DATA DEVELOPMENT FOR IMPROVING MAINTENANCE PERFORMANCE

Ralph C. Parsons
Consulting Manager
H. B. Maynard & Co., Inc., Management Consultants

A wide gap exists between the way maintenance procedures are engineered, specifications defined, materials selected and maintenance procedures carried out in the field. This gap is caused in part by variations in the backgrounds of the engineers and the first levels of maintenance supervision, the organizational structure of the maintenance department, and the lack of adequate staff support.

The problems arising from these conditions can be lessened by a sound standards development program which must do more than just measure. It must also enable adequate control. This means maintenance measurements must be consistent, and must be based on correct procedures, which in turn must be carried out using proper methods.

It all sounds complicated, but it can be done. It is being done (although it's still a rarity). And the results certainly justify the effort. They include: lower unit costs; better quality of service and repair work (both in terms of amount of work done and the individual repairs themselves); and higher work crew morale.

Sound like Utopia? Yes, but it can be achieved ... using simple logic and existing engineering skills. Figure 1 spells out the basic steps.

Control should start with a systematic and continual procedure for identifying what needs to be repaired. Next comes development of work procedures and methods which, when followed, will result in quality repair work. Training should begin with the foremen, and then the work crew through the foremen. They should learn how to do it, when to do it and finally how long it is expected to take. The final basic step is to provide feedback to the various levels of management so proper control action can be taken.

Better Work from Fewer People

In talking road maintenance to administrators -- no matter whether at the state, county or city/town level -- the invariable response to comments about things not being in good repair is, "If we only had the people, we could do the job. We are so horribly understaffed."

But then when you go out and watch people doing the job, you find performance generally low, jobs badly over-staffed and crews not using good work methods or procedures. They are not given proper direction, and in some cases they are spending more time traveling to the job than on the job.

In highway and street maintenance (as in plant maintenance) it is generally true that management can keep an existing level of maintenance, perhaps go even a little higher, with one quarter to one third less people! Or, where maintenance quality is unsatisfactory, it can be improved considerably by adopting proper procedures and controls over the same number of people.

If this is possible, why haven't we done more about it? Basically, because people in the business of measuring factory jobs and other types of work have been very slow in facing up to maintenance. Maintenance measurement, they've found, presents problems. Take the concept of units of work, for example. How do you measure them in a maintenance situation? The answer, we feel, lies in adopting the one unit of measure in maintenance work that cannot be questioned ... and the one that is easiest to administer. That is the standard hour of work.

What constitutes a standard hour of work? While we were training a group of 20 foremen recently, we approached the subject by announcing that, "Today we are going to instruct someone exactly how to fix a hole in the street." The foremen thought this was hilarious ... so elementary that it wasn't even worth discussing. So we had them take a piece of paper and write down the instructions they would give. A comparison of the answers showed there were no two alike. And that not one would be satisfactory. By then, the foremen began to realize it wasn't so easy.

The next step was to discuss and then write down the various things we would do from the time we arrived at the job site until we left. Over a period of a couple of sessions we checked all the specifications and finally got a procedure everybody agreed was a procedure. The result was an illustrated, detailed description like the one shown in Figure 2.

In this way, we helped the foremen develop the thinking process that would lead to the kind of repairs that should be made, and helped them realize that this was not what was being done by the crews out on the street.

From Procedure to Measurement

Having established the procedure, measurement comes next. For this measurement, we recommend a system widely used in industry and by the Federal government, and one that leads directly to development of standard hour data. The system is called methods-time measurement. Instead of using a stopwatch, MTM involves analyzing the motions necessary to do a job, writing down the standard times needed to complete them (see Figure 3), and adding the individual motion times together. The total represents, in standard hours, the unit of time needed to accomplish a particular operation.

Obviously, if you were studying a wide variety of work in any street or highway maintenance operation, it would take a lot of time to accumulate all the data needed for overall standards. But individual motion-by-motion analyses are not necessary. The job has already been done. Based on work sampling studies, we've found exactly what people do when they are working ... in terms of type of work, the actual amount of time spent shoveling, using a pickaxe, broom, jackhandle, etc. When we completed these studies, we had the tools for measuring virtually every type of maintenance work. We were able to measure -- on a standard hour basis -- all of the activities performed by people assigned to a given type of work. (Figure 4 shows how data have been built up into standard hour formulas.)

