CHAPTER V
RESEARCH RESULT AND DISCUSSION

A. Identification Result of Road Damage Types

From the observation data obtained of road condition about the type and the extent of damage occurring in each road segment. As for the division segment on Jl. AdiSumarmo – Solo, the segment can be seen in Table 5.1 below:

Table.5.1. Division of Road Segment on AdiSumarmo– Solo

No	Road Segment	Width of Road
1	Km 0+000 - 0+100	6 m
2	Km 0+100 - 0+200	6 m
3	Km 0+200 - 0+300	6 m
4	Km 0+300 - 0+400	6 m
5	Km 0+400 - 0+500	6 m
6	Km 0+500 - 0+600	6 m
7	Km 0+600 - 0+700	6 m
8	Km 0+700 - 0+800	6 m
9	Km 0+800 - 0+900	6 m
10	Km 0+900 - 1+000	6 m
11	Km 1+000 - 1+100	6 m
12	Km 1+100 - 1+200	6 m
13	Km 1+200 - 1+300	6 m
14	Km 1+300 - 1+400	6 m
15	Km 1+400 - 1+500	6 m
16	Km 1+500 - 1+600	6 m
17	Km 1+600 - 1+700	6 m
18	Km 1+700 - 1+800	6 m
19	Km 1+800 - 1+900	6 m
20	Km 1+900 - 2+000	6 m

The result of the type and extent of damage occurring on each road segment can be seen in Table 5.2 as follows:

Table 5.2 Type and extent of damage accruing on each road segment

Number of segment	1. Alligator crack (m^2) 2. Bleeding (m^2) 3. Block crack (m^2) 4. Corrugation (m^2) 5. Depression (m^2) 6. Bump and sags						7. JT. Reflection 8. longitudinal & Transversal (m) 9. Potholes (m^2) 10. Patching (m^2) 11. Polished Aggregate (m^2) 12. Ravelling/ Weathering (m^2)					13. Rutting (m^2) 14. Shoving (m^2) 15. Slippage crack (m^2) 16. Swell (m^2) 17. Edge crack (m^2) 18. Shoulder drop off (m)						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	14.05							3.25	15.23	2.66		0.48	2.46				3.98	28
2	4.545			6.59	4.11			15.04	15.01	7.75		1.2		0.315			20	9.8
3	13.9		1.08	1.5	5.01			3.2	27.95	9.81		2.28		2.4			10	
4	23.51				5.5			15.3	27.94	5.73			3.3	8.12			18.19	
5	20.73							10.83	39.33	1		6.09	10.6	5.966			11.95	23.6
6	8.35				7.16			3.1	40.45			3.57	3.08				38.25	20
7	48.69		20.26	3.54				7.1	19.29			4	13.96	3.565			39.7	20.9
8	46.33		16.26		16.52			18.17	6.309				16.4	1.89			20.7	29.3
9	13.65		15.79		2.817			27.3	1.5				14.8				52.9	19.9
10	51.14		25.95		4.42			14.5	2.77				6.32	7.01			37.05	46.5
11	30.03		25.7	5.87				44.17	8.874	6.5			17.89	3.468			45.92	18.9
12	53.63		61.46	8.902	4.255				10.83	4.5			43.6				7.66	48.4
13	37.95		36.11	2.1	1.62			13.7	3.03	5.28			32.33				5.11	44.9
14	19.97		39.09						12.22	9.33			18				15.16	
15	14		38.4						18.05	5.58			32.21				25.41	
16	18.86		48.63		4.37				5.064	8.05			13.34				26.5	
17			55.54						4.406			1.05	24.93				29.35	34.1
18			23.34						12.72	2.25			16.57				39.4	
19			15.85						5.882	7.55			10.38	4.61			29.95	31.3
20	16.57		25.69						1.68	28.9		9.27	16.41	3.082			35.62	
Σ	435.9		449.1	28.5	55.78			175.7	278.5	104.9		27.94	296.6	40.43			512.8	376

Based on Table 5.2 the type of damage to the road segment Jl. Adi Sumarmo - Solo Km 0 +000 – Km 2 +000 are alligator cracks, block cracks, corrugation, depression, lengthwise and transverse, patches, potholes, raveling/ weathering, rutting, shoving, edge cracks, and shoulder drop off. Potholes and edge cracks are existed all over the road segments, while corrugation is the less road damage exists at Jl. Adi Sumarmo segments. The biggest area of road damage type is edge crack with 512.8 m^2 and the smallest area of road damage type is revelling/ weathering with 27.94 m^2.

