	24	38	30	20	15	13	155	925	1.81	511.0	25
	Stanly	53	43	71	89	81	85	82	95	83	682				
	Rushdy	9	10	11	30	16	14	14	12	16	132				
	Sidi Gaber	34	49	67	70	55	96	81	62	74	588				
4	Cleopatra	80	80	95	81	54	84	77	69	97	717				
	Sporting	20	32	42	57	33	40	62	52	36	374				
	Ibrahimeya	15	30	31	52	52	82	58	62	54	436				
	Camp shesar	18	29	56	81	66	83	91	95	43	562				
	Shatby	99	136	125	142	99	143	105	143	129	1121	4612	4.99	924.2	33
	Anfushy	13	16	25	43	34	34	35	40	39	279				
5	Mansheya	25	26	35	55	33	35	54	48	52	363				
	Selsela	10	11	32	74	41	68	63	30	20	349	991	3.53	280.7	21
	Total	623	789	1039	1334	1007	1196	1272	1301	1160	9721	9721	16.93	574.2	

With regard to accidents number in road sectors, sector 4, which includes distance between Stanly and Shatby is the highest one (4612 in nine years). Moreover, Sidi Bishr is the highest region in terms of number of accidents (1531). On the other hand, sector 3 is the lowest sector (925 in nine years), and Saba Pasha is the lowest region (155). The western region of the Corniche (sector 5), which was not developed because of submerged remains of Ptolemaic royal quarters in the Eastern Harbour, is the third lowest sector in respect to number of accidents (991 in nine years).

4.2.6 Identify accident scenarios (the main causes of the highest number of accidents)

Sector 4, a 4.55 km distance, has the widest road section (more than 33 m). This encourages many drivers to exceed speeds of more than 100 km/h. The main reason for crossing road in this sector is for passive water related and non-related activities. The walking distance between some underpasses is extremely far. It reaches 1290 m between Ibrahimeya and Shatby. Pedestrians' running into the road without looking is the main factor of pedestrian collisions. In this scenario, driver does not have time to react to avoid crashes.

In Sidi Bishr, an extremely crowded region located in sector 1, a key safety problem is that while the sidewalk has been widened, it does not have enough width in some places, especially at the junction of Ibn Elwaleed Street. Pedestrians, particularly summer visitors, largely use this sidewalk. The shortage of pavement width along the shopping area side prompts pedestrians to walk out of the pavement between the two sides of the Corniche. The main reason for crossing road in this region is for active, passive water related and non-related activities.

5. THE PROPOSED SOLUTION

The proposed performance objectives to reduce pedestrian crashes in the Corniche are as follows: (a) reduce speed of motor vehicles, (b) reduce exposure for pedestrians, (c) improve pedestrian access and mobility, (d) improve compliance with traffic law, and (e) eliminate behavior that leads to crashes. Table 6 illustrates pedestrian problems and possible solutions that achieve these objectives:

Table 6. Pedestrian problems and possible solutions

Description of Problem	Possible Solutions	Limitations in Applicability	Cost	Comment
Difficulty of crossing the Corniche	Design for reduced street width	The Corniche sectors have different widths Sector 1 should be widened to 4 lanes. Sector 5 has a restricted width.	High	The Corniche width must be unified. (4 lanes).
	Introduce additional traffic signals to facilitate pedestrian crossings.	Could only be done in a few selected locations.	Low	More feasible where pedestrians crossing is concentrated at one point
	Provide pedestrian bridges	They will disturb the opposite buildings Only effective when they have escalators	High	
	Provide pedestrian underpasses	Only effective when they have escalators	High	
	Speed- limit (60 km/h)	Incompliance with traffic law	Low	It should be rigorously enforced
	Eliminate behavior that lead to crashes	Long run solution	Low	pedestrian / driver education Police enforcement
Inadequate sidewalk width in some areas	Increase sidewalk width	Sidewalk is always occupied by shops and restaurants extensions	Moderate	Sidewalk should be provided with appropriate furniture

The proposed solution is to widen the Corniche sidewalk, decrease the number of car lanes to 4 and unify the road sections, except section 5, which has a restricted width, and increase the number of underpasses. Furthermore, additional traffic signals should be introduced to facilitate pedestrian crossings and speed cameras should rigorously enforce speed- limit, possibly. Figure 12 illustrates a proposed typical section of the Corniche concerning some pedestrian-friendly considerations. On the other hand, alternative roads should be improved to decrease traffic capacity.

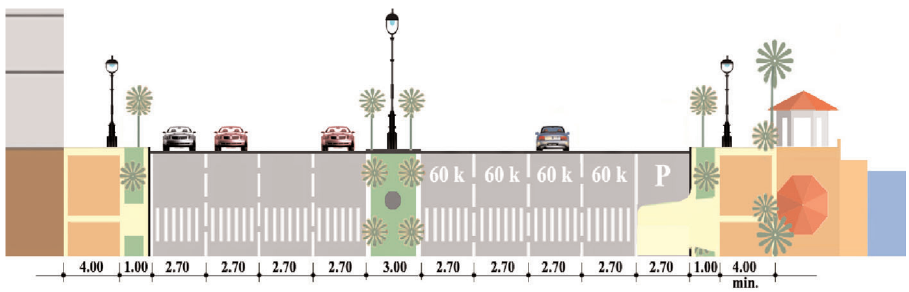


Figure 12. A Proposed section in the Corniche

CONCLUSION

Urban road improvement project should take into account pedestrian-friendly consideration to achieve a balance between the various forms of transit: cars, buses, bikes, and pedestrians rather than making motorized traffic a priority.

