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The Economic Feasibility of Rebuilding Al-Isra University Tunnel – Mechanical Factors

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Abstract: Economic feasibility is the cornerstone in the decision making on an economic venture. The more positive the economic signs, the less the risk and foreseen losses. This study throws light on some economic advantages of rebuilding Al-Isra tunnel, especially in terms of shortening the car/bus trip by six kilometers go and fro, and in terms of reducing the trip schedule by five minutes. That is by using an alternative road through one of the present tunnels available on the way to the university. The study makes also a comparison between the construction cost and the emanating benefits in terms of saving time and vehicle operation. The sensitivity analysis shows that the B/C ratio is 3.05, and in worst cases it is 2.03. While these results definitely prove the economic feasibility of the project, they also point to the risk reduction of traffic accidents, due to road shortening.

Key words: Economical feasibility, tunnel rebuilding, mechanical factors, sensitivity analysis

INTRODUCTION

Al-Isra University lies on Queen Alia International Airport Road, some 27 kilometers from Amman city centre to the south. In its vehicle schedule, Al-Isra looks unique among the state and private universities. Due to the desert nature of the area, and the scarcity of inhabitation communities, south to the university, vehicles tend to go north toward Amman, while they run along the road to the airport across Al Qastal Bridge when destined to university. In this very case, vehicles would have passed the university campus and thus turn on a parallel road, and subsequently lengthen their distance to the university.

Since several tunnels are located on the road before vehicles can come to the university, the renovation of one of them is possible with a view to shortening the two way distance. This study presents a proposal for achieving this goal by reforming one of the closest tunnels to Al-Isra University. It also argues about the economic consequences of this project.

Project Description: The idea behind this project is to find an alternate shorter road for vehicles destined to Al- Isra University. The projected road will use the nearest tunnel to the university, and will cut the vehicle trip by six kilometers, and its scheduled time by five minutes as drivers are usually obliged to slow down to make a turn, or run over a bridge, in order to finally enter a course parallel to the highway.

Figure (1) shows the required shortened distance both ways between the reconstructed tunnel and the university. The red line in the drawing shows the vehicle direction to the university across Al Qastal Bridge, then makes a turn to the campus, whereas the white line shows the return direction of the vehicle from the university to the north; i.e. to Amman.

Figure (2) specifies the road proposed to cross through the reconstructed tunnel up to the campus. The red line in the drawing the road will be used by the university and staff vehicles after the tunnel's reconstruction, while the white line indicates the vehicles return trip from the university to Amman. Noteworthy is the fact that by the white line there would be no need for the vehicles to go through the reconstructed tunnel, in their return trip, as the reconstructed road meets with the highway.

Fundamentals of the Study[1,2]:
Data base:
No. of faculty members, 166.
No. of staff members, 340.
No. of vehicles, 52.

Assumptions: The average salary of the faculty members is 900 Jordanian Dinar (JD).
The average salary of staff members is 250 JD
The working hours of faculty members are (5-6) hours.
The month is 23 days.
The year is 11 months.
The values are approximated to Jordanian Dinar.

The project's construction cost: The distance between the reconstructed tunnel and the university campus is approximately one kilometer long. Half of this road needs to be paved, and the other half repaved at six meters wide. According to current cost estimates in other similar construction projects, one square meter of road pavement costs JD5, thus making the total construction cost about JD 30 000,

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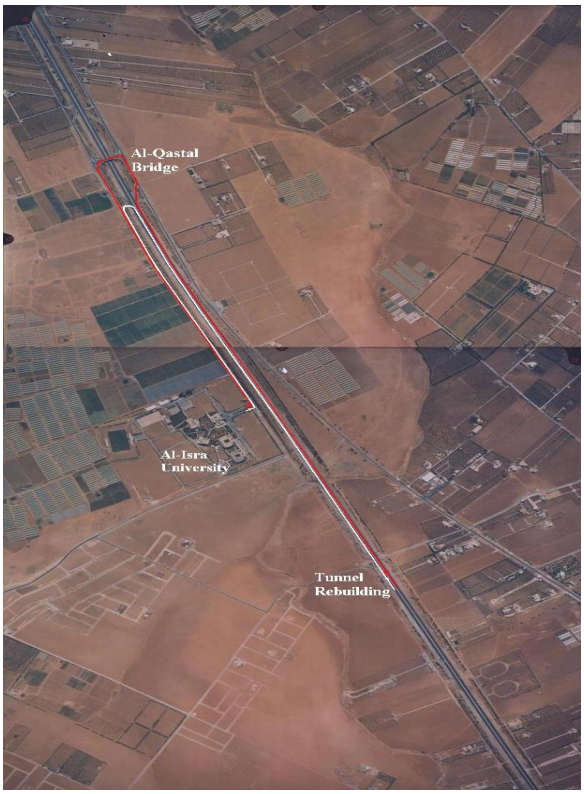