Otherwise, the type of damage that not available at Jl. Adi Sumarmo is bleeding, bump and sags, JT. reflection, polished aggregate, slippage crack, and swell.

B. The Value of Road Pavement Condition (PCI)

From the results of visual observations in the field obtained the extent of damage, the depth or width of the crack will be used to determine class damage. The next step is to calculate the density valve damage. The density of this damage is affected by the quantity of each type of damage and the extent of the road segment being reviewed. Determination of deducting value can be immediately calculated after the class of damage and density is obtained. Each type of damage has its own deduct value, medium for types of damage that is not having its own deduct value graph, then to determine ita deduct value graph is used for the type of damage that resembles and how to handle it the same. In this case study for hole damage, exfoliation, broken edges, the same as the type of damage eroded (raveling), to edge deterioration damage is the same as the type of damage (depression), whereas for diagonal crack and middle crack equal to crack lengthwise and transverse.

Total deduct value (TDV) and corrected deduct value (CDV) can immediately calculate after the stages above its value are known. Stage the

end of the pavement condition analysis is to determine the value of Pavement. Condition Index (PCI), which in principle to set priorities handling damage only.

Form the data obtained the type, area, and severity of road damage accruing at segment 2 can be seen in Table 5.3

Table 5.3 Type, area, and severity of road damage accruing at segment 2

Corrugation	1.8 L	1.6 L	1.59 M	1.6 L			
Edge Crack	20 M						
Alligator crack	1.31 L	0.9 L	1.4 M	0.94 M			
Patching	3.75 L	1 M	3 M				
Potholes	0.77 M	1.32 M	1.64 M	3.32 L	3.04 L	2.4 L	2.52 M
Shoulder drop off	9.8 L						
Depression	0.56 L	0.35 L	0.8 L	0.8 L	1.44 M	0.96 L	
Long & Trans	7.77 L	4.4 H	2.87 H				
Shoving	0.315 M						
Raveling/ Weathering	1.2 L						

The next step is summing up the total area of each severity for each road damage type as can be seen in Table 5.4

Table 5.4 The total area of each severity for each road damage types in segment 2

Road damage	Total severity (m^2)		
	L	M	H
Corrugation	5	1.59	
Edge Crack		20	
Alligator crack	2.209	2.336	
Patching	3.75	4	
Potholes	8.765	6.248	
Shoulder drop off	9.8		
Depression	2.67	1.44	
Long & Trans	7.77		7.27
Shoving		0.315	
Raveling/ Weathering	1.2		

The next step is calculating the density (area of damage divided by total area) for each severity as follow:

Total area of segment 2 = width x length

= 6 m x 100 m

= 600 m^2

The density of corrugation low severity = $\frac{Area\ of\ damage}{Total\ Area}$ x 100%

