Contract Maintenance in Urban Areas

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ABSTRACT

Since 1979 the city of Boulder, Colorado, has been involved in upgrading the city's street maintenance program. This work has involved improving staff maintenance procedures and identifying maintenance activities that, from a cost-effectiveness standpoint, can be contracted instead of completed in-house. Based on a specific cost, skill, and equipment capability analysis, it was decided by the city that some maintenance activities would be done in-house, and a portion of other maintenance tasks would be done in-house and other portions for tasks such as snowplowing, permanent asphalt patching, and median mowing and maintenance would be contracted. There was also a decision to contract certain maintenance tasks, such as major street repair and street overlays, with no work on the task being done in-house. The program that was developed has resulted in a 35 percent reduction in permanent staff, from 27 to 19. Approximately 30 percent of the maintenance budget is now spent on contract maintenance. This maintenance process has enabled the city to improve its overall management of maintenance. In the past personnel, equipment, and material were usually used to do catch-up, short-term repair work. Now maintenance is systematic, and more of the budget is spent on permanent repairs instead of on patching.

Boulder, Colorado, is a city of 90,000 people supported by a 253-mile street system, of which 52 miles are arterial and collector streets. In 1982 the total budget for street maintenance, including overlays, was $1,920,000. The budget breakdown was as follows: trash, $90,000; street patching, $460,000; major street repair, $275,000; snow and ice control, $190,000; street sweeping, $120,000; bikeway maintenance, $75,000; median maintenance, $90,000; overlay, $510,000; and management, $110,000.

Since 1979 the city has been involved in upgrading the street maintenance program. This work has improved staff maintenance procedures. It has also involved identifying maintenance activities that, from a cost-effectiveness standpoint, could be contracted instead of completed in-house.

Based on a specific cost, skill, and equipment capability analysis, it was decided by the city that certain maintenance tasks would be done in-house, such as pothole patching, hand cleaning, and crack sealing. It was decided that a portion of other maintenance tasks would be done in-house and portions for tasks such as snowplowing, permanent asphalt patching, and median mowing and maintenance would be contracted. There was also a decision to contract certain maintenance tasks, such as major street repair and street overlays, with no work on the task being done in-house.

The decision as to which activities to do in-house, which to contract, and which to share with contractors is based on an analysis of the maintenance capabilities of the staff and their equipment. When the staff can do the work in a cost-effective manner, the staff does it. When the staff can do part of the task, contractors are hired to do the overload.

The program that was developed has resulted in a 35 percent reduction in permanent staff, from 27 to 19. Approximately 30 percent of the maintenance budget is now spent on contract maintenance.

ANALYSIS PROCESS

Performing necessary maintenance on an urban street system can be done in a variety of ways. The majority of cities do all maintenance work with in-house staff and equipment. Some cities have contracted all maintenance to a single firm. Other cities have contracted maintenance tasks to more than one firm. Boulder has chosen another alternative; part of the work is done in-house and part of the work is contracted to a number of firms.

Before a decision about whether or not to contract certain maintenance activities can be made, capabilities of the agency staff, and the equipment available to the staff, must be quantified. The amount of work and types of work an agency staff is capable of doing and equipped to do must be determined, and the cost of performing each work task must also be quantified. Therefore, data concerning man-hours and equipment hours available for maintenance work, tons of material, and costs per unit of work must be collected.

By knowing staff size, equipment mix, costs of operation, and historical data concerning types and amounts of maintenance tasks required, policy decisions can be made concerning what tasks to do in-house, what tasks to contract, and what tasks to share between in-house and contractors.

After analyzing maintenance activities in Boulder, it was determined that not all maintenance activities should be done each month. By sorting through all maintenance activities, evaluating equipment and staff capabilities, and evaluating effectiveness of maintenance operations during certain seasons, decisions concerning which activities should be done each month were developed. The final distribution of maintenance activities done each month is given in the following list:

1. January, February, and March--street sweeping, pothole patching, snow removal, crack sealing, gravel street grading, and signal maintenance;
2. April, May, and June--street sweeping, flushing streets, annual trash pickup, pothole patching, snow removal, asphalt leveling, gravel street grading, concrete repair, dust control, median maintenance, right-of-way (ROW) mowing, and signal maintenance;
3. July, August, and September--street sweeping, permanent asphalt patching, chip and seal, seal coating, gravel street grading, concrete repair, dust control, median maintenance, ROW mowing, bikeway maintenance, and signal maintenance; and
4. October, November, and December--street sweeping, snow removal, crack sealing, gravel street grading, concrete repair, bikeway maintenance, and signal maintenance.