Fig. 1: An aerial photograph of the university location, Al Qastal Bridge, the reconstructed tunnel and the distance to be shortened both ways between the tunnel and the campus

Fig. 2: An aerial photograph of the new road to be crossed from the reconstructed tunnel both ways to the university

including a 10 percent reserve, whereas the maintenance of that sum of road (patching and surface mix) costs in average about JD 3.5[3], with a total cost of JD 420 000 throughout the project's 20 year duration.

The project's benefits: The project's immediate benefits lie in saving time and in reducing the mobility of the vehicles. Other indirect benefits are not included the project's economic feasibility as it is hard to appreciate.

Time saving: Using the proposed alternate road saves five minutes time in each trip to the university for every staff member. In an overview, the figures emerging should not be underestimated. As shown earlier by the fundamentals of this study, this project saves 13.83 hours per day for faculty members. The average salary, working hours, and the cost of each working hour for faculty members, all make the value of time saving per day about JD 69. Taking out the week ends (Fridays and Saturdays), and considering that faculty members work nearly eleven months a year (the first, second and summer semesters supposedly), it concludes that a total of about JD 17500 is the value of an annual time saving for them. The study fundamentals also show that the same applies to staff members, not to mention the time saving for students as an economic factor of the project. Table 1 shows the details of time saving for faculty members and staff, which amounts to about JD 25 184 per year.

Vehicle operation saving: Reduction in vehicle operation in this project includes several aspects of saving, such as saving in fuel consumption, spare parts and car annual corrosion.

Fuel consumption saving: Table 2 shows the university vehicles destination to 27 sites. It also shows the distance between the university and each site, the number of daily trips run by each vehicle (trip means go and fro), and the extra kilometers that are covered every day if this project is not implemented. The table evidently shows that the university vehicles run 13 122 kilometers per day in carrying students to and from the campus, including an extra 1284 kilometers (10 percent of the total distance) every day. (We will, however, take in this percentage in our calculations of the vehicle corrosion beyond the tunnel).

The table shows that university vehicles cover 214 trips per day, in addition to 52 trips for refueling during the morning program, and 10 trips in the evening program, namely when they are free of student

Table 1: Time saving

	Daily Saving in Hours	Daily Saving in JD	Monthly Saving in JD	Yearly Saving in JD
Faculty Members	13.83	69	1590	17495
Staff Members	29.16	30	699	7689
Total				25184

Table 2: Shows the university vehicles destination[2]

Vehicles Motion Direction From The University to The Site	The Distance Between The University and The Site	No. of Daily Trip to The Site	Daily Extra Kilometers
Marj Al Hammam	20	16	96
Nazal	22	25	150
Al Zohor	20	4	24
Al Wehdat	25	4	24
Ragadan	33	35	210
Al Abdali	33	17	102
Al Sakan	40	22	132
Madaba	21	22	132
Tabarboor	54	4	24
Abu Alanda	25	3	18
Al Quwasmeh	25	4	24
Sahab	25	5	30
Al Gardens	35	4	24
Jabal Al Hussen	40	2	12
Al Nozha	44	3	18
Al Zarqa	55	7	42
Al Hashmi	37	3	18
Al Baiader	26	4	24
Jabal Amman	34	3	18
Jaber Compass	28	3	18
Suwaylih	35	8	48
Al Bnayiat	23	5	30
Al Nasser & Manara	25	3	18
Abu Nussir	43	2	12
Jordan University	40	4	24
Marka	38	4	24
Al Russayfah	45	1	6
Total	13122	214	1284