= (5/600) x 100%

= 0.833 %

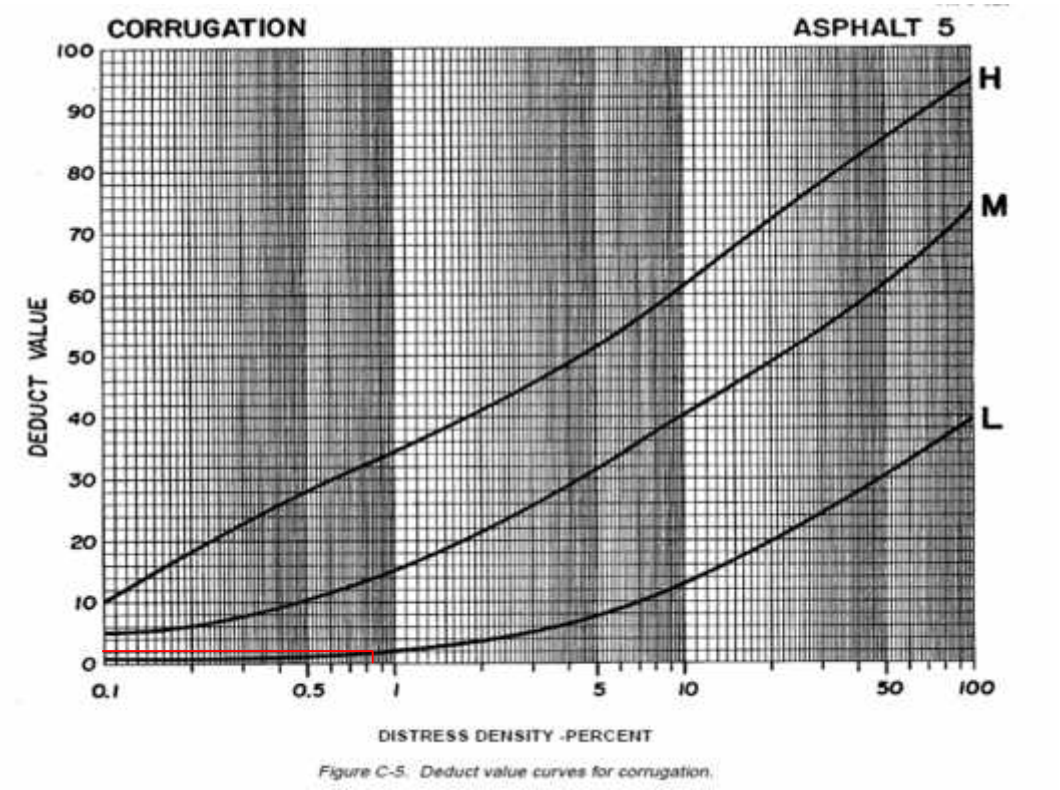

Figure 5.1 Deduct value curve for corrugation (Austroad, 1987)

Based on the graph above the deduct value of corrugation low severity equal to two. The same process has been done for each type of damage at segment 2 as can be seen in Table 5.5

Table 5.5 Density and deduct value for each type of road damage at segment 2

Distress type	Severity	Total Severity (m^2)	Density %	Deduct Value
Corrugation	L	5	0.833%	2
Corrugation	M	1.59	0.265%	7
Edge crack	M	20	3.333%	16
Alligator crack	L	2.209	0.368%	4
Alligator crack	M	2.336	0.389%	13
Patching	L	3.75	0.625%	1
Patching	M	4	0.667%	7
Potholes	L	8.765	1.461%	4
Potholes	M	6.248	1.041%	35
Shoulder drop off	L	9.8	1.633%	3
Depression	L	2.67	0.445%	4
Depression	M	1.44	0.240%	8
Long & Trans	L	7.77	1.295%	3
Long & Trans	H	7.27	1.212%	20
Shoving	M	0.315	0.053%	3
Raveling/ Weathering	L	1.2	0.200%	1

Afterward is calculating the total deduct value by summing up the deduct value

Total deduct vale = 2 + 7 + 16 + 4 + 13 + 1 + 7 + 4 + 35 + 3 + 4 + 8 + 3 + 20 + 3 + 1

= 131

The next step is to determine q (number of deducting value greater than 5)

q = 7

Afterward is determining the corrected deduct value by using Figure 3.46 corrected deduct value curve as follow:

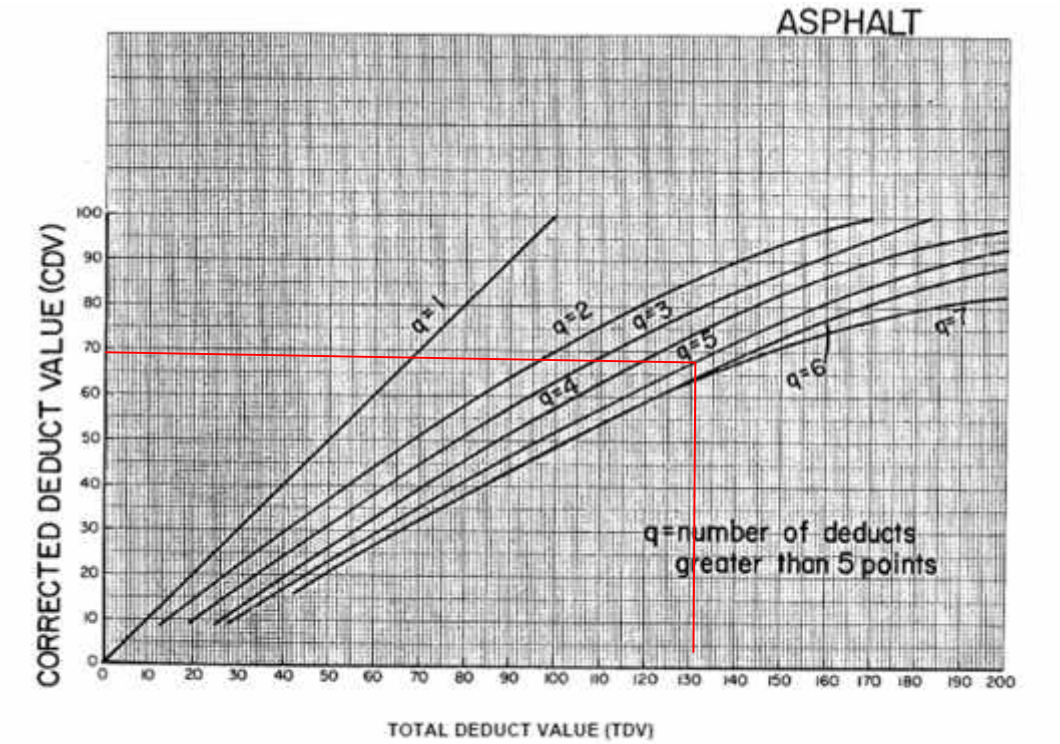

Figure 5.2 corrected deduct value curve (Austroad, 1987)

Based on the corrected deduct value graph, the corrected deduct value (CDV) at segment 2 equal to 66

The next step is calculating PCI by using Equation 3.2

PCI = 100 – CDV

= 100 – 66

= 34

The same processes have been done for each segment at Adi Sumarmo street as can be seen in Appendix C. The recapitulation result of PCI analysis for each road segment and average PCI value (overall pavement condition value) on Adi Sumarmo street - Solo (KM 0+000 – 2+00) can be seen in Table 5.6, Figure 5.3 as follows:

Table 5.6 PCI Value of Each Segment and Average PCI

Number of segment	Area of segment (m^2)	PCI	Area x PCI
1	600	21	12600
2	600	34	20400
3	600	18	10800
4	600	18	10800
5	600	24	14400
6	600	25	15000
7	600	20	12000
8	600	19	11400
9	600	28	16800
10	600	28	16800
11	600	14	8400
12	600	24	14400
13	600	29	17400
14	600	30	18000
15	600	19	11400
16	600	36	21600
17	600	35	21000
18	600	43	25800
19	600	48	28800
20	600	37	22200
Total	12000		330000
Average of PCI = Σ (Area x PCI) : Σ Area			27.5
Pavement Condition			Poor

