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COST COMPARISON OF RIGID AND FLEXIBLE PAVEMENTS: APPLICATIONS IN TURKEY

SELÇUK UÇAR, TÜMER AKAKIN, YASİN ENGİN

Abstract

In this paper, the economic analysis, which constitute one of the decision-making stages in selection of highway pavement type has been studied. Both the initial and life cycle cost of rigid and flexible pavements in different conditions has been determined in accordance with the 2005 Turkish State unit cost analysis. In the case of flexible pavements, we employed the Design Manual for Flexible Pavements published by the Turkish General Directorate of Highways, and in the case of rigid pavements, given the absence of a relevant design manual in Turkey, we used the AASHTO 93 design guidelines, which conform to the criteria established by the General Directorate of Highways and to the conditions in Turkey. For the purposes of this paper, rigid pavements of two different types have been designed: jointed plain and continuously reinforced concrete pavements.

Keywords

Pavement, Concrete Road, Cost Comparison, Initial Cost, Life-Cycle Cost

Biographical notes

Selçuk Uçar, Civil Engineer, Master of Science degree from Bogazici University Civil Engineering Department, working for 6 years in Turkish Ready Mixed Concrete Association KGS Certification Enterprise as the Manager of KGS Certification Enterprise.

Tümer Akakın, Civil Engineer, Master of Science degree from Bogazici University Civil Engineering Department, working for 9 years in Turkish Ready Mixed Concrete Association as the Technical Manager.

Yasin Engin, Civil Engineer, Bachelor of Science degree from Bogazici University Civil Engineering Department, working for 2 years in Turkish Ready Mixed Concrete Association as a Technical Expert.

1. INTRODUCTION

The flexible road being studied in this paper consists of pavement, base and subbase courses. Taking into consideration the type of flexible pavement that currently enjoys wide application by the General Directorate of Highways in Turkey, we designed the surfacing layer as a bi-bituminous hotmix consisting of wear and binder courses; we utilised hot bituminous base and plantmix base at the base course and we selected crushed stone as the subbase course.

In accordance with AASHTO93, rigid pavement was designed to consist of a layer of concrete pavement and subbase course of crushed stone. We designed two types of rigid pavement: jointed unreinforced type and continuously reinforced type.

2. METHODS OF DESIGN AND CRITERIA

The principal criterion in the design of pavements is traffic. Taking as basis the standard single axle load, which is 8.2 tonnes according to General Directorate of Highways (GDH) criteria, $T_{8,2}$ "number of recurrences of an equivalent standard single axle load of 8.2 tonnes on the road within a selected period of analysis" was derived from Annual Average Daily Traffic (AADT) values and taken as the traffic load in this study.

This study examines 11 different categories of traffic. These categories were determined on the basis of the conditions on Turkish highways and the number of recurrences of an equivalent standard single axle load of 8.2 tonnes within the selected period of analysis, that is $T_{8,2}$ varies between 3 millions to 250 millions.

Another important criterion in pavement design is the load bearing capacity of subgrade soil. In this study, the load-bearing capacity of subgrade soil was taken as "medium level" (CBR= %10). The load bearing capacity of subgrade soil is of greater importance in flexible pavements than in rigid ones. The costs of improving subgrade soil were not taken into account in this analysis. The thicknesses of road pavements were calculated for different types of roads and traffic using the above-mentioned methods of design.

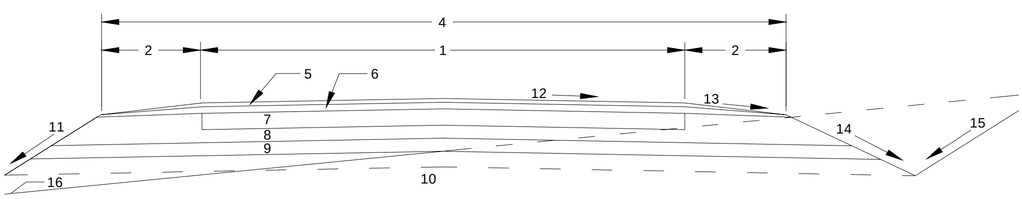

Figure 1. Flexible Pavement Cross-section

1. Width of driving lanes
2. Shoulder width
4. Platform width
5. Wearing course surfacing
6. Binder course surfacing
7. Bituminous base course
8. Plantmix base and shoulder backfill course
9. Crushed stone subbase layer
10. Road Base (Subgrade soil)
11. Backfill slope
12. Horizontal slope of road
13. Shoulder slope
14. Ditch slope
15. Cut off slope

