PLANNING FOR THE OPERATION SEAL BITUMINOUS AND CONCRETE PAVEMENTS

by

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INTRODUCTION

This report covers an examination of the operation seal bituminous and concrete pavements. It also examines planning and other considerations which are essential to achieving improvements in this operation. The data providing the basis for this report were obtained from studies of sealing on 18 different jobs. Two of the studied jobs are presented in detail, showing chronologically the activity of each man and each unit of equipment during a day's operation. An examination is made of the factors affecting the productivity of these two jobs. In the light of this examination, a schedule is set up for a selected sealing job in order to test the idea that planning would improve efficiency and increase production. Finally, the results of a trial run on the selected job are reported.

MATERIAL APPLICATION RATES

The rates at which asphalt and aggregate are applied during sealing oprations provide a limited indication of quality of work. They are also worthy of note because of their effect on accomplishment. Adequate control of these rates is necessary to produce quality work at minimum cost.

There are rather obvious consequences attendant to deficient or excessive rates of application of asphalt, or aggregate, or both. Aggregate in excess of that needed to cover the asphalt is whipped off by traffic and often wasted in the ditch. Excess asphalt requires excess aggregate cover and frequently requires follow-up applications of gravel because of bleeding. Seal coats which do not meet specification can logically be expected to need early replacement. On all of the jobs studied, experience and judgment of the workmen were the only means for determining the proper rates of material application.

State maintenance and construction standard specifications and the Construction Field Manual, provide for specific control in the quantities of asphalt and aggregate applied during sealing operations. These are as follows:

	Asphalt	Aggregate
Maintenance standard specifications	0.25 gal./sq. yd.	25 pounds/sq. yd.
Construction standard specifications	0.30 gal./sq. yd	30 pounds/sq. yd
Construction Field Manual	----	10 pounds/0.10 gal.

Asphalt application rates for the 18 sealing jobs studied varied between 0.15 and 0.50 gallon per square yard. Only on four jobs, did the rates fall between 0.20 and 0.35 gallon per square yard. Aggregate spreading rates for the 18 jobs varied from 18 to 61 pounds per square yard. On eleven of the jobs, rates fell between 20 and 35 pounds per square yard. For all 18 jobs the quantity of aggregate per 0.10 gallon of asphalt varied between 5 and 27 pounds. Rates on only 6 jobs fell between 8 and 12 pounds of aggregate per 0.10 gallon of asphalt.

Rates of accomplishment on the 18 jobs varied between 15 and 86 square yards of sealing completed for each man-hour of effort. From an examination of data on the various studies, it appears that variations in material application rates was one of the factors affecting accomplishment. Obviously, the number of square yards sealed with a 500-gallon distributor load of oil is a function of the amount of asphalt applied per square yard. On two jobs where the rate of accomplishment was 68 and 86 square yards per man-hour, respectively, the asphalt application rate was 0.15 gallon per square yard. On the other hand, one job was encountered where the asphalt application rate was 0.48 gallon per square yard, and accomplishment was at the rate of only 18 square yards per man-hour.

LABOR AND EQUIPMENT TIME UTILIZATION

Study data for the 18 jobs show very little uniformity either in crew sizes, number of equipment units utilized, and patching accomplishment per man-hour. This lack of uniformity is evident in the following figures:

	Minimum	Maximum
Number of men assigned to crew	4	11
Number of equipment units per crew	4	10
Square yards of sealing per man-hour	15	86

It is also significant that very little correlation exists between square yards per man-hour and the size of the crew or number of equipment units employed. Square yards of patching per man-hour were observed for different jobs to be both high and low for large crews, but this was equally true for small crews.

Data for all 18 jobs studied show, on the average, that about 45 percent of crew NAWT was nonproductive, 35 percent was expended on supporting work items (including travel, haul and return), and 20 percent was productively used for sealing. These figures suggest that perhaps the easiest way to increase sealing accomplishment, or productivity, is to identify and eliminate nonproductive time. For the most part this consisted of waiting on asphalt to heat, wait for spraying asphalt, wait for spreading aggregate, wait for hauling asphalt and/or aggregate, wait on instructions and inspections, personal and idle time.