The first result of this analysis was a reduction in full-time staff from 27 to 19. During the spring and summer the full-time staff is supplemented by 12 temporary employees. The cost savings are significant because temporary employees are not paid fringe benefits.

The second result of this analysis was a decision to contract all of certain maintenance activities to outside contractors, to share some maintenance activities with outside contractors, and to do some maintenance activities entirely in-house. Based on a unit-cost analysis, work tasks such as sweeping, seal coating, pothole patching, and grading have been determined to be most cost effective if done in-house. Items such as pavement reconstruction and street overlay have been determined to be most cost effective if done by contractors. The determination for each task was made by quantifying in-house costs to do a specified amount of work and then bidding the same work. If it was less expensive to do the work in-house, the work stayed in-house. If it was less expensive to do the work by contract, the work was contracted by bidding. If it was about the same cost for in-house or contract, the base level of work was kept in-house and the peak periods of work were contracted.

Items such as mowing, trash pickup, and snow removal are shared tasks. The philosophy behind these shared tasks is that it is most cost effective to use in-house staff to handle the normal flow of work and to contract for additional personnel and equipment to handle the peaks. For example, the city is staffed and equipped to handle snowfalls of 4 to 6 in., the normal situation. A larger snowfall triggers the decision to have a contractor supply personnel and equipment to supplement the in-house staff.

Items such as permanent asphalt patching, asphalt paving, and major street repairs are also shared tasks, but these are shared tasks because of economy-of-scale considerations and not because of peak-use conditions. For example, in the case of permanent asphalt patching (as shown in Figure 1), the cost of having a contractor do a small patch of less than 40 ft^2 is greater than the cost of doing the work in-house. The cost of a contractor doing a patch of 500 ft^2 is 50 percent of the in-house cost.

COMPUTERIZED MAINTENANCE MANAGEMENT

A computerized maintenance management system was developed specifically for the city that is maintenance-task oriented. The system quantifies maintenance work according to one of 28 tasks in terms of street address, types of equipment, equipment hours and cost, types and quantities of material used to perform the task, and man-hours of regular and overtime work needed to perform the task. The listing of the tasks is as follows:

0100-bikepath maintenance;
0200-spring cleanup;
0300-spot seal patching;
0400-permanent asphalt patching;
0500-pothole patching;
0600-base repair;
0700-dust control;
0800-grading or graveling;
0900-concrete repair;
1000-new concrete construction;
1100-structural concrete;
1200-miscellaneous street maintenance;
1300-yard operations;
1400-chip and seal;
1500-snow/ice, sanding, plowing;
1600-snow storm standby;
1700-snow and ice materials acquisition;
1800-asphalt paving;
1900-major street repair;
2000-storm cleanup;
2100-mechanical sweeping;
2200-flushing;
2300-hand cleaning;
2400-haul sweeping;
2500-crack sealing;
2600-median and ROW mowing;
2700-median maintenance; and
2800-overhead hours.