Table 1. Cross-section Thicknesses for Flexible Pavement

Pavement (cm)	Traffic Category ($T_{8,2}$: number of recurrences of an equivalent standard single axle load of 8.2 tonnes on the road within whole life of the road)										
	3-10 Milllion	10-20 Milllion	20-30 Milllion	30-40 Milllion	40-50 Milllion	50-65 Milllion	65-80 Milllion	80-100 Milllion	100-160 Milllion	160-250 Milllion	>250 Milllion
Wear	5	5	5	5	5	5	5	5	5	5	5
Binder	8	6	6	6	7	7	7	8	8	8	8
Bituminous Base	0	8	9	10	10	11	12	12	14	16	18
Plantmix Base	20	20	20	20	20	20	20	20	20	20	20
Crushed Stone Subbase	25	20	20	20	20	20	20	25	25	25	25

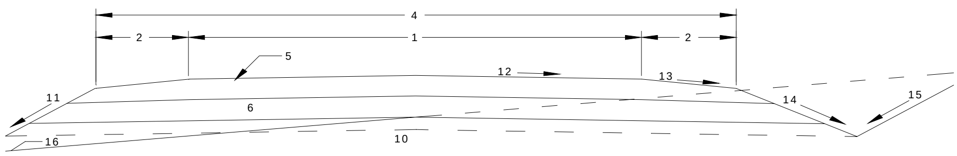

Figure 2. Rigid Pavement Cross-section

1. Width of driving lanes
2. Shoulder width
4. Platform width
5. Concrete pavement
6. Crushed stone subbase layer
10. Road Base (Subgrade soil)
11. Backfill slope
12. Horizontal slope of road
13. Shoulder slope
14. Ditch slope
15. Cut off slope

Table 2. Cross-section Thicknesses for Jointed Plain Concrete Pavement

Pavement (cm)	Traffic Category ($T_{8,2}$: number of recurrences of an equivalent standard single axle load of 8.2 tonnes on the road within whole life of the road)										
	3-10 Milllion	10-20 Milllion	20-30 Milllion	30-40 Milllion	40-50 Milllion	50-65 Milllion	65-80 Milllion	80-100 Milllion	100-160 Milllion	160-250 Milllion	>250 Milllion
Concrete Pavement	19	22	23	25	25	26	27	30	33	36	38
Crushed Stone Subbase	20	20	20	20	25	25	25	25	25	25	25

Table 3. Cross-section Thicknesses for Continuously Reinforced Rigid Pavement

Pavement (cm)	Traffic Category ($T_{8,2}$: number of recurrences of an equivalent standard single axle load of 8.2 tonnes on the road within whole life of the road)										
	3-10 Milllion	10-20 Milllion	20-30 Milllion	30-40 Milllion	40-50 Milllion	50-65 Milllion	65-80 Milllion	80-100 Milllion	100-160 Milllion	160-250 Milllion	>250 Milllion
Concrete Pavement	18	20	22	24	25	25	26	28	32	35	36
Crushed Stone Subbase	20	20	20	20	25	25	25	25	25	25	25

3. PAVEMENT PROPERTIES

3.1 Geometrical Properties

Cost analyses for one type of flexible pavement and two types of rigid pavement were made for 11 different traffic categories. The geometrical properties of the road for which cost analysis was made are as follows:

Length of road: 1000 m
Platform width: 12 m
Total shoulder width: 5 m
Width of driving lanes: 7 m (2 lanes)

In the rigid pavement, both the course of concrete pavement and the base course continue without any change into the shoulders. In the flexible pavement, a plantmix backfill layer takes the place of the hot bituminous base course in the shoulders while wear and binder courses continue into the shoulder.

When preparing unit price cost estimates, we used only Turkish General Directorate of Highways (GDH) unit price analyses and rates in the calculations for wear, binder and bituminous base courses called bituminous hotmixes in plantmix base and crushed stone subbase courses; while we employed GDH, Turkish Ministry of Public Works and Turkish State Aviation Agency 2005 unit price analyses and rates in the calculations for concrete pavements.

We used dowels and tie-rods in the joints of jointed unreinforced concrete pavements. Three longitudinal joints are placed over the total road width, with one between the two lanes and two where driving lanes meet the shoulders. Transverse joints shall be cut at an average of every 5 m as contraction joints. Joints are sawed down 1/3 joint thickness and a fiber is placed, coated up to 15 mm and sealed with cold joint sealer. Dowels are placed at an average of every 30 cm in transverse joints. Dowels are flat, S220a class, ∅25 and 60 cm long. While tie-rods are ribbed, S420a class, ∅12 and 80 cm long and are placed every 80 cm in longitudinal joints. Dowels are coated with bitumine to prevent both adhesion with concrete and corrosion.