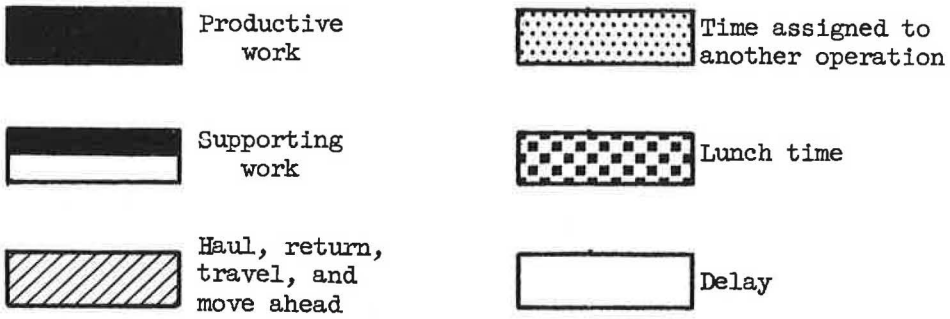
The key to the problem of nonproductive time appears to be the lack of balance in equipment employed and the custom of initial heating of asphalt after the beginning of scheduled shift time (8 a.m.). An inadequate number of trucks for hauling and spreading aggregate means that an entire distributor load of asphalt cannot be sprayed without waiting for trucks to return to the stockpile for more aggregate. An inadequate number of distributors or insufficient distributor capacity means periodic waits between distributor loads while the asphalt is heating. For different job conditions and haul distances, equipment balance is obviously not static. This is an important area of responsibility of the foreman in planning and

scheduling work assignments. As for heating asphalt in the morning, the cost of overtime for one man to do this before scheduled shift time can be recovered several times over by eliminating the time the entire crew loses while waiting for asphalt to heat.

Beyond the elimination or reduction of nonproductive time, better organization of the sealing operation in general offers possibilities for reducing time required for related work with a comparable increase in time available for productive work. Increases in accomplishment during productive time are also possible through improvement in (1) work methods and (2) individual effort.

DETAILED ANALYSIS OF TWO SEALING JOBS

In order to facilitate evaluation of the information obtained from detailed studies of sealing operations, two of the jobs studied, designated A and B, were selected for presentation on gang process charts. These charts are shown in figures 43 and 44. They provide for easier analysis of the operation by permitting visual evaluation of the extent to which coordination and balance were obtained between various men. Similar charts would be used to evaluate the coordination of equipment units. It should be noted that some short periods of work or delay time were not indicated on the two examples in order to avoid making the charts excessively complex. The following symbols were used on the charts.



From the charts it can readily be seen that there are opportunities for certain changes which will result in increased productivity. It is axiomatic that accomplishment can be no greater than the area sprayed with asphalt, yet during job "A" work directly associated with spraying asphalt amounted to only 40 man-minutes (for 2 men) out of a crew total of 1,570 man-minutes for the day's job. The 40 minutes include maneuvers and short move aheads between work areas. During job "B" work directly associated with spraying asphalt, including maneuvers, and short move aheads amounted to 86 man-minutes (for 2 men) out of a crew total of 2,470 man-minutes for the job.

On each of the jobs, the distributor operator spent more than 7 hours, which was either nonproductive or not directly contributing to accomplishment. This seven hours includes a variety of activity, but a major portion involves waiting for asphalt to heat. On job "A" the most time-consuming item was filling the distributor with asphalt. The delay that occurred most frequently was waiting for trucks to spread aggregate. Other lost time resulted from quit early, excess lunch time, wait for loading aggregate, and wait to receive instructions.

There is always an irreducible quantity of time required for morning preparations and evening shutdown whenever an array of men, equipment, tools, and materials perform work at a worksite located away from the maintenance garage. The starting up and shutting down routines generally require about the same amount of time and effort regardless of whether crew spends three hours or six hours at the worksite. This is quite possibly a significant reason why the actual accomplishment per man-hour on jobs "A" and "B" is not substantially higher. On job "A", only one distributor load of asphalt was used; on job "B" a little over one-half of a distributor load was used. Any increase in the amount of asphalt applied with accompanying greater accomplishment reduces the percent of total job time absorbed in morning and afternoon supporting effort. On the two jobs referred to, several of the crew members devoted and charged a portion of their total shift time for the day to other operations unrelated to the sealing operation. Even without lost motion involved in the transition from one assignment to the other, such practice does not contribute to the essential need for devoting a greater percentage of the day's effort to the actual work of sealing.