Research demonstrates the need to evaluate road layout improvements. Indeed, they may involve changes in practices that generate new pedestrian safety problems. Since data plays a critical role in traffic safety as, the Government should actively promote the collection and provision of information as well as the use of information technology. Furthermore, in order to develop more effective and appropriate traffic safety measures, the Government should improve and strengthen comprehensive investigation and analysis of the causes of traffic accidents, and promote necessary research and development efforts, as the basis for such measures.

REFERENCES

[1] WHO (World Health Organization), *Global Status Report on Road Safety: time for action,* WHO Library Cataloguing in Publication Data, Switzerland, 2009.

[2] Central Agency for Public Mobilization and Statistics (CAPMAS), *Egypt in Figures*, Cairo, 2011.

[3] M. A. Ismail and M. M. Samar, Cost of Road Traffic Accidents in Egypt, *World Academy of Science, Engineering and Technology*, 2010, 66, 1322-1328.

[4] L. Evans, *Traffic safety,* Science Serving Society, Bloom Field Hills, Michigan, 2004.

[5] E.A. Vasconcellos, *Urban Transport, Environment and Equity: The Case For Developing Countries*, Earthscan Publications, London, 2010.

[6] J.J. Fruin, Pedestrian Accident Characteristics in a One-Way Grid. *Highway Research Record*, 1973, 436, 1-7.

[7] B. Dave and P.E. Daubert, Chapter 9, *Design and Safety of Pedestrian Facilities: a recommended practice of the institute of transportation engineers*, ITE Technical Committee 5A-5, Washington, DC, 1998, 72.

[8] N. Fred and P.E. Ranck, Chapter 3, *Design and Safety of Pedestrian Facilities: a recommended practice of the institute of transportation engineers*, ITE Technical Committee 5A-5, Washington, DC, 1998, p. 34.

[9] C.V. Zegeer, J.R. Stewart, and H. Huang, and P. Lagerwey, Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Analysis of Pedestrian Crashes in 30 Cities. *Transportation Research record*, 2001, 1773, 56-68.

[10] K. Brain, P.E. Kemper, and P.M. Fernandez, Chapter 12, *Design and Safety of Pedestrian Facilities: a recommended practice of the institute of transportation engineers,* ITE Technical Committee 5A-5, Washington, DC, 1998, 89-92.

[11] B.J. Campbell, C.V. Zegeer, H.H. Huang, and M.J. Cynecki, *A Review of Pedestrian Safety Research in the United States and Abroad*, the National Technical Information Service, Virginia, 2004, 119-120.

[12] C. Gallon, *Tactile surfaces in the pedestrian environment: Experiments in Wolverhampton*, Transport Research Laboratory (Contractor report 317), England: Crowthorne, 1992.

[13] M. Aboul-Ela, M. Soliman, and M. Amin, *Urban Waterfronts between Cultural and Physical Influences: Proceedings of 43rd ISOCARP congress,* Antwerp, 2007.

[14] G. Dato, *Aspetti della marginalità urbana nei paesi in via di sviluppo: il caso di Alessandria d'Egitto*, Biblioteca del senide, Italy, 2003, 62-63.

[15] M. Turchiarulo, *Building Styles brought to Egypt by the Italian Community between 1850 and 1950: The Style of Mario Rossi: Proceedings of Third International Congress on Construction History*, Berlin, 2009.

[16] R. Ilbert, *Alexandrie, 1830–1930: Histoire D'une Communauté Citadine,* Institut Francais d'Archéologie Orientale, Cairo, 1996, 320-321.

[17] T. Brenac, *Evaluation Ex Post De L'effet D'aménagements Sur La Sécurité De La Circulation Automobile*, Les Notes de MA, 2001.

[18] L. Herrstedt, Traffic Calming Design: A Speed Management Method – Danish Experiences On Environmentally Adapted Through Roads, *Accident Analysis and Prevention*, 1992, 24 (1), 3-16.

[19] M. Millot, *The Influence Of Urban Planning On Road Safety: Proceedings of the 2004 European Transport Conference*. Strasbourg, 2004.

[20] M. Millot, and B. Hiron, *Does Modern Urban Road Layout Improve Road Safety: Which Assessment?: Proceedings of European Transport Conference*. Leeuwenhorst, The Netherlands, 2008.

[21] S.E. Asogwa, The Use Of The Police For Limited Road Accident Data Collection In Developing Countries, *Accident Analysis & Prevention,* 1982, 14 (3), 203–208.