It is presumed that a slipform paver will be employed to construct concrete pavements.

3.2 Material Properties

Following are the specifications of the concrete we decided to use in road pavement:
Strength: C40 (f_{ck}=40 MPa),
Cement dosage: 375 kg/m^3,
Water/cement ratio: 0.41,
Maximum aggregate size: 30 mm,
Consistency: S1 (between 0-5 cm).

As for the flexible pavement, the specifications of the material chosen are as follows:
Bitumine type: AC 60/70,
Bitumine weight ratio for wear coarse: 5.35%,
Bitumine weight ratio for binder coarse: 4.4%,
Bitumine weight ratio for hot bituminous base: 3.45%.

3.3 Reinforcement Properties

In the case of continuously reinforced concrete pavements (CRCP), we first calculated road thickness, and then on the basis of this thickness and other factors we arrived at a reinforcement percentage. The coefficients adopted for both types of rigid pavement are indicated below:

f_{ct} (S'_c) = 4,83 MPa (700 psi),
E_c = 29950 MPa (4340000 psi),
C_d = 1, J = 2,7 (JPCP), J = 2,5 (CRCP),
k (subgrade soil) = 1,38 MPa (200 psi),
Crack spacing= 3,5<X<8,0 feet,
Crack width = < 0,04 inch,
α_s/α_c = 1,32 (in./in.),
ΔT_D = 12,8°C,
Indirect tensile strength of concrete f_t=4,14 MPa (600 psi),
Contraction (Z) = 0,0004
Reinforcement diameter = 16 mm (ϕ16)
Friction constant (F) = 1,5

For continuously reinforced pavements, we calculated longitudinal reinforcement percentage and reinforcement spacing as follows:

Table 4. Reinforcement Percentages in Continuously Reinforced Rigid Pavement

Reinforcement	Traffic Category ($T_{8,2}$: number of recurrences of an equivalent standard single axle load of 8.2 tonnes on the road within whole life of the road)										
	3-10 Milllion	10-20 Milllion	20-30 Milllion	30-40 Milllion	40-50 Milllion	50-65 Milllion	65-80 Milllion	80-100 Milllion	100-160 Milllion	160-250 Milllion	>250 Milllion
Long. Reinfor. Ratio (%)	0,35	0,35	0,4	0,42	0,44	0,46	0,47	0,50	0,53	0,65	0,73
Long. Reinfor. spacing (cm)	34	30	24	21	20	17	17	15	12	9	8
Tran. Reinfor. spacing (cm)	56	51	46	43	41	41	38	33	25	25	25

4. COST CALCULATIONS

4.1 Initial Cost

The following table and graphic indicate the construction (initial) costs calculated on the basis of above criterias:

Table 5. Construction Costs, 1000 $/km

Pavement (cm)	Traffic Category ($T_{8,2}$: number of recurrences of an equivalent standard single axle load of 8.2 tonnes on the road within whole life of the road)										
	3-10 Milllion	10-20 Milllion	20-30 Milllion	30-40 Milllion	40-50 Milllion	50-65 Milllion	65-80 Milllion	80-100 Milllion	100-160 Milllion	160-250 Milllion	>250 Milllion
Flexible Pavement	312	333	340	348	358	366	373	400	415	429	444
JPCP	263	280	292	301	322	328	336	352	374	394	407
CRCP	263	285	309	324	354	363	376	403	450	498	522