An examination of the study data on jobs "A" and "B" also points up several facts which have a direct bearing on accomplishment. On job "B" the principal assignment of two men on the crew was that of hand shoveling and brooming aggregate. Where it is practical for mechanical spraying of the asphalt, mechanical application of the aggregate should also be practical and of course much more productive per man-hour. The truck driver started after aggregate in the morning without knowing definitely where he could obtain it. He drove for 30 minutes to a quarry only to find no aggregate. After considerable confusion and further travel to stockpiles and garages, unhitching and hitching the roller, and securing a loader, he finally obtained a load of aggregate. Planning opportunities also exist in the placing and moving of warning signs at the worksite. Key men such as the distributor operator and aggregate truck drivers should not interrupt or delay operations to move or wait for the moving of signs. Where frequent moving of signs is desirable, a second set would permit placing at the next worksite while work is being completed at the previous worksite.

PLANNED SEALING JOB

Up to this point, we have discussed the 18 jobs studied and have indicated ways in which they might have been improved. In order to determine if planning would promote greater efficiency and higher productivity, an actual job was selected for a test. This job was located in the three-county control area and consisted of a road section about 6 miles long with numerous distressed areas. It was estimated that the total area in need of sealing exceeded 15,000 square yards, but not all of this was to be accomplished during the planned job. Aggregate for sealing had already been stockpiled at one end of the section under a contract. Ample numbers of men and equipment were available so it was decided to use a large crew in the planned job.

Figure 45 shows a proposed schedule for the selected job. This figure is a gang process chart similar to those presented for jobs "A" and "B". The chart provides a schedule for each man, based on time and performance observed during the 18 jobs studied. This schedule attempts to provide the best possible balance between spraying asphalt and hauling and spreading aggregate under the conditions anticipated to prevail at the selected worksite. For example, with the desired rates of application set at 5 tons