Table 3: Shows the cost of spare parts which are saving with the project

Type	Virtual Life-long (Km)	No. of change during the Year	No. of Spare Parts during the Year	Unit Cost in JD	Total Cost in JD
Tires	80000	5	30	80	2400
Overhaul	200000	2	1	2000	4000
Oils	3000	140	1680 litter	1	1680
Fuel Filter	10000	40	1	8	320
Front Brakes	20000	21	1	10	210
Back Brakes	100000	4	1	15	60
Batteries	60000	7	14	80	1120
Starters	100000	4	1	360	1440
Total					11230

Table 4: Shows the annual corrosion ratio at the large size vehicle and its value with and without the project

Year	Annual Vehicle Corrosion	New Vehicle Cost in JD	Annual Corrosion Value Without The Projects	Annual Corrosion With The Project
1st Year	10%	28800	3200	320
2nd Year	10%	25920	2880	288
3rd Year	10%	23328	2592	259.2
4th Year	5%	22161	1166	116.64
5th Year	5%	21053	1108	110.8
6th Year	5%	20000	1052	105.2
7th Year	5%	19000	1000	100
Total				1300

Table 5: shows the annual corrosion ratio of the medium size vehicle and its value with and without the project

Year	Annual Vehicle Corrosion	New Vehicle Cost in JD	Annual Corrosion Value without the Projects	Annual Corrosion with the Project
1st Year	10%	24300	2700	270
2nd Year	10%	21870	2430	243
3rd Year	10%	19683	2187	218.7
4th Year	5%	18698.85	984.15	98.415
5th Year	5%	17763.9	934.94	93.494
6th Year	5%	16875.7	888.19	88.819
7th Year	5%	16032	843.8	84.38
Total				1096

Table 6: Shows the ratio between the costs and the benefits

Costs and Maintenance of the Project	
Construction Cost	30 000
Maintenance Cost	420 000
Total of Costs (C)	450 000
The Benefits During Its Virtual Life-long Period (B)	
1. Time Saving	503 680
2. Vehicle Operation Saving	
a. Full Consumption Saving	462 000
b. Spare Parts Saving	224 600
c. Annual Vehicle Corrosion	181 840
Total of Benefits	1 372 120
	Ratio of B/C = 3.05

passengers. This means that the vehicles have to drive about 12 kilometers both ways for refueling from the nearest gas station. So their daily trips mount to 276 with 1656 kilometers, that is 419 000 kilometers per year, the whole of which could be saved by the tunnel. Hence the increase in fuel consumption will be approximately 105 000 liters of diesel if we presume that each vehicle consumes 20 liters per 80 kilometers. In that case, the total cost of fuel will come to JD 23 100 annually, or to JD 462 000 throughout the project's duration[4].

Spare parts saving: The current prolonged distance does not only involve an increase of fuel consumption, but also extends to reach vehicle maintenance. Table 3 elaborates on the spare parts which require service or purchase. It also points to the virtual life-long of each, and how often they ought to be changed after 419000 kilometers in use.

The table includes, too, the price of each item, and the total value of the spare parts that amounts to JD 11230 per year. However, those spare parts that are mentioned in the table are not exclusive, but exemplary. To explain the terms of some, we can say that the virtual age of a vehicle tires is 80 000 kilometers. So after having run 419 000 kms, those tires have to be duly changed five times. And since each vehicle needs six wheels, then it eventually comes that the total number of tires which need to be changed in each vehicle is 30. Counting that each tire costs JD 80, the total cost of tires change will be JD 2400. The same applies to the other items. Hence the emanating saving in spare parts, throughout the 20 year duration of the project, will be JD 224 600.

Annual vehicle corrosion: Al Isra University has 52 vehicle fleet; 32 of them are of large size, and 20 of medium size. The former type costs JD 32 000 each, and the latter type costs JD 27 000 each. Table 4 and 5 shows the annual corrosion of both types respectively through the first seven years of the vehicles life-long. Corrosion is calculated in this study as 10 percent in the first three years, and 5 percent in the other four years. The two tables also show the vehicle corrosion beyond the project's implementation. It is estimated that the total corrosion cost in the larger vehicle, in the first seven years of its life-long, is JD 1300, and JD 1096 in the medium vehicle (i.e. JD 186 and JD 157 annually in both types respectively). This means a total corrosion cost of JD 3720 and JD 3140 for each large and medium size vehicle respectively during the project's period of time. Hence, the corrosion cost of all vehicle after the project is JD 181 840 in 20 years.