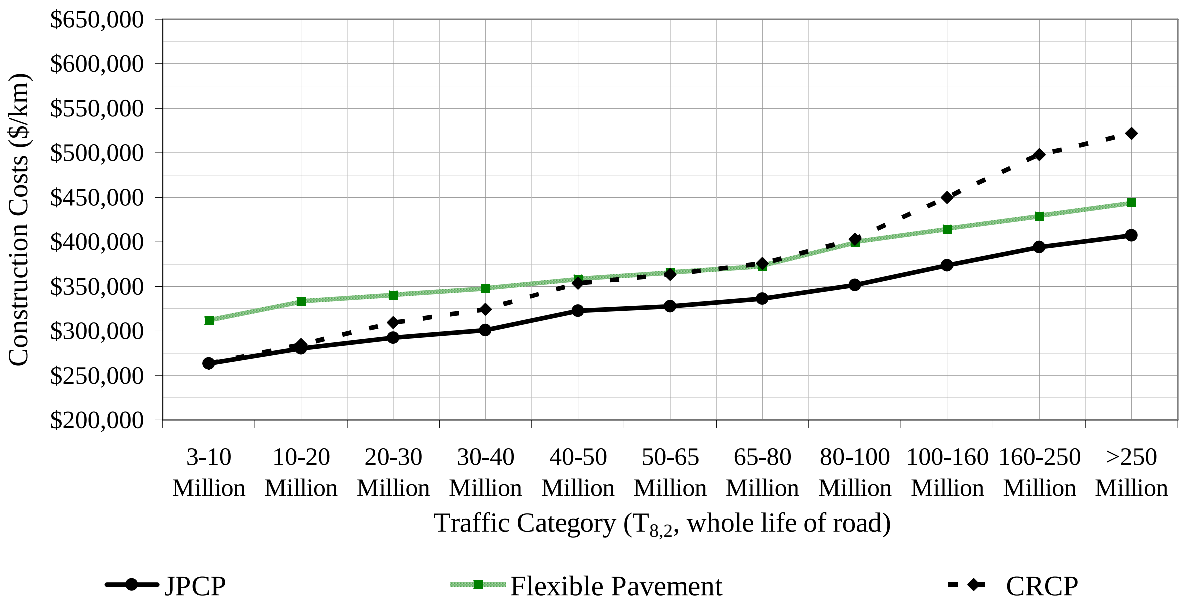

Figure 3. Construction Costs

4.2 Life-CycleCost

The costs of all operations that need to be done throughout the lifespan of pavements after their construction were calculated assuming an annual price increase of 2% and expressing these in terms of 2005 rates. These operations and costs incurred are as follows:

a. For flexible pavements, wear course will need to be renewed in the 7th and 14th years of a 20 year life cycle and there will be annual maintenance costs. This calculation was carried out on the basis of data provided by the GDH Maintenance Department Directorate concerning annual maintenance costs (6) and wear course renewal costs according to unit price indices.

Patching works costs of flexible road		= 912.50 $/km
Other maintenance services		= 2,188.95 $/km
	Total	= 3,101.45 $/km
Renewal of wear course		= 71,147.80 $/km

b. For rigid pavements, joints fillers are to be replaced every 5 years and surface grinding is to be carried out on the 10th year. In addition, a hypothetical 1% reconstruction is taken into account every 5 years.

Replacement of Joint Fillers	= 3.31 x 12 x 1000 = 39,720 $/km
Grinding off 1 cm of surface	= 8,711 $/km

Table 6. Life Cycle Costs, according to 2004 unit prices – 1000 $/km

Pavement (cm)	Traffic Category ($T_{8,2}$: number of recurrences of an equivalent standard single axle load of 8.2 tonnes on the road within whole life of the road)										
	3-10 Milllion	10-20 Milllion	20-30 Milllion	30-40 Milllion	40-50 Milllion	50-65 Milllion	65-80 Milllion	80-100 Milllion	100-160 Milllion	160-250 Milllion	>250 Milllion
Flexible Pavement	478	500	507	515	525	532	540	567	581	596	611
JPCP	375	393	405	414	436	441	450	465	488	509	523
CRCP	277	299	324	339	369	379	392	419	467	516	540