Once you have a standard hour measuring system, it becomes possible to establish and maintain practical schedules and plans. And to set up time reports, like the one shown in Figure 5. Reports like this give maintenance management a truly effective means of making the right decisions, taking appropriate action to improve maintenance activity, and thereby boosting performance and lowering unit cost.

1. Determine the procedures to follow for effective maintenance.
2. Select the best work methods possible for carrying out these procedures.
3. Measure maintenance operations by type of work, not by what is accomplished.
4. Combine these times in sequence, and in accordance with good maintenance procedures, including safety procedures.
5. Determine optimum crew sizes.
6. Develop job instructions for use in training both the supervision and the maintenance worker.
7. Set up a good reporting system to keep all levels of maintenance management adequately informed of progress and accomplishment.

Figure 1.

Seven Steps Towards
Better Control of Maintenance

Procedure For Small Bituminous Repair

The truck driver parks the truck at the side of the road and then assists the laborer in setting barricades and cones, diverting traffic around the work area. The truck is then positioned at the repair.

The driver and laborer then remove the required tools from the truck, and place them alongside the defective area. These may include the shovel, pick, mattock, broom, hand tamp, and hand roller.

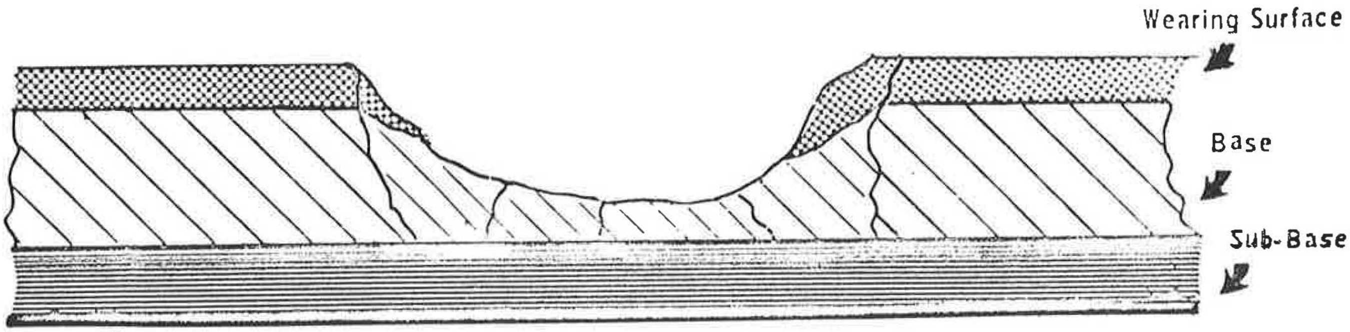
When patch work is required, the surface is swept clean. The sweepings are shoveled into the front end of the truck. The tack coat is applied to the surface of the area to be patched. Material is obtained for small patches by raising the truck gate and shoveling bituminous mix through the gate. Material is obtained for larger patches by raising the truck bed and spot dumping the bituminous material. The patch is raked to grade, rolled, and compacted with the hand roller.

Dig out work is required when there is an actual break through the wearing surface such as is shown in A.

Working as a team, the driver and laborer are expected to follow the procedure as outlined:

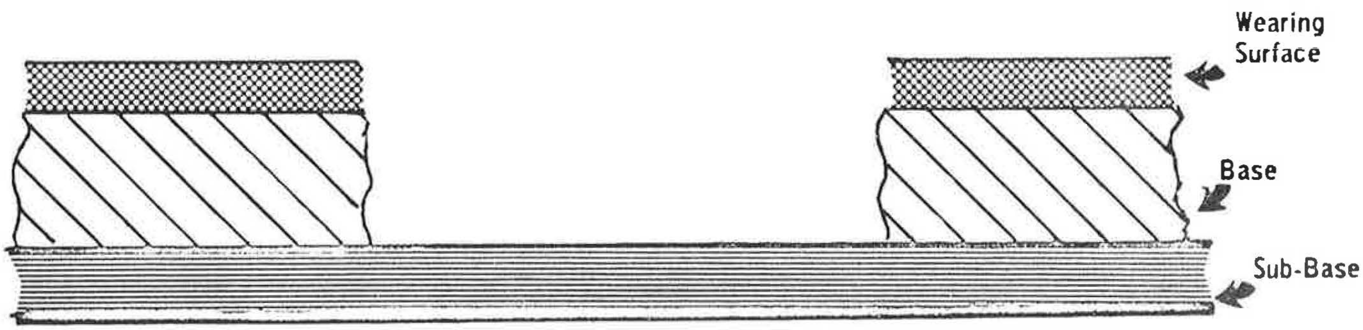
1. Mark the area to be replaced or patched with keel. This area should be rectangular in shape, if possible.
2. Loosen material by picking along lines as marked.
3. Remove all loose material by shoveling directly into truck.
4. Trim vertical edges with mattock (B).
5. Hand tamp sub-base.
6. Sweep top and edges free of dirt and dust.
7. Using toy broom, brush all faces of cut with emulsified asphalt. Apply tack coat to bottom of repair if asphalt or concrete base.
8. Allow tack coat to break.
9. Place hot bituminous mix in the repair in approximately four-inch courses, and compact each as hole is filled.
10. Hand tamp for compaction.
11. Repeat steps 9 and 10 until excavation is filled to within 1 1/2 inches.
12. Place and grade wearing surface layer of hot bituminous asphalt, allowing a slight crown to rise above the existing pavement (C) in order to gain additional compaction from traffic.
13. Compact with hand roller.
14. Spread dry cement over surface with broom to decrease tire pickup of the hot mix.

Fig. 2 (Part A)



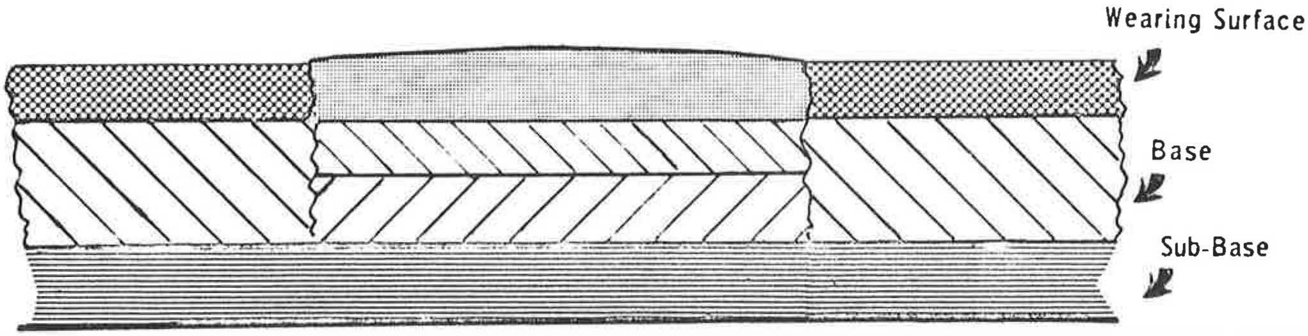
Defect in pavement requiring removal

A



Defect removed, edges trimmed to obtain true vertical faces

B



Repaired pot hole with lifts of 4 inches of compacted mix, with a 1-1/2 inch topping

C

Fig. 2 (Part B)