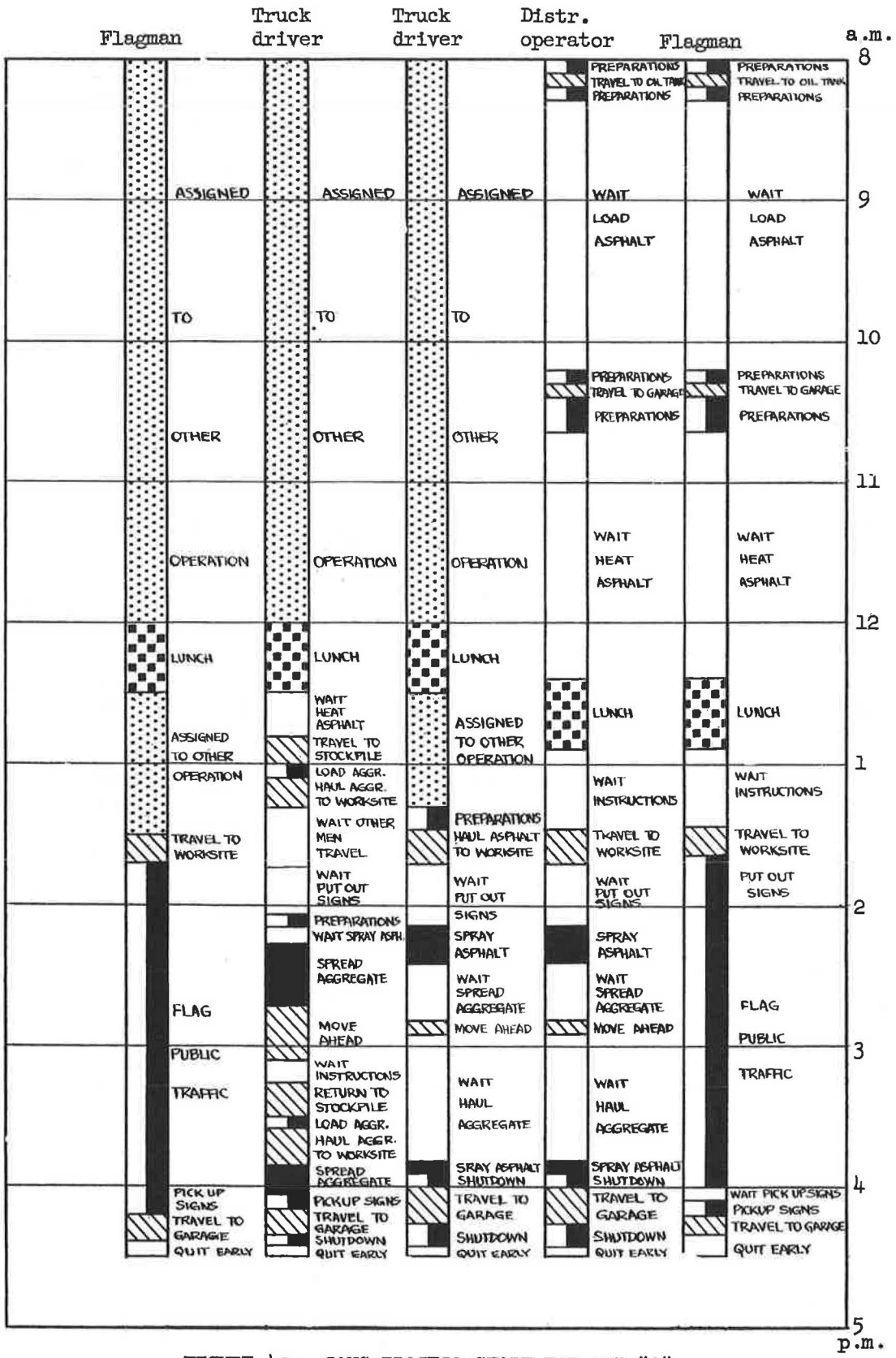


FIGURE 43. GANG PROCESS CHART FOR JOB "A"