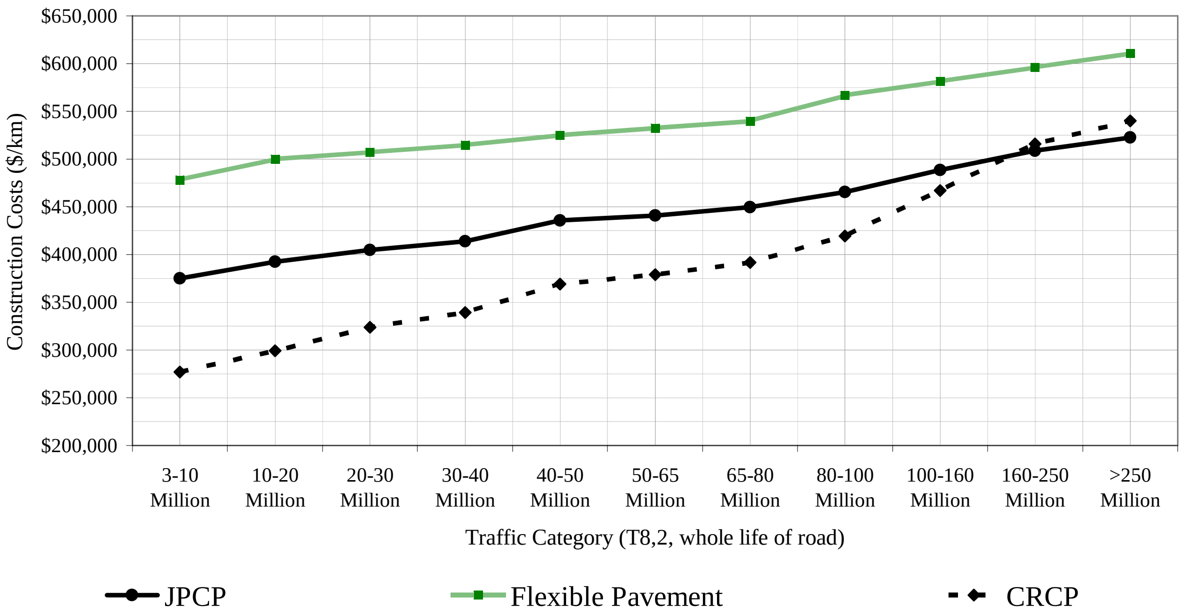

Figure 4. Life Cycle Costs

5. CONCLUSIONS AND PROPOSALS

As seen in Table 5 and Figure 3, construction costs for rigid pavements and flexible pavements turn out to follow each other very closely, in contrast to what is generally thought. It can be observed that the cost for jointed unreinforced rigid pavement is a little less than that for flexible pavement. As for continuously reinforced rigid pavements, their cost is lower than that of flexible pavements under conditions of light traffic, but higher under conditions of heavy traffic; however when compared to the cost of jointed unreinforced pavements, the cost of continuously reinforced rigid pavements is higher under all traffic conditions.

In terms of life cycle costs, as can be observed in Table 6 and Figure 4, continuously reinforced rigid pavements yield better results than both jointed reinforced rigid pavements and flexible pavements. However, it is important to keep in mind that the actions that will need to be taken throughout the lifespan of the pavement, will need to be determined based on practical experience on the conditions of our country.

It is of great importance to select a type of rigid pavement that is suitable for Turkey and to concentrate research and experiments on that type of pavement. The necessary economical comparisons as well as all the technical and application criteria can be specified on the basis of this research and similar ones.

Turkey has a good deal of experience on the construction of asphalt pavements. In fact, there also exists an undeniable amount of experience on concrete pavements, emanating from airports and various field concretes. Most asphalt pavement constructors in Turkey already have such kind of experience.

APPENDIX 1

Bills of Quantities Estimates

Analysis:		Concrete Pavement				Meas. Unit: M3
Code	Pose No	Definition	Unit	Quantity	Unit Cost	Cost
CONCRETE MIX COMPONENTS						
BAY	04.006/C	GRANULOMETRIC SAND	M3	0.49	$8.74	$4.28
BAY	04.031	WATER	M3	0.155	$1.79	$0.28
KAY	08.023/K	PREPARATION OF CRUSHED STONE OF MAX. 30MM FROM QUARRY STONE USING CRUSHER	M3	0.73	$10.88	$7.94
BAY	04.008/3	CEMENT PRICE (PC 42,5) (INCL. CONTRACTOR PROFIT, PLUS 25%)	TONS	0.375	$67.86	$25.45
		SUB-TOTAL	M3			$37.94
BETON KARIŞIMININ HAZIRLANMASI (400 M3 /gün Kapasiteye Göre)						
KAY	07.006/K	TRANSPOTATION OF SAND (20 km) F=AxYx1.25xKx(0.0007xM+0.01) A=1 Y=1,6 K=84.000.000 M=20	M3	0.49	$2.88	$1.41
KAY	07.006/K	TRANSPOTATION OF CRUSHED STONE (20 km) F=AxYx1.25xKx(0.0007xM+0.01) A=1 Y=1,6 K=84.000.000 M=20	M3	0.73	$2.88	$2.10
KAY	07.005/K	TRANSPORTATION OF WATER (10.000 m) F=Ax1.25xKx0.00017xM^0,5 A=1 K=84.000.000 M=10,000m	TONS	0.155	$1.28	$0.20
KAY	07.006/K	TRANSPORTATION OF CEMENT F=1,25xKxA(0,0007xM+0,01) A=1 K=84.000.000 M=150km	TONS	0.375	$8.63	$3.23
KAY	4470	PUTTING CEMENT IN PLANT SILO	TONS	0.375	$1.34	$0.50
BAY	01.015	CONCRETE MASTER WORKMAN	HRS	0.075	$2.02	$0.15
BAY	01.403	MACHINE OPERATOR	HRS	0.0006	$2.02	$0.00
BAY	01.409	FOREMAN	HRS	0.025	$2.90	$0.07
BAY	01.501	UNSKILLED WORKER	HRS	0.125	$1.32	$0.17
BAY	04.109	FUEL OIL (DIESEL FUEL)	KG	0.2	$1.14	$0.23
BAY	03.070	AUTOMATED CONCRETE PLANT	UNIT	6.075E-06	$38,185.71	$0.23
KAY	1930	1 HR PRICE FOR ELEVATOR	HRS	0.1	$2.89	$0.29
KAY	1932	1 HR PRICE FOR CEMENT SILO	HRS	0.075	$6.57	$0.49
BAY	03.511	1 HR PRICE FOR 185 DHP TRACTOR BULLDOZER	HRS	0.025	$40.63	$1.02
BAY	03.521	1 HOUR PRICE FOR RUBBER TIRED LOADER	HRS	0.025	$19.48	$0.49
KAY	07.006/K	TRANSPORTATION OF MIX (20 km) F=AxYx1.25xKx(0.0007xM+0.01) A=1 Y=2,4 K=84.000.000 M=20	M3	1	$4.32	$4.32
		SUB-TOTAL	M3			$14.90
PAVING AND LEVELLING CONCRETE (400 M3 /Day)						
BAY	01.404	MACHINE OPERATOR	HRS	0.06	$2.30	$0.14
BAY	01.409	FOREMAN	HRS	0.025	$2.90	$0.07
BAY	01.501	UNSKILLED WORKER	HRS	0.2	$1.32	$0.26
BAY	04.109	FUEL OIL (DIESEL FUEL)	KG	0.35	$1.14	$0.40
BAY	01.512	RUNWAY CONCRETE PAVING MASTER WORKMAN	HRS	0.25	$2.02	$0.51
BAY	03.062/3	SLIPFORM PAVER	UNIT	6.075E-06	$331,808.57	$2.02
		SUB-TOTAL	M3			$3.40
					1 m3 Total =	**$56.24**