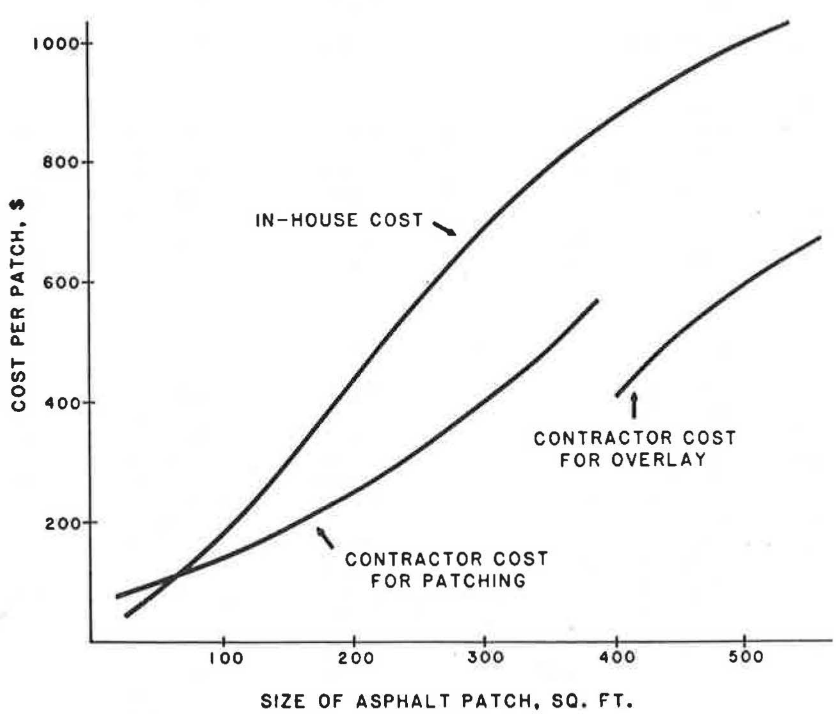

FIGURE 1 In-house/contractor cost relationship.

Sample printouts for permanent asphalt patching and pothole patching are given in Tables 1 and 2, respectively.

Data concerning each task are tabulated on the computerized file and summarized at the end of each 4-week period. Comparing work output on a period-by-period basis enables decision makers to continually assess staff productivity and capability based on the variation from period to period in man-hours per task, equipment hours per task, and unit costs. The computerized data file is also used to determine when the frequency of minor repairs for a task such as pothole patching has reached the point where more major repairs are required.

PRODUCTIVITY IMPROVEMENT PROGRAM

Improving productivity by involving staff in the search for improvements has resulted in payoffs in terms of better working procedures and in terms of improved specifications for materials and equipment. This was achieved by using a productivity improvement program (PIP).

PIP is a variation on the quality-circle concept. It consists of two phases: (a) idea generation and analysis, and (b) idea implementation. In the idea-generation phase the improvement team develops ideas for improving work procedures. If an idea receives an 80 percent vote of approval from the improvement team, the idea is passed on to the coordination team. If the idea receives an 80 percent vote of approval from the coordination team, it goes into analysis, which is done by a subgroup of the coordination team. The analysis phase consists of a benefit-cost study and other appropriate quantitative evaluations. If the idea appears to be economical, it is prepared for implementation. If implementation does not require purchase of additional material or equipment, the implementation process is started immediately. But if additional expenditures are required, the request goes to the city manager for review and approval.

The improvement team is composed of maintenance staff. The coordination team is composed of the traffic engineer construction project coordinator, maintenance superintendent, director of transportation, and two administrative assistants.

Discussions and ideas about what to contract and which maintenance tasks to do during certain periods have lead to improvements in maintenance procedures and identification of projects suitable for contract maintenance. The other payoff from this activity is related to equipment and material purchases. The staff is now using exactly the types of materials they have determined that they need, and they are driving exactly the types of equipment that they have determined are needed.

PAVEMENT REPAIR

Pavement repair activities require approximately 65 percent of the total maintenance budget. Because the costs are significant, a specific plan on ways to cut pavement repair costs was initiated.

The process of determining when a street should be repaired or maintained and what type of repair is needed is shown in Figure 2. As shown in the figure, the city street network is visually surveyed in such a manner so that the arterials are evaluated on a semiannual basis, the collectors on an annual ba-