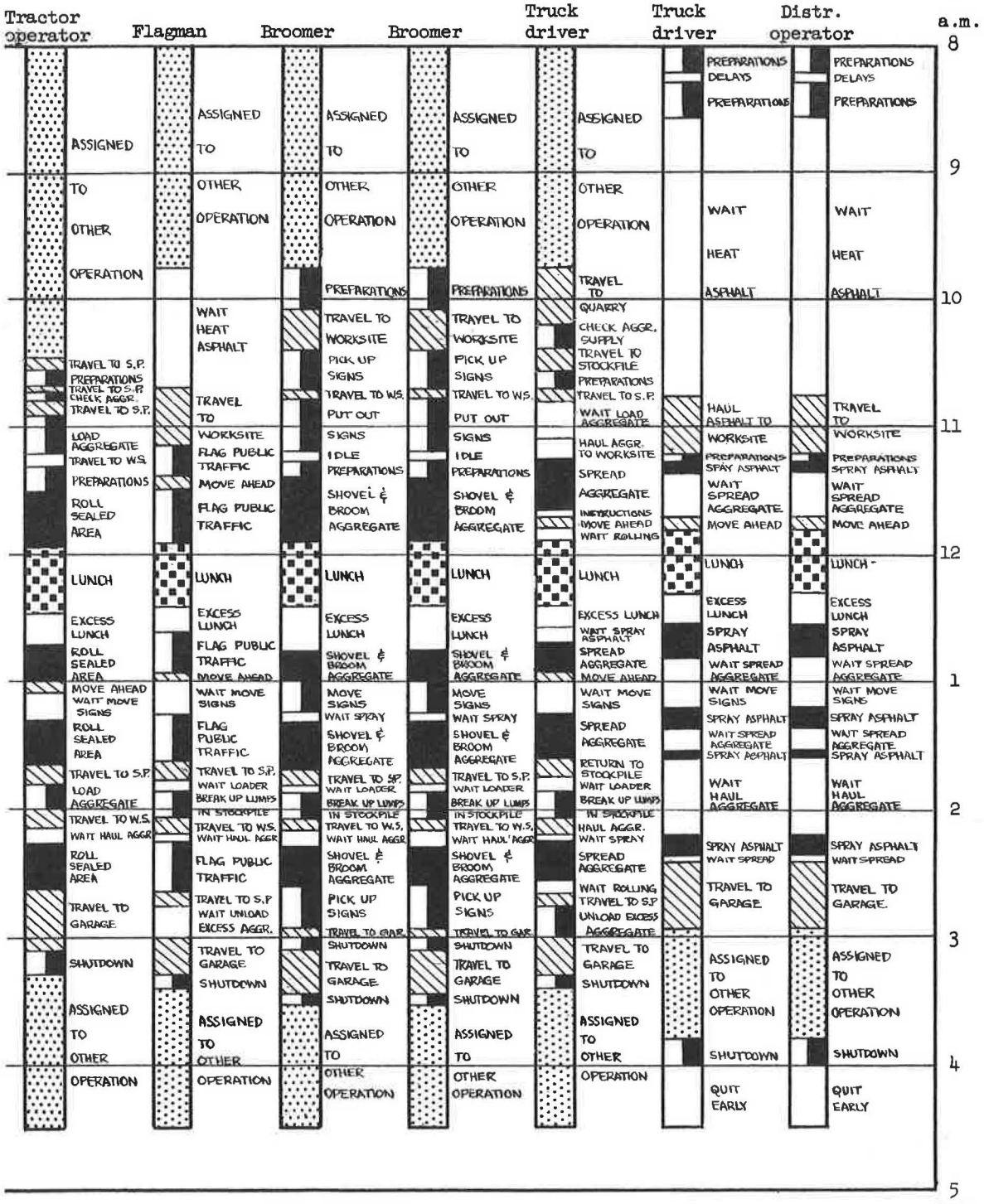


FIGURE 44. GANG PROCESS CHART FOR JOB "B"