Analysis::		OTHER WORKS OF CONCRETE PAVEMENT (JPCP)				Meas. Unit: M2
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
CURING CONCRETE						
BAY	04.613/1F	CONCRETE CURING SUBSTANCE	KG	0.35	$1.43	$0.50
KAY	4392	SPRAYING CURING COMPOUND USING TRAILER DISTRIBUTOR (MANUAL)	DA	0.001	$32.75	$0.03
		SUB-TOTAL	M2			$0.53
OPENING JOINTS						
BAY	01.015	CONCRETE MASTER WORKMAN	HRS	0.092	$2.02	$0.19
BAY	01.403	MACHINE OPERATOR	HRS	0.06624	$2.02	$0.13
BAY	01.501	UNSKILLED WORKER	HRS	0.046	$1.32	$0.06
BAY	04.031	WATER	M3	0.046	$1.79	$0.08
BAY	04.109	FUEL OIL (DIESEL FUEL)	KG	0.0069	$1.14	$0.01
BAY	03.117	JOINT CUTTING MACHINE	UNIT	1.5916E-05	$3,087.14	$0.05
BAY	03.117	JOINT CUTTING MACHINE	UNIT	0.00014	$3,087.14	$0.43
DLH	07.005/D	TRANSPORATION OF OTHER CONSTRUCION MATERIALS FROM EXCAVATION SITE	M3	0.046	$2.94	$0.14
BAY	03.517	1 HOUR COST OF COMPRESSOR (210 CFM COMP)	HRS	0.0033	$19.65	$0.06
		SUB-TOTAL	M2			$1.15
PLACEMENT OF JOINT FILLER						
Market Search		JOINT FILLING MATERIAL (APPLIED COLD)	LT	0.07425	$11.43	$0.85
Market Search		COATING MATERIAL FOR JOINT FILLER	KG	0.00225	$35.71	$0.08
Market Search		JOINT FIBER	M	0.45	$0.02	$0.01
BAY	01.010	ISOLATION MASTER WORKMAN	HRS	0.2	$2.02	$0.40
BAY	01.210	ISOLATION MASTER WORKMAN AID	HRS	0.2	$1.43	$0.29
BAY	01.501	UNSKILLED WORKER	HRS	0.4	$1.32	$0.53
		SUB-TOTAL	M2			$2.16
JOINT REINFORCEMENTS						
BAY	04.252	REINFORCING STEEL BARS FOR CONCRETE (JOINT REINFORCEMENT)	KG	2	$0.35	$0.70
-	-	BITUMEN FOR JOINT REINFORCEMENT COATING (MC)	KG	0.15	$0.42	$0.06
KAY	23.002/K	IRON WORKS (CUTTING TRANSVERSAL REINFORCEMENT, COATING WITH BITUMEN, MAKING A SEHPA)	TONS	0.003	$162.14	$0.49
KAY	23.015/K	IRON WORKS (CUTTING LONGITUDINAL REINFORCEMENT)	TONS	0.00075	$183.72	$0.14
KAY	23.002/K	IRON WORKS (PLACING)	TONS	0.003	$162.14	$0.49
KAY	07.006/K	TRANSPORTATION OF IRON RODS (AVE. RAILWAY + HIGHWAY)	TONS	0.003	$32.14	$0.10
		SUB-TOTAL	M2			$1.97
					1 m2 Total =	**$5.82**