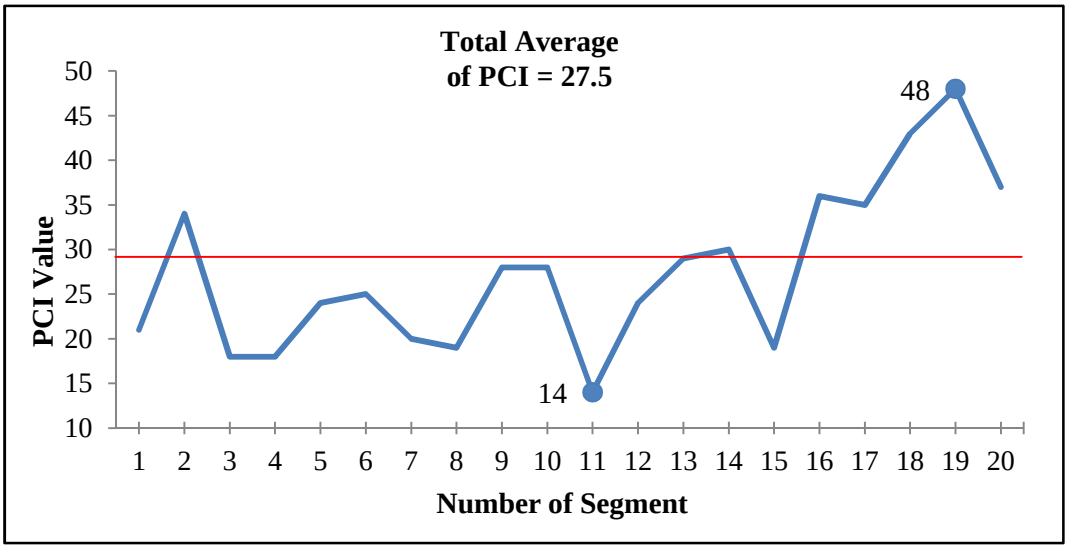

Figure 5.3 PCI Value of Each Segment

Based on Table 5.6 and Figure 5.3 the value of pavement condition index average (PCI Average) that obtained 27.5 so pavement condition on Adi Sumarmo street – Solo is (poor). The worst condition on Adi Sumarmo street founded at segment 11 with 14 PCI value (very poor), while the best condition founded at segment 19 with 48 PCI value (fair).

C. the calculation result of Road Damage Handling

The required damage-handling methods can be seen on the sheet recapitulation of observations. Method of handling this road damage includes:

1. P2 (Local asphalt labels)
2. P3 (Coating cracks)
3. P4 (Filling cracks)
4. P5 (Patching hole)
5. P6 (Flattening)

The steps of handling, material needs, and tools which are needed can be read in Chapter III. The quantity of damage that must be handled by the method above can be seen in Table 5.4 as follow:

Table 5.7 Quantity of Handling Damage

Number of Segment	The quantity of Handling Damage (m^2)					
	P1	P2	P3	P4	P5	P6
1		21.17		3.25	15.23	2.46
2		1.2	4.545	15.04	42.763	11.015
3		12.28	14.98	3.2	37.755	8.91
4		47.43		15.3	36.055	8.8
5		33.68		10.83	51.3864	10.6
6		3.57	8.35	3.1	78.702	10.24
7		20.26		7.1	111.675	21.065
8		16.26		18.17	89.859	18.29
9			29.43	27.3	54.4	17.6125
10		25.95		14.5	97.97	10.74
11		62.2263		44.17	54.7935	27.224
12		12.16			169.5235	13.1569
13		10.39		13.7	109.42	3.72
14		35.13			78.642	
15		5.58	14		114.068	
16		18.86			88.246	17.71
17		1.05			114.228	
18		25.59			52.115	16.57
19		15.846			47.992	10.38
20		42.262			75.47	19.491
Total		410.8943	71.305	175.66	1520.293	227.9844

Based on Table 5.7 method of handling road damage at Jl. AdiSumarmo - Solo Km 0 + 000 – Km 2 + 000 using P2, P3, P4, P5,P6 with the quantity of damage that each method should deal with are: P2 = 410.894 m2, P3 = 71.305 m2, P4 = 175.66 m, P5 = 1520.293 m2, P6 = 227.984 m2 .