TABLE I—REACH—R

Distance Moved Inches	Time TMU A	Time TMU B	Time TMU C or D	Time TMU E	Hand In Motion A	Hand In Motion B	CASE AND DESCRIPTION
¾ or less	2.0	2.0	2.0	2.0	1.6	1.6	**A** Reach to object in fixed location, or to object in other hand or on which other hand rests.
1	2.5	2.5	3.6	2.4	2.3	2.3	
2	4.0	4.0	5.9	3.8	3.5	2.7	
3	5.3	5.3	7.3	5.3	4.5	3.6	**B** Reach to single object in location which may vary slightly from cycle to cycle.
4	6.1	6.4	8.4	6.8	4.9	4.3	
5	6.5	7.8	9.4	7.4	5.3	5.0	
6	7.0	8.6	10.1	8.0	5.7	5.7	
7	7.4	9.3	10.8	8.7	6.1	6.5	**C** Reach to object jumbled with other objects in a group so that search and select occur.
8	7.9	10.1	11.5	9.3	6.5	7.2	
9	8.3	10.8	12.2	9.9	6.9	7.9	
10	8.7	11.5	12.9	10.5	7.3	8.6	
12	9.6	12.9	14.2	11.8	8.1	10.1	**D** Reach to a very small object or where accurate grasp is required.
14	10.5	14.4	15.6	13.0	8.9	11.5	
16	11.4	15.8	17.0	14.2	9.7	12.9	
18	12.3	17.2	18.4	15.5	10.5	14.4	
20	13.1	18.6	19.8	16.7	11.3	15.8	
22	14.0	20.1	21.2	18.0	12.1	17.3	**E** Reach to indefinite location to get hand in position for body balance or next motion or out of way.
24	14.9	21.5	22.6	19.2	12.9	18.6	
26	15.8	22.9	23.9	20.4	13.7	20.2	
28	16.7	24.4	25.3	21.7	14.5	21.7	
30	17.5	26.8	26.7	22.9	15.3	23.2	

TABLE II—MOVE—M

Distance Moved Inches	Time TMU A	Time TMU B	Time TMU C	Hand In Motion B	Wt. (lb.) Up to	Factor	Constant TMU
¾ or less	2.0	2.0	2.0	1.7	2.5	1.00	0
1	2.5	2.9	3.4	2.3			
2	3.6	4.6	5.2	2.9	7.5	1.06	2.2
3	4.9	5.7	6.7	3.6			
4	6.1	6.9	8.0	4.3			
5	7.3	8.0	9.2	5.0	12.5	1.11	3.9
6	8.1	8.9	10.3	5.7			
7	8.9	9.7	11.1	6.5	17.5	1.17	5.6
8	9.7	10.6	11.8	7.2			
9	10.5	11.5	12.7	7.9	22.5	1.22	7.4
10	11.3	12.2	13.5	8.6			
12	12.9	13.4	15.2	10.0	27.5	1.28	9.1
14	14.4	14.6	16.9	11.4			
16	16.0	15.8	18.7	12.8	32.5	1.33	10.8
18	17.6	17.0	20.4	14.2			
20	19.2	18.2	22.1	15.6	37.5	1.39	12.5
22	20.8	19.4	23.8	17.0			
24	22.4	20.6	25.5	18.4	42.5	1.44	14.3
26	24.0	21.8	27.3	19.8			
28	25.5	23.1	29.0	21.2	47.5	1.50	16.0
30	27.1	24.3	30.7	22.7			

CASE AND DESCRIPTION

A Move object to other hand or against stop.

B Move object to approximate or indefinite location.

C Move o… act loca…

TABLE III—TURN AND APPLY PRESSURE—T AN…

Weight	30°	45°	60°	75°	90°	105°	120°	135°	1…
Small— 0 to 2 Pounds	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	
Medium—2.1 to 10 Pounds	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	1…
Large— 10.1 to 35 Pounds	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	2…

(Time TMU for Degrees Turne…)