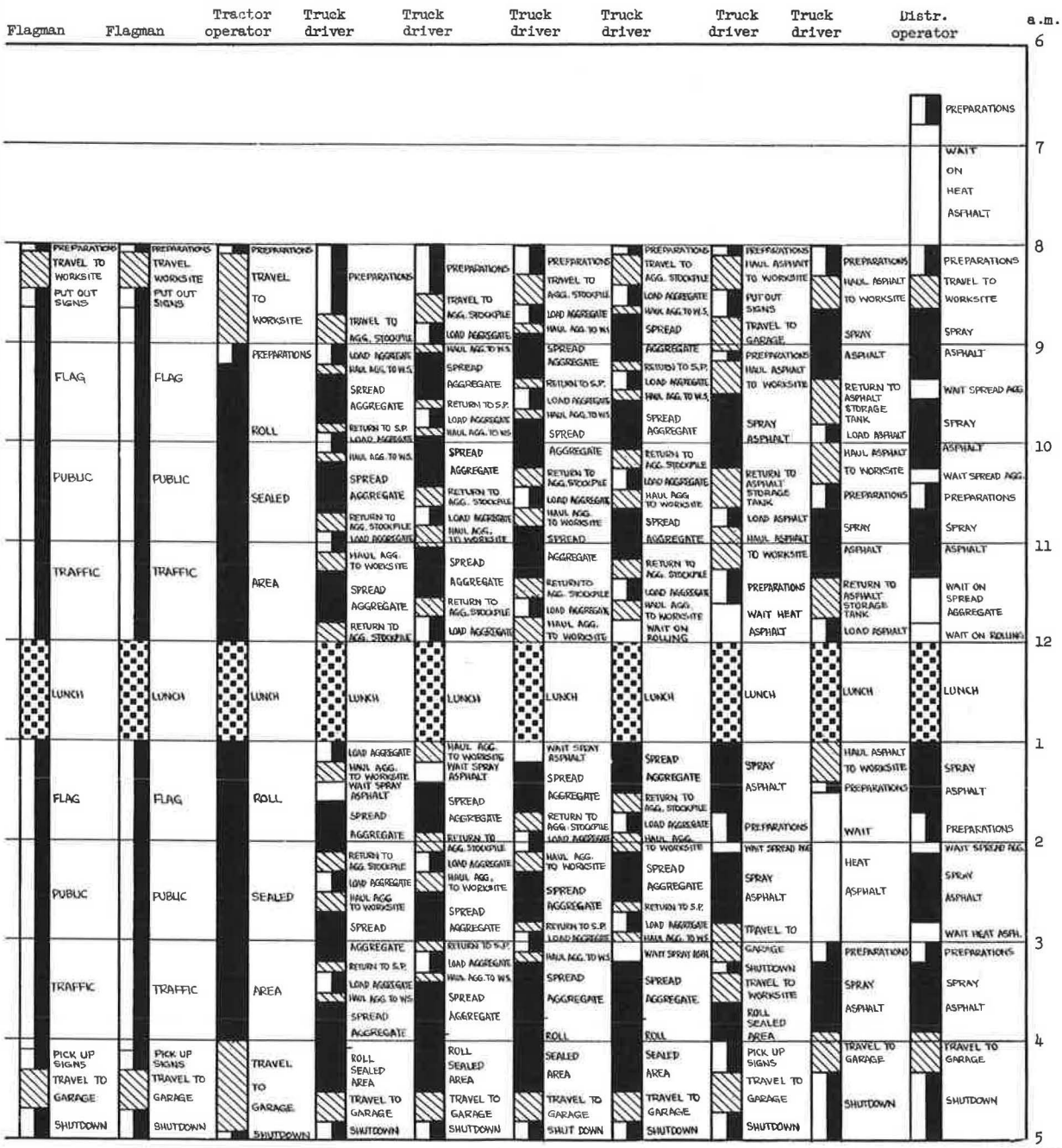


FIGURE 45.

GANG PROCESS CHART FOR PLANNED SEALING JOB

of aggregate per 100 gallons of asphalt, 20 tons of aggregate should be ready at hand or on the way for each 400-gallon distributor load of asphalt. This would permit an entire distributor load to be sprayed without having to wait for aggregate. Since aggregate was already stockpiled adjacent to one end of the job, the allowance for aggregate haul distance ranged from zero to six miles. The asphalt storage tank was 10 miles from one end of the job. On the basis of these conditions, 10 men, three distributors and four trucks were deemed to provide a balanced crew for an efficient operation.

The complete listing of men and equipment for the planned job was as follows:

Men	Equipment
1 Distributor operator	3 Trailer-mounted distributors
4 Truck drivers	4 Trucks with spreader beds to haul and spread aggregate
2 Truck drivers	2 Trucks to tow distributors
1 Tractor-roller operator	1 Frontend loader
2 Flagmen	1 Wheel tractor
	1 Towed rubber-tired roller

The planning for this job provided that the three trailer-mounted distributors be loaded with asphalt the night before and spotted at the garage. One man was then scheduled to report early so as to have the three loads of asphalt hot by the beginning of scheduled shift time (8 a.m.), thus avoiding any need for more than one man to mark time while the asphalt was heating. The plans also called for marking out the areas to be sealed on a prior day. In addition, the loader was to be spotted at the aggregate stockpile prior to the day of the job.

The total accomplishment considered feasible for the day's operation called for six distributor loads of asphalt. This meant that each of the three distributors would have to return to the asphalt storage tank, reload, haul to the worksite, and heat the asphalt during the course of the day's operation. For this particular job, the scheduled coordination was such as to provide for a quite satisfactory arrangement, whereby the lunch period occurred while two of the three distributors were in the process of heating. Had it been necessary for any of the three distributors to heat an additional load during the course of the afternoon, it might have been difficult to avoid an extensive wait, possibly affecting the entire crew, while the asphalt proceeded to heat.

Once the basic ingredients of equipment balance and coordinated operation, required for an efficient job performance, have been developed and adjusted through practice, much of the tedious detail of complete scheduling will become superfluous and unnecessary in the process of adjusting to routine variations in job conditions.

Aside from the efforts to obtain balance and coordination in equipment operations, the essential departure in this schedule from the pattern observed during studies involves utilization to the fullest possible extent of the entire crew for the full day on the operation of sealing. To facilitate coordinated effort, each man should know at the start what his scope of activity is for the entire day as well as any miscellaneous duties, so as to require a minimum of waiting for instructions, for other operations, etc.

The scheduled use of trucks to assist in the rolling operation was designed to complete the necessary rolling quickly at the close of the

operation, thus avoiding any overtime on the part of the roller operator.

TRIAL OF PLANNED SEALING JOB

A trial of the planned sealing job took place on October 11, 1960. It was judged to be completely successful, and results, if anything, exceeded expectations. Except for some raggedness at the very start, all work was accomplished on time or ahead of schedule. This verified the fact that the schedule, based on data obtained from the various studies, was generally lenient. Total accomplishment for the day was 12,780 square yards sealed, using 6 distributor loads of oil. This reduces to a figure of 156 square yards per man-hour, based on a 10-man crew working 82-hours. However, a figure of 130 square yards per man-hour is obtained when all time properly chargeable to the job is included. Asphalt was applied at the average rate of 0.24 gallon per square yard; aggregate at the average rate of 28.4 pounds per square yard. Maintenance specifications call for 0.25 gallon of asphalt and 25 pounds of aggregate per square yard. Because of the size of this job, two flagmen were used, whereas only one was standard practice on jobs studied.