Based on BinaMarga (1999) the calculation of the requirements for each method as follows:

At segment 1 for method P2 (Local Asphalt) the damaged area equal to 21.17 m^2, the material needed is emulsion asphalt RS-1 as 1.5 l/m^2, and fine aggregate (5 mm)as 0.01 m / m^2

Asphalt emulsion RS1 (L) = 1.5 x Area
= 1.5 x 21.7
= 31.755 L

Fine aggregate (5 mm) = 0.01 x Area
= 0.01 x 21.17
= 0.2117 m^3

At segment 2 for method P3 (Coating Crack) the damage area equal to 4.545 m^2, the material needed are asphalt cut back MC70 as 0.2 l/m^2, coarse sand as 40 Kg/m^2, and Asphalt emulsion RS1 as 55 Kg/m^2

Asphalt cut back MC70 (L) = 0.2 x Area
= 0.2 x 4.545
= 0.909 L

Coarse sand (Kg) = 40 x Area
= 40 x 4.545
= 181.8 Kg

Asphalt emulsion RSI (Kg) = 55 x Area
= 55 x 4.545
= 249.975 Kg

At segment 1 for method P4 (Filling Crack) the damage length equal to 3.25 m, the material needed are coarse sand as (0.003 m width x 0.05 m depth) / m, and Asphalt emulsion RS1 as 0.22/m^2.

Asphalt emulsion RS1 = 0.22 x Length
= 0.22 x 3.25
= 0.715 L

Coarse sand = L x 0.003 m x 0.05 m
= 3.25 x 0.003 x 0.05
= 0.000488 m^3

At segment 1 for method P5 (Patching holes) the damaged area equal to 15.23 m^2, the material needed are aggregate type A as with thickness 100 mm, coarse aggregate with minimum thickness 25 mm, fine aggregate with minimum thickness 15 mm, asphalt emulsion RS1 as 7 l/m^2, and asphalt cut back MC70 as 0.5 l/m^2.

Aggregate type A	=	0.1 m x Area
	=	0.1 x 15.23
	=	1.523 m^3
Coarse aggregate	=	0.025 x 15.23
	=	0.396 m^3
Fine aggregate	=	0.015 x Area
	=	0.015 x 15.23
	=	0.2589 m^3
Asphalt emulsion RS1	=	7 x area
	=	7 x 15.23
	=	106.61 L
Asphalt cut back MC70	=	0.5 x area
	=	0.5 x 15.23
	=	7.615 L

At segment 1 for method P2 (Alignment/ Flattening) the damage area equal to 2.46 m^2, the material needed are tack coat as 0.2 l/m^2, cold asphalt up to 1/3 above the area of damage (minimum thickness 10 mm).

Tack coat	=	0.2 x Area
	=	0.2 x 2.46
	=	0.492 L
Cold Asphalt	=	(Area x 20 mm) + (1/3 (Area x 20 mm))
	=	(2.46 x 0.02) + (1/3 (2.46 x 0.02))
	=	0.0656 m^3

The same processes have been done for each handling method along Jl. AdiSumarmu – Solo. The resource requirements for each handling method can be seen in Table 5.8 to Table 5.12

Table 5.8 Resource Requirement for Method P2
(Local Asphalt)

Number of Segment	Material	
	Asphalt Emulsion RS1 (L)	Fine Aggregates 5 mm (m^3)
1	31.755	0.2117
2	1.8	0.012
3	18.42	0.1228
4	71.145	0.4743
5	50.52	0.3368
6	5.355	0.0357
7	30.39	0.2026
8	24.39	0.1626
10	38.925	0.2595
11	93.3395	0.6223
12	18.24	0.1216
13	15.585	0.1039
14	52.695	0.3513
15	8.37	0.0558
16	28.29	0.1886
17	1.575	0.0105
18	38.385	0.2559
19	23.769	0.1585
20	63.393	0.4226
Total	616.3415	4.1089

Based on Table 5.8 the total martial quantity that needed for method P2 (Local Asphalt) are 616.3415 L asphalt emulsion RS1, and 4.1089 m^3 Fine Aggregate (5 mm).

Table 5.9 Resource Requirement for P3 Method
(Coating the Cracks)

Number of Segment	Material		
	Coarse Sand (Kg)	Asphalt Emulsion RS1 (Kg)	Asphalt Cut back MC70 (L)
2	181.8	249.975	0.909
3	599.2	823.9	2.996
6	334	459.25	1.67
9	1177.2	1618.65	5.886
15	560	770	2.8
Total	2852.2	3921.775	14.261

Based on Table 5.9 the total martial quantity that needed for method P3 (coating crack) are 2852.2 Kg coarse sand, 3921.775 Kg Asphalt emulsion RS1, and 14.261 L asphalt cut back MC70.