Analysis::		OTHER WORKS OF CONCRETE PAVEMENT (CRCP)				Meas. Unit: M2
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
CURING CONCRETE						
BAY	04.613/1F	PROTECTIVE CURING COMPOUND FOR CONCRETE SURFACES	KG	0.35	$1.43	$0.50
Market Search		CORROSION INHIBITOR	M2	1	$1.43	$1.43
KAY	4392	SPRAYING CURING COMPOUND USING TRAILER DISTRIBUTOR (MANUAL)	DA	0.002	$32.75	$0.07
		SUB-TOTAL	M2			$1.99
					1 m2 Total =	**$1.99**

Analysis::		Reinforcement Works for Concrete Pavement (CRCP)				Meas. Unit: 1 KG İÇİN M2'de
PREPARATION AND PLACEMENT OF REINFORCEMENT						
BAY	04.252	REINFORCING STEEL BARS FOR CONCRETE	KG	1	$0.35	$0.35
KAY	23.015/K	RIBBED BAR WORK FOR REINFORCED CONCRETE	TONS	0.001	$183.72	$0.18
KAY	07.006/K	TRANSPORTATION OF RODS (AV. RAILROAD+HIGHWAY)	TONS	0.001	$10.71	$0.01
					Toplam =	**$0.55**

Analysis::		Wear Course Construction				Meas. Unit: TON
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
KAY	6400	CONSTRUCTION OF ASPHALT CONCRETE WEAR COURSE	TONS	1	$24.13	$24.13
KAY	07.005/K	TRANSFER OF QUARRY STONE FROM QUARRY TO CRUSHER F=Ax1.25xKx0.00017xM^0,5-0,0026K A=1 K=84.000.000 M=5km	TONS	0.948	$0.75	$0.71
KAY	07.006/K	TRANSFER OF MIXTURE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 M=25km	TONS	1	$2.06	$2.06
KAY	07.006/K	TRANSFER OF ADHESIVE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 M=25km	TONS	0.0021	$2.06	$0.00
KAY	07.006/K	TRANSFER OF BITUMEN FROM REFINERY TO CONS. SITE F=Ax1.25xKx0.00017xM^0,5 A=1 M=250km	TONS	0.0536	$13.88	$0.74
KAY	4358	HEATING BITUMEN THAT COOLED DOWN DURING TRANSPORATION	TONS	0.0536	$9.59	$0.51
-	-	BITUMEN PRICE (AC)	TONS	0.0536	$213.17	$11.43
					1 Ton Total =	$39.58

Analysis::		Binder Course Construction				Meas. Unit: TON
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
KAY	6300	CONSTRUCTION OF ASPHALT CONCRETE BINDER COURSE	TONS	1	$23.43	$23.43
KAY	07.005/K	TRANSFER OF QUARRY STONE FROM QUARRY TO CRUSHER F=Ax1.25xKx0.00017xM^0,5-0,0026K A=1 K=57.750.000 M=5km	TONS	0.957	$0.75	$0.71

KAY	07.006/K	TRANSFER OF MIXTURE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	1	$2.06	$2.06
KAY	07.006/K	TRANSFER OF ADHESIVE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	0.0014	$2.06	$0.00
KAY	07.006/K	TRANSFER OF BITUMEN FROM REFINERY TO CONS. SITE F=Ax1.25xKx0.00017xM^0,5 A=1 K=57.750.000 M=250km	TONS	0.0441	$13.88	$0.61
KAY	4358	HEATING BITUMEN THAT COOLED DOWN DURING TRANSPORATION	TONS	0.0441	$9.59	$0.42
-	-	BITUMEN PRICE (AC)	TONS	0.0441	$213.17	$9.40
					1 Ton Total =	$36.65