It should not be overlooked that several factors encountered on the trial run were all favorable to the results obtained. The spirit of the crew was excellent and it was evident that they were constantly striving to stay even with or ahead of the schedule with which each man was supplied. The areas sealed were considerably larger than those normally encountered and the length of section encompassing the day's operation was undoubtedly less than could normally be expected for that much accomplishment. The stockpile of aggregate was located adjacent to one end of the section being sealed. A new tractor frontend loader was used which was somewhat faster than the ones previously employed, although this meant that the loader was new to the truck drivers who had to operate it. The weather on the day of the trial run was highly favorable, being calm, clear, and in the low 80's. The mild morning temperature was favorable to prompt heating of asphalt.

The extent and quality of rolling obtained on this job was also considered to exceed that normally obtained. This was in part due to the fact that although the schedule called for rolling assistance from trucks at the finish of operations in the afternoon, the job consistently ran ahead of schedule and this permitted the trucks to assist in the rolling with their wheels before lunch as well as after 4 o'clock in the afternoon.

This report touches upon only a small parcel of the data available from the Iowa Maintenance Study. However, it is broadly indicative of the general opportunity available for careful examination and appraisal of total maintenance effort. The opportunities for improvement can be listed in accordance with the following five basic ingredients essential to an effective maintenance organization. These are: (1) planning, (2) scheduling, (3) work methods, (4) tools, materials, equipment, and (5) organization and supervision.

CONCLUSIONS

Although seasonal variations in the workload are inevitable, careful thought to long range planning can do much to anticipate and relieve the pressure from peak workload periods. Failures in this area are reflected in the less than desirable levels of maintenance quality which are

frequently apparent. The solution should involve joint efforts of the foremen, the resident maintenance engineers, and their district superiors. The general size of the maintenance task forces and areas of responsibility deserve re-evaluation. For example, it might be desirable to place operation's responsibility for sealing work at the residency level. This would facilitate more experienced and highly skilled supervision, and use of larger and more productive equipment. The nucleous of this residency level crew could be supplemented as needed by men from county crews.

The responsibility of the foreman should begin when the general plan and pattern of the workload has been formulated. He is then in a position to schedule his work and assign his crews and equipment. Once the basic schedule of an efficient operation has been developed, the foreman should be able to modify the schedule for changing job conditions, with perhaps only occasional assistance.

A review of data obtained from comprehensive studies shows that maintenance crews sealed portions of a 0.62-mile section of road on eight different occasions within a 12-week period. The total area sealed was 10,800 square yards although there were only 7,030 square yards of pavement in this small section. In other words, parts of this section were sealed more than once during the 12-week period. Less than a week after the last day of sealing work on this section was completed, a contract was let for sealing the entire section. In preparation for the contractor's work, a state crew spent one day removing part of the seal previously applied by state forces since it was bleeding badly. Following the contract work, a state crew spread 34 cubic yards of aggregate over bleeding areas.

A thorough evaluation of all the factors and problems concerning case histories of the type cited for the 0.62-mile section of road may conceivably provide rational support for actions taken. However, such evaluation also offers excellent opportunities for planning and programing so that considerably less effort is involved in achieving the necessary accomplishment.

Perhaps the fact of greatest significance evident from production studies is that the planning and scheduling of a day's operation frequently failed to outline an adequate amount of work to permit efficient accomplishment by the crew. The amount of equipment used and size of the crew employed, must of necessity be flexible because of the operating variables attendant to individual job circumstances. For example, total length of road section over which the work is spread, size of sealed areas, haul distances from material stockpile to worksite, and from garage to worksite, are all variables affecting the amount of the end product which can be considered a reasonable day's accomplishment. But given these ingredients, the foreman should plan and lay out the work in suitable daily quantities to facilitate efficient operations. Data from the maintenance studies show that the foreman frequently planned the operations for the day after the crew reported for work. Numerous instances were encountered where the foreman performed various functions and chores while members of the crew were spending their time nonproductively.