Table 5.10 Resource Requirement for P4 Method
(Filling the Cracks)

Number of Segment	Material	
	Coarse Sand (m^3)	Asphalt Emulsion RS1 (L)
1	0.000488	0.7150
2	0.002256	3.3088
3	0.000480	0.7040
4	0.002295	3.3660
5	0.001625	2.3826
6	0.000465	0.6820
7	0.001065	1.5620
8	0.002726	3.9974
9	0.004095	6.0060
10	0.002175	3.1900
11	0.006626	9.7174
13	0.002055	3.0140
Total	0.026349	38.6452

Based on Table 5.10 the total martial quantity that needed for method P4 (Filling the cracks) are 38.6452 L asphalt emulsion RS1, and 0.026349 m^3 coarse sand.

Table 5.11 Resource Requirement for Method P5 (patching of holes)

Number of Segment	Material				
	Aggregate Type A (m^3)	Coarse Aggregate (0.5-2cm) (m^3)	Fine Aggregate (<0.5cm) (m^3)	Asphalt Emulsion RS1 (L)	Asphalt Cut back MC70 (L)
1	1.5230	0.3960	0.2589	106.6100	7.6150
2	4.2763	1.1118	0.7270	299.3410	21.3815
3	3.7755	0.9816	0.6418	264.2850	18.8775
4	3.6055	0.9374	0.6129	252.3850	18.0275
5	5.1386	1.3360	0.8736	359.7048	25.6932
6	7.8702	2.0463	1.3379	550.9140	39.3510
7	11.1675	2.9036	1.8985	781.7250	55.8375
8	8.9859	2.3363	1.5276	629.0130	44.9295
9	5.4400	1.4144	0.9248	380.8000	27.2000
10	9.7970	2.5472	1.6655	685.7900	48.9850
11	5.4794	1.4246	0.9315	383.5545	27.3968
12	16.9524	4.4076	2.8819	1186.6645	84.7618
13	10.9420	2.8449	1.8601	765.9400	54.7100
14	7.8642	2.0447	1.3369	550.4940	39.3210
15	11.4068	2.9658	1.9392	798.4760	57.0340
16	8.8246	2.2944	1.5002	617.7220	44.1230
17	11.4228	2.9699	1.9419	799.5960	57.1140
18	5.2115	1.3550	0.8860	364.8050	26.0575
19	4.7992	1.2478	0.8159	335.9440	23.9960
20	7.5470	1.9622	1.2830	528.2900	37.7350
Total	152.0293	39.5276	25.845	10642.054	760.1467

Based on Table 5.11 the total martial quantity that needed for method P5 (Patching Holes) is 152.0293 m^3 aggregate type A, 39.5276 m^3 coarse

aggregate, 25.845 m^3 fine aggregate, 10642.054 L asphalt emulsion RS1, and 760.1467 L asphalt cut back.

Table 5.12 Resource Requirement for Method P6 (Flattening)

Number of Segment	Material	
	Tack coat (L)	Cold Asphalt Mixture (m^3)
1	0.4920	0.0656
2	2.2030	0.2937
3	1.7820	0.2376
4	1.7600	0.2347
5	2.1200	0.2827
6	2.0480	0.2731
7	4.2130	0.5617
8	3.6580	0.4877
9	3.5225	0.4697
10	2.1480	0.2864
11	5.4448	0.7260
12	2.6314	0.3509
13	0.7440	0.0992
16	3.5420	0.4723
18	3.3140	0.4419
19	2.0760	0.2768
20	3.8982	0.5198
Total	45.5969	6.0796

Based on Table 5.12 the total martial quantity that needed for method P6 (Alignment/ Flattening) are 45.5969 L tack coat, and 6.0796 m^3cold asphalt.