Other benefits of the project: The shortening by six kilometers both ways of the trip between the city centre and the university, out of 54 kilometers both ways, (i.e. by 11 percent), means a similar reduction in the possible car accidents for the road users. Statistics of accidents on the Airport road, where the university is located, indicate that 1117.4 car accidents occur per 10 000 vehicles from 1999 to 2001[5].

The tunnel reconstruction involves also environment protection and reduction of gas emission emanating from vehicles. Certainly this implies a positive return to the university environment. Moreover, the students will gain the advantage of time saving and reduce their possible exposure to car accidents on the road.

The project incorporates a saving in car operating by faculty and staff members. If every private car user cuts six kilometers per one trip, then its annual consumption of oil and fuel mounts to about JD 50, and if the number of private car users at the faculties and staff members is put at JD 250, then the total cost of oil and fuel consumption will be about JD 12500 per year for an extra distance of 37950 kms.

The project's economic yield: Based on the estimated economic cost and benefits of the project during its virtual life-long period, as summarized by Table 6, it turns out that the B/C ratio is 3.05 which is fine, and testifies to the economic feasibility of the project.

Table 7: The sensitivity analysis

1.	Basic Case: - Costs	C=450 000 JD	B/C = 3.05
	- Benefits	B=1 372 120 JD	
2.	Costs Increase by 10%	C=495 000 JD	B/C = 2.77
		B=1 372 120 JD	
3.	Cost Increase By 20%	C=540 000 JD	B/C = 2.54
		B=1 372 120 JD	
4.	Benefits Decrease By 10%	C=450 000 JD	B/C = 2.74
		B=1 234 908 JD	
5.	Benefits Decrease By 20%	C=450 000 JD	B/C = 2.44
		B=1 097 696 JD	
6.	Cost increase by 10%	C=495 000 JD	B/C = 2.49
	Benefits Decrease by 10%	B=1 097 696 JD	
7.	Cost Increase by 20%	C=540 000 JD	B/C = 2.03
	Benefits Decrease by 20%	B=1 097 696 JD	

The sensitivity analysis: Table 7 shows the results of the economic B/C test of a number of the project's variables in terms of estimated costs and benefits[6]. It also shows that if costs increase by 10 percent, the B/C ratio is 2.77, and if they increase by 20 percent, the B/C ratio is 2.54. If benefits are declined by 10 percent, the B/C ratio is 2.74, and if they decrease by 20 percent, the B/C ratio is 2.44.

These results prove that in worst cases of costs increase by 20 percent, and of benefits reduce by 20 percent, the B/C ratio will be 2.03. However, the project remains feasible economically.

RECOMMENDATIONS AND CONCLUSION

Below are the concrete recommendations and conclusions drawn up by this study, and could be counted for in application terms:

* The immediate reconstruction of the tunnel, or the building of a fixed bridge that would directly connect the university with the main road to the airport.
* The creation of a specific and legal means of refilling the diesel from a fuel tank to be installed in the campus. * In that case, saving in fuel consumption will amount to JD 23 100 per year.
* Reduction in road accidents owing to road shortening ensuing from the tunnel and / or the bridge.
* Expansion by 10 percent of the vehicle's life long.
* Contribution to environment protection.
* In economic terms, this project will save Jordanian economy about 105000 liters of diesel consumed by the university vehicles alone, and about 40 000 liters of benzene consumed by the cars of the faculty and staff members per year.
* The estimated (3.05) B/C ratio found in this study is good economically.
* Economic feasibility tends always upwards in terms of advantages, especially as students' enrollment is constantly rising. It also entails increase in the trip schedule.

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REFERENCES

1. Personal Department Records, Al-Isra University, 2004.
2. Service Department Records-Al-Isra University, Vehicles Schedule of 2003.
3. Engineering House. Economic Feasibility of Amman Road Circle, 2001
4. Ministry of Energy and Mineral Resources. Energy 2004, Figures and Numbers.
5. Jordanian Traffic Institute, August 2002. Traffic Accident in Jordan of 2001.
6. Trag, S.L., Economic Feasibility of Project: Managerial and Engineering Practice, 2004. McGraw-Hill Book Company. Pp: 112-128.