TABLE 1 Permanent Asphalt Patching, Quarterly Summary by Zone, 2nd Quarter, 1983

ZONE	ADDRESS	CUT SLIP	DATE	CITY/ CONT.	REGULAR HOURS	O.T. HOURS	CREW NO.	FLEET EQUIPMENT	EQUIP. HOURS	TYPE MATERIAL	TONS	SQ.FT.	AGENCY
06	1600 Broadway	420	830228	Cont.									PSCo.
06	1821 Marine	468	830300	Cont.									
06	2900 Moorehead	448	830406	Cont.									PSCo.
06	2905 Morehead	222	830516	City	20.0	0.0	4	Standard	5.0	H/M	4.50	225.0	Water
06	3000 Moorehead	449	830406	Cont.									PSCo.
06	385 32nd Street	230	830516	City	20.0	0.0	4	Standard	5.0	H/M	3.50	175.0	Water
07	1500 Columbine	432	830311	Cont.									PSCo.
07	1950 Dartmouth	337	830525	City	10.0	0.0	4	Standard	2.5	H/M	3.0	111.0	Sewer
07	2190 Dartmouth	334	830510	City	8.0	0.0	4	Standard	2.0	HM	5.25	160.0	Sewer
07	2190 Dartmouth		830510	City	6.0	0.0	4	Standard	1.0	HM	1.25	50.0	PSCo
07	2250 Dartmouth	338	830523	City	12.0	0.0	4	Standard	3.0	H/M	4.0	168.0	Sewer
07	2335 Dartmouth	335	830523	City	4.0	0.0	3	Standard	2.0	H/M	3.0	96.0	Sewer
07	2365 Dartmouth	336	830510	City	6.0	0.0	4	Standard	2.0	HM	2.50	112.0	Sewer
07	2590 Dartmouth	339	830525	City	10.0	0.0	4	Standard	2.5	H/M	9.0	234.0	Sewer
07	635 22nd	470	830322	Cont.									
08	Briarwood/Viewpoint	329	830602	City	8.0	0.0	4	Standard	2.0	H/M	3.5	120.0	Sewer
08	Broadway and Grinnell	393	830316	Cont.									Mt.Bell
08	Edinboro and Yale	223	830610	City	7.50	0.0	3	Standard	2.50	H/M	1.50	64.0	Water
08	Kendall and Judson	110	830610	City	15.0	0.0	3	Standard	5.0	H/M	1.50	60.0	Sewer
08	1405 Kendall	109	830609	City	19.0	0.0	4	Standard	5.0	H/M	3.50	96.0	Sewer
08	1725 Ithaca	229	830610	City	7.50	0.0	3	Standard	2.50	H/M	7.0	160.0	Water
08	1825 Viewpoint	327	830525	City	10.0	0.0	4	Standard	2.5	H/M	3.0	104.0	Sewer
08	1825 Viewpoint	328	830525	City	10.0	0.0	4	Standard	2.5	H/M	4.0	131.0	Sewer
08	2200 Howard Pl.	440	830323	Cont.									PSCo
08	2448 Briarwood	330	830602	City	8.0	0.0	4	Standard	2.0	H/M	4.0	115.0	Sewer
08	2519 Briarwood	326/124	830607	City	24.0	0.0	4	Standard	6.0	H/M	15.0	300.0	Sewer
08	2535 Briarwood	331	830603	City	16.0	0.0	4	Standard	4.0	H/M	9.0	228.0	Sewer
08	2540 Briarwood	332	830603	City	8.0	0.0	4	Standard	2.0	H/M	4.0	104.0	Sewer
08	2593 Briarwood	333	830603	City	16.0	0.0	4	Standard	4.0	H/M	4.0	96.0	Sewer
08	2815 Iliff	235	830608	City	8.0	0.0	4	Standard	2.0	H/M	8.0	230.0	Water
08	2821 Kenyon	120	830609	City	15.0	0.0	3	Standard	5.0	H/M	4.50	112.0	Sewer
08	2855 Iliff	234	830608	City	8.0	0.0	4	Standard	2.0	H/M	4.50	130.0	Water
08	3161 Endicott	111	830608	City	12.0	0.0	4	Standard	3.0	H/M	8.0	230.0	Sewer
08	3181 Endicott	112	830608	City	12.0	0.0	4	Standard	3.0	H/M	3.0	112.0	Sewer
08	3770 Longwood	441	830328	Cont.									PSCo.