APPLY PRESSURE CASE 1—16.2 TMU. APPLY PRESSURE CASE …

TABLE IX—BODY, LEG AND FOOT MOTIONS

DESCRIPTION	SYMBOL	DISTANCE	TIME TMU
Foot Motion—Hinged at Ankle. With heavy pressure. Leg or Foreleg Motion.	FM FMP LM —	Up to 4" Up to 6" Each add'l. inch	8.5 19.1 7.1 1.2
Sidestep—Case 1—Complete when leading leg contacts floor. Case 2—Lagging leg must contact floor before next motion can be made.	SS-C1 SS-C2	Less than 12" 12" Each add'l. inch 12" Each add'l. inch	Use REACH or MOVE Time 17.0 .6 34.1 1.1
Bend, Stoop, or Kneel on One Knee. Arise. Kneel on Floor—Both Knees. Arise.	B,S,KOK AB,AS,AKOK KBK AKBK		29.0 31.9 69.4 76.7
Sit. Stand from Sitting Position. Turn Body 45 to 90 degrees— Case 1—Complete when leading leg contacts floor. Case 2—Lagging leg must contact floor before next motion can be made.	SIT STD TBC1 TBC2		34.7 43.4 18.6 37.2
Walk. Walk.	W-FT. W-P	Per Foot Per Pace	5.3 15.0

E. Move Rake Around Corner of Patch

DESCRIPTION — LEFT HAND	No.	LH	TMU	RH	No.	DESCRIPTION — RIGHT HAND
Move Rake off Material		M14B4m	47.3	SS24C2		Side step around corner of patch
				~~M12Bm~~		Move rake off material
Move Rake to Material		M14B4m	24.2	SS24C1		Step around corner of patch
				~~M12Bm~~		Move rake to material
			71.5			

Figure 3

Example of motion pattern and time standard for a portion of the operation, "Rake with Asphalt Rake". Individual motion times are selected from the MTM data card, portions of which are shown above.

Typical example of how standard hour data have been built up to cover all types of maintenance operations.

EXAMPLE OF BUILDUP OF DATA

Bituminous Material -- inspect, loosen, rough and finish grade per square foot.

Code	Description	Time
K5	Inspection to determine if patch is on grade	.0001
B	Rake Bituminous Material to rough grade	.0001
K3	Rake material to finish grade	.0012
K4	Loosen material with rake	.0002
		.0016 hrs.

TABLE 1

Smooth Bituminous Material to Grade Using Rake for Short Trench Replacement and Small Bituminous Repairs.

Operation Description	Symbol	Hours	Unit
Obtain, clean after use and put away	I	.0081	Per Patch
Rough grade, finish grade, loosen and inspect	II	.0016	Per Square Foot of Patch
Rake to edge, position rake for finish grade	III	.0004	Per Foot of Perimeter

Fig. 4

DAILY WORK SHEET
SMALL BITUMINOUS REPAIR

Speedometer Reading:

End of Day 22,346

Beginning of Day 22,309

Mileage for Day 37

x.064

Travel Time 2.37

Emergency Calls (✓) 3

Date July 7, 1961

District A

	Crew Members	Work Hours
1.	R. Jones	8
2.	A. Reed	8
3.		
	Total	16

Material Drawn 2 tons

Material Used 1-3/4 tons

DIG OUT AND REPLACE					PATCH				
Emer.	Location	Size	No.	Std.	Emer.	Location	Size	No.	Std.
	Valerio & Gothic	2x2		.19		9300 Wilbur	2x2		.08
	673 Gothic	2x6		.46		675 Gothic	3x18	.2x3	.63
✓	1232 Krebs	2x3		.25		7200 S.Irvine	3x7		.27
	16206 Plume	2x3		.25		Louise Ave.	2x2	.08x2	.16
	Roscoe & Baird	1x1	.07x2	.14		between			
	Roscoe & Baird	2x4		.32		Kingsbury		3x5	.18
						& Chatsworth			
	Total for Repair			1.61		Total for Patch			1.32

SUMMARY	
Craft Time	3.79
Site Preparation/Site 8 x .08	.64
Travel Time 2.37 x 2 men	4.74
Standard Hours	9.17
Allowance 16%	1.47
Total Earned Hours	10.64

Total for Patch	1.32
Total for Repair	1.61
Other Work	.26
Daily Preparation .3 x 2 men	60
Total Craft Time	3.79

$\frac{10.64}{16} = 66.5\%$

Other work:		
	✓ Pick up glass in street (Amestoy and Ethel).	.06
	✓ Haul trailer to yard for patch crew (4 miles).	.20
		.26

Crew Leader R. Jones

Figure 5. Daily work sheet showing typical day's production.