Analysis::		**Bituminous Base Course Construction**				**Meas. Unit: TON**
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
KAY	6200	CONSTRUCTION OF BITUMINOUS BASE COURSE	TONS	1	$22.75	$22.75
KAY	07.005/K	TRANSFER OF QUARRY STONE FROM QUARRY TO CRUSHER F=Ax1.25xKx0.00017xM^0,5-0,0026K A=1 K=57.750.000 M=5km	TONS	0.966	$0.75	$0.72
KAY	07.006/K	TRANSFER OF MIXTURE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	1	$2.06	$2.06
KAY	07.006/K	TRANSFER OF ADHESIVE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	0.00085	$2.06	$0.00
KAY	07.006/K	TRANSFER OF BITUMEN FROM REFINERY TO CONS. SITE F=Ax1.25xKx0.00017xM^0,5 A=1 K=57.750.000 M=250km	TONS	0.0344	$13.88	$0.48
KAY	4358	HEATING BITUMEN THAT COOLED DOWN DURING TRANSPORATION	TONS	0.0344	$9.59	$0.33
-	-	BITUMEN PRICE (AC)	TONS	0.0344	$213.17	$7.33
					1 Ton Total =	$33.68

Analysis::		**Plantmix Base Course Construction**				**Meas. Unit: TON**
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
KAY	6100/2	CONSTRUCTION OF PLANTMIX BASE COURSE	TONS	1	$12.72	$12.72
KAY	07.005/K	TRANSFER OF QUARRY STONE FROM QUARRY TO CRUSHER F=Ax1.25xKx0.00017xM^0,5-0,0026K A=1 K=57.750.000 M=5km	TONS	0.957	$0.75	$0.71
KAY	07.006/K	TRANSFER OF MIXTURE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	1	$2.06	$2.06
KAY	07.006/K	TRANSFER OF ADHESIVE TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	0.0021	$2.06	$0.00
KAY	07.006/K	TRANSFER OF BITUMEN FROM REFINERY TO CONS. SITE F=Ax1.25xKx0.00017xM^0,5 A=1 K=57.750.000 M=250km	TONS	0.0021	$13.88	$0.03

KAY	07.006/K	TRANSFER OF WATER TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	0.01	$2.06	$0.02
KAY	07.005/K	TRANSFER OF WATER TO PLANT F=Ax1.25xKx0.00017xM^0,5 A=1 K=57.750.000 M=5km	TONS	0.043	$0.90	$0.04
-	-	BITUMEN PRICE (MC)	TONS	0.0021	$416.28	$0.87
					1 Ton Total =	$16.47

Analysis::		**Construction of Subbase**				**Meas. Unit: TON**
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
KAY	6100/3-1	CONSTRUCTION OF PLANTMIX SUBBASE (USING CRUSHED QUARRY STONE)	TONS	1	$10.70	$10.70
KAY	07.005/K	TRANSFER OF QUARRY STONE FROM QUARRY TO CRUSHER F=Ax1.25xKx0.00017xM^0,5-0,0026K A=1 K=57.750.000 M=5km	TONS	0.957	$0.75	$0.71
KAY	07.006/K	TRANSFER OF SUBBASE MAT. TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	1	$2.06	$2.06
KAY	07.006/K	TRANSFER OF WATER TO ROAD F=Ax1.25xKx(0.0007xM+0.01) A=1 K=57.750.000 M=25km	TONS	0.01	$2.06	$0.02
KAY	07.005/K	TRANSFER OF WATER TO PLANT F=Ax1.25xKx0.00017xM^0,5 A=1 K=57.750.000 M=5km	TONS	0.043	$0.90	$0.04
					1 Ton Total =	$13.54

Analysis::		**Construction of Sand-Gravel Subbase**				**Meas. Unit: TON**
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
KAY	6010	CONSTRUCTION OF Gsand GRAVEL SUBBASE	M3	1	$2.50	$2.50
KAY	07.005/K	TRANSFER OF QUARRY STONE FROM QUARRY TO WORK PLACE F=Ax1.25xKx0.00017xM^0,5-0,0026K A=1 K=57.750.000 M=30km	M3	1	$3.72	$3.72
KAY	07.005/K	TRANSFER OF WATER TO PLANT F=Ax1.25xKx0.00017xM^0,5 A=1 K=57.750.000 M=5km	TONS	0.043	$0.90	$0.04
					1 m3 Total =	$6.25

Analysis::		**Grinding of Concrete Surface**				**Meas. Unit: km**
Code	**Pose No**	**Definition**	**Unit**	**Quantity**	**Unit Cost**	**Tutarı**
KAY	07.005/K	TRANSPORTATION OF GRINDED MATERIAL FROM WORK PLACE F=Ax1.25xKxYx(0.0007xM+0.01) A=1 Y=1,6 M=30km	M3	120	$3.72	$446.40
KAY	40.130	GRINDING EVERYTYPE OF SURFACE WITH GRINDING MACHINE	M3	480	$17.22	$8,264.61
					1 km Total =	$8,711.01