TABLE 2 Pothole Patching, Quarterly Summary by Zone, 3rd Quarter, 1983

ZONE	LOCATION	DATE		MANHOUR	OT	FLEET EQUIP.	EQ.HOURS	H.M.	C.M.	SILVEX
	Coors Classic Special	830701	City	40.0	0.0	Standard	10.0	5.50		
01	Broadway & Union	830826	City	2.0	0.0	Standard	1.0	0.10		
01	Locust W. of Broadway	830819	City	4.0	0.0	Standard	2.00	0.20		
01	Locust-Broadway-8th	830819	City	2.0	0.0	Standard	1.00	0.50		
01	Oak/20th-21st	830712	City	2.0	0.0	Standard	1.00	0.1		
01	Orange Ct. & Poplar	830901	City	2.0	0.0	Standard	1.0	0.10		
01	Union W. of Broadway	830825	City	3.0	0.0	Standard	1.50	.25		
01	1000 Poplar	830901	City	2.0	0.0	Standard	1.0	0.10		
01	1000 Union	830712	City	1.0	0.0	Standard	.50	0.1		
01	1030 Poplar	830901	City	2.0	0.0	Standard	1.00	0.10		
01	1070 Union	830701	City	2.0	0.0	Standard	1.00	.10		
01	1770 Oak	830804	City	6.0	0.0	Standard	3.00	1.0		
01	19th & Oak	830901	City	2.0	0.0	Standard	1.00	0.10		
01	21st & Oak	830712	City	1.0	0.0	Standard	.50	0.1		
01	2500 Nowrood	830712	City	1.0	0.0	Standard	.50	0.1		
01	770 Union	830817	City	1.0	0.0	Standard	.50	0.10		
01	840 Union	830817	City	1.0	0.0	Standard	.50	0.10		
01	880 Union	830817	City	1.0	0.0	Standard	.50	0.10		
01	9th & Union	830817	City	1.0	0.0	Standard	.50	0.10		
01	905 Union	830817	City	1.0	0.0	Standard	.50	0.10		
01	923 Union	830817	City	1.0	0.0	Standard	.50	0.10		
01	933 Union	830817	City	1.0	0.0	Standard	.50	0.10		
01	990 Poplar	830901	City	2.0	0.0	Standard	1.0	0.10		
				41.00	.00		20.50	3.75		
02	Alleys	830617	City	10.0	0.0	Standard	5.0	1.5		
02	Alleys	830715	City	20.0	0.0	Standard	10.0	2.0		
02	Broadway & Portland	830819	City	2.0	0.0	Standard	1.00	0.20		
02	Broadway & Portland	830819	City	2.0	0.0	Standard	1.00	0.20		
02	Broadway N. of Pearl	830824	City	2.0	0.0	Standard	1.00	0.10		
02	1140 Portland	830701	City	1.0	0.0	Standard	.50	.10		
02	2500 6th	830901	City	2.0	0.0	Standard	1.00	0.30		
02	5th & Maxwell	830817	City	1.0	0.0	Standard	.50	0.10		
02	6th S. of Canyon	830804	City	2.0	0.0	Standard	.50	1.0		
02	9th & Mapleton	830826	City	2.0	0.0	Standard	1.0	0.10		
02	900 Walnut	830624	City	2.0	0.0	Standard	1.0	.20		
				46.00	0.0		22.50	5.80		

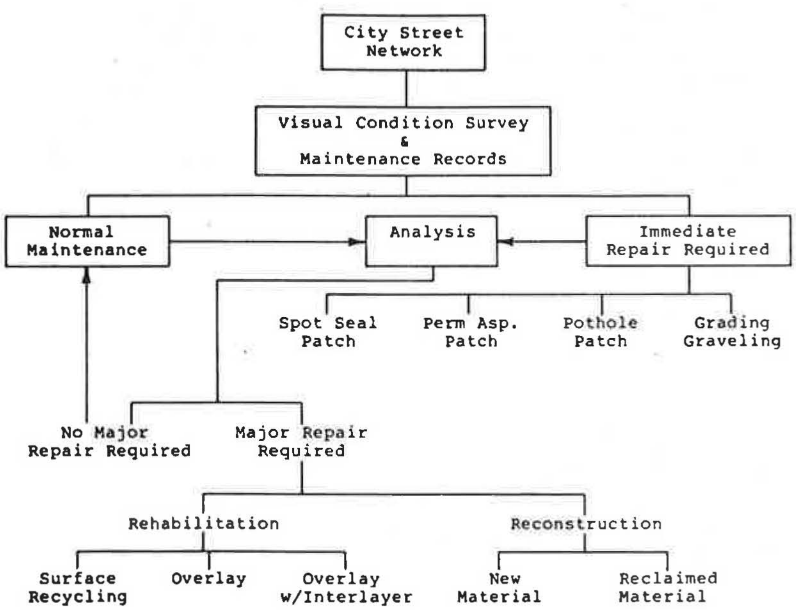

FIGURE 2 Boulder street maintenance process.

sis, and the local streets on a biannual basis. Each visual condition survey is made by using standard Asphalt Institute and Portland Cement Association techniques. In addition to the visual survey, the computerized street maintenance management system is used to identify sections that have experienced a high frequency of maintenance repair.

By knowing the visual condition and the historical record of repair requirements on the street, a decision is made concerning whether the street should continue under normal maintenance, be scheduled for major repair, or whether immediate repair is needed. Normal maintenance consists primarily of seal coating and crack sealing. Immediate repair consists of pothole patching, permanent asphalt patching, or grading and graveling.

At the same time that normal maintenance or immediate repair is occurring, all streets in the city are evaluated on a systematic basis to determine if major repairs are needed. This evaluation is based on pavement deflection data and the computerized historical maintenance record file. Dynaflect tests are run on all arterial and collector streets in the city on a periodic basis. Benklemen beam tests are run on all local streets with a history of requirements for immediate repairs. Coring is also done on an as-needed basis.

If the analysis indicates that major repairs are needed, a decision based on a pavement design is made concerning whether to do pavement rehabilitation or pavement reconstruction of the street section.

Results of the computerized maintenance records are used to identify sections that require high maintenance as well as to detail the type of maintenance and quantities of materials and man-hours required for repairs. High maintenance sections are defined as those locations where the maintenance crew is required to return for repairs more than three times per year, or locations where large quantities of materials are required to effect the repair.

A list of high maintenance sections is prepared and compared with results of the deflections tests. In 1982 two categories of information were gained from the comparison. The first category dealt with street sections that were experiencing both surface and base failure. These sections appeared on both the high-maintenance list and the high-deflection list. The second category dealt with street sections that were beginning to experience surface failure but still had a stable base. These street sections appeared on the list of high-maintenance frequency but did not necessarily appear on the high-deflection list.

The indication from comparison of the two categories is that many times the surface of a street section fails before the base begins to fail. By quickly locating and identifying sections of surface failure, repairs can be made before the base failure begins. The computerized maintenance record system enables rapid identification of surface failure and has allowed major pavement surface repairs to be made before base failure has occurred.

RESULTS

In addition to the reduction in full-time staff previously discussed, several other measurable benefits have resulted from the program. In 1979 there were more than 600 sites that required major pothole repair. In 1982 the number of sites was reduced to 252, primarily because of the rapid method of problem identification and repair.

Since 1980 the maintenance budget has been increasing at a rate of 5 percent per year, even though costs of labor have been increasing at more than 10 percent per year and costs of materials have been increasing at a rate of more than 15 per- cent per year. Repair costs would have been much higher if the program had not been implemented.

The key to being able to add contractors into the process, has been a contracting technique termed "small public works contracts." In January each year the city advertises a number of contracts that request bids for certain types and quantities of work without specifying the location of the work. Following this process, contractors are selected, on 12-month contracts, to do base and paving maintenance, concrete maintenance, landscaping maintenance, or traffic signal maintenance. Contractors are also selected on an hourly rate basis to provide drivers and various pieces of construction equipment. A contractor is also selected (through a competitive bid) to do all the overlay work for one construction season. Having the contractors selected and available to work on short notice enables the maintenance foreman to have the assistance he needs when it is needed.

The maintenance process has enabled the city to move from a crisis basis, where personnel, equipment, and material were always used to do catch-up, short-term repair work, to a basis of preventative maintenance, where maintenance is systematic and more of the budget is spent on permanent repairs instead of on patching. It is anticipated that cost savings for maintenance will become significant by the end of 1984 because more of the maintenance budget is being spent on overlays and pavement reconstruction and also because the frequency of crisis repairs is decreasing.

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Optimum Shop Staffing Levels: An Application of Queuing Theory

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ABSTRACT

Optimum equipment shop staffing levels are determined for the Louisiana Department of Transportation and Development by application of a simple queuing model. Poisson arrival and exponential service distribution assumptions are used and verified to a limited degree. Louisiana's equipment management system is used to obtain source data