Priority Rating of Highway Routine Maintenance Activities

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This paper presents a procedure for determining priority ratings of highway routine maintenance activities by highway class and distress condition. In contrast to the common practice of assigning priority ratings based on an aggregated pavement condition index, a scheme that generates maintenance activity specific priority ratings was adopted in this study. Since there exists a large number of maintenance activity–highway class–distress severity combinations to be rated, a partitioned two-stage survey procedure was adopted to reduce the number of factors in each rating phase to a size manageable by raters. This rating procedure was used to obtain priority factors for routine maintenance activities in Indiana. These priority data have been incorporated into an optimal routine maintenance programming model proposed for use at the district and subdistrict levels of the Indiana Department of Highways. Using the application as an example, the paper describes the salient features of the procedure and the steps involved in computing the final priority scores for individual maintenance activities. It also provides an analysis of the Indiana data to demonstrate how other useful information on routine maintenance practice could be derived from this form of study.

Efficient programming and scheduling of routine maintenance activities are vital to the success of pavement maintenance management at both project and network levels. More and more agencies are now using or looking into the possibility of using computer mathematical models to perform the work of programming and scheduling pavement maintenance activities (*1–5*).

While mathematical programming of routine maintenance activities using the computer undoubtedly has great potential for improving efficiency and reducing costs, the applicability and usefulness of the results obtained from such an analysis depend on the accuracy and reasonableness of input and constraint factors (*1*, *5*). The priority ratings of various routine maintenance activities are one of the most important input factors, with a great impact on the final outcome of a mathematical programming analysis. Unfortunately, the complete priority information that is required for a meaningful programming and scheduling analysis is very often not available.

Because of the lack of priority information on routine maintenance activities, a survey was recently conducted in Indiana to acquire the necessary data. This paper describes the rating procedure adopted and the steps involved in arriving at the final priority ratings for different routine maintenance activities by highway class and severity level of road distress condition. Using the Indiana data, analyses were performed to illustrate how other useful information on routine maintenance practice could be derived from this form of study. Finally, the need for each highway agency to establish maintenance priority ratings appropriate for its own program is stressed.

CONSIDERATIONS IN PRIORITY RATING ASSESSMENT

A number of different priority assessment schemes have been reported in the literature (*1*, *3*, *6–8*). Practically all of these schemes rely on defining certain numeric indices, such as pavement condition index, maintenance needs index, and defect rating value, which are computed using data obtained from pavement condition surveys. These indices form the basis for priority assessment purposes. The key difference between these schemes and the scheme proposed in this study is that, instead of using an aggregate index to represent maintenance needs and to set priorities, the present study developed maintenance-activity-specific priority ratings. In other words, priority ratings are assigned explicitly to routine maintenance activity types.

Advantages and Disadvantages of Present Approach

The form of priority ratings generated by the scheme described in this study has been incorporated in a highway routine maintenance optimization programming model (*9*). The experience shows that the advantages of this approach include the following:

1. Maintenance-activity-specific priority ratings have a clearcut physical meaning that is easily understood by both planning and field maintenance personnel. In contrast, using a numeric index to represent different distress conditions involves data transformation and subjective judgment that may not be shared by the maintenance personnel at different levels.
2. Specific routine maintenance activities can be easily matched with labor, material, equipment, construction productivity, and time requirements. This link is particularly useful in programming and scheduling routine maintenance activities for agencies directly involved with planning and executing field maintenance. The establishment of such a link is not straightforward in schemes where aggregate pavement conditions indices are used as the basis for priority rating.
3. Data collected in the maintenance-activity-specific priority rating scheme can be further processed, as illustrated in a

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later section of this paper, to extract useful information on routine maintenance practice. Much of this information would be lost if maintenance needs data are aggregated into a common numeric index.

The disadvantage of the proposed approach is with the acquisition of priority rating data. The number of entries to be priority rated is much bigger and more difficult to handle, compared with a single index variable in most condition-index-based priority-setting schemes.

Factors Affecting Priority Ratings

The relative priorities of various routine maintenance activities are influenced by a number of factors. The following possible factors were identified in the present study:

1. Routine maintenance activity type. Highway pavement routine maintenance encompasses activities undertaken on a regular or continual basis to serve as (a) preventive measures against pavement deterioration or as (b) corrective measures to repair minor pavement damages. Each of these activities has a different impact on restoring pavement condition and lengthening of pavement service life.
2. Highway class. Highways of different classification receive different degrees of attention from highway agencies. A highway with a higher degree of importance will receive maintenance earlier than another highway needing the same type of maintenance.
3. Road distress condition. A highway section with a more severe distress would be repaired sooner than one with a less severe distress condition.
4. Seasonal effect. Not all maintenance activities can be performed throughout the year. For instance, certain activities may have to be suspended in the winter because of either weather constraints or considerations of repair effectiveness. These activities would therefore be given no priority during the winter months, even though they might have high priorities in the other seasons of the year.
5. Climatic and environmental factors. Pavements in regions with different climate and environmental conditions behave differently. The prevailing types of pavement distresses in different regions are not likely to be the same. The priority ratings for different maintenance activities would therefore be different.
6. Maintenance practice and policy. Highway agencies with different maintenance practices and policies place different emphases on different aspects of maintenance. Their priority ratings for various routine maintenance activities would not be the same.
7. Miscellaneous factors. Priority ratings of maintenance activities may also be affected by safety consideration, environmental concern, political influence, and other factors.

In theory, if n_1, n_2, n_3, n_4, n_5, n_6, and n_7 represent respectively the number of variables in each of the seven factors above, one would have to rate in priority order a total of $(n_1 \times n_2 \times n_3 \times n_4 \times n_5 \times n_6 \times n_7)$ combinations. This is, however, rarely the case in practice. For example, Factors 5 and 6 are likely to be location specific and would not vary greatly over a relatively large area. To account for Factor 4, one may choose to produce different sets of priority lists for different seasons.

In the present study, Factors 1, 2, and 3 were considered explicitly. Factors 5 and 6 were addressed at the survey sampling stage, when areas with different conditions in the two factors were identified and sampled separately. Because the survey was conducted in the summer, the results may not be applicable to winter months due to seasonal effects. Factor 7 was not included, but it is likely that miscellaneous factors influenced individual raters in arriving at their priority scores.

THE SURVEY PROCEDURES

The survey began with a statistical sampling of surveyed units, followed by field interviews of maintenance personnel in the selected units. Details of the two phases are described below.

Statistical Sampling

The survey units in this study were selected from a stratified random sampling process (*10*, *11*). A stratified random sampling is a restricted randomization sampling design in which the experimental units are first sorted into homogeneous groups or blocks. The required number of experimental units is then randomly selected within each group.

There are three levels of maintenance management in the Indiana Department of Highways (IDOH): central office level, district level, and subdistrict level. Figure 1 shows the district locations in Indiana. The six districts clearly provide a logical

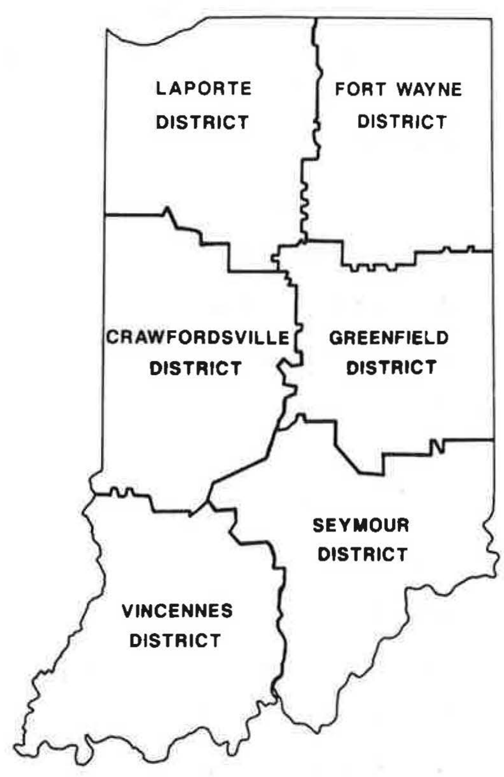


FIGURE 1 Highway districts in Indiana as stratification basis for survey sampling.

basis for stratification. Two subdistricts were randomly selected from each district to form the survey units.

The stratification by district also serves well to represent two distinct climatic conditions found in Indiana. Past studies in Indiana (*12,13,14*) have indicated the presence of two climatic regions: the colder north region, represented by the two northernmost districts; and the relatively warmer south region, which includes the remaining four districts. A total of 36 representatives of maintenance staff from the survey units were surveyed. Sixteen of the staff surveyed were from the north region and 20 from the south region.

Priority Rating Procedure

The factors included in the survey were maintenance activity type, highway class, and distress severity level of the road needing the activity. Fourteen routine maintenance activities involving pavement, shoulder, and drainage were investigated. Table 1 presents the list of maintenance activities investigated.

The highway classes defined were (a) Interstate and (b) other state highways (OSH). OSH was further broken into two categories: high-traffic-volume OSH, with more than 400 vehicles per day (vpd); and low-traffic-volume OSH, with less than 400 vpd. The traffic volume classification was chosen to provide broad guidelines for differentiating maintenance priorities of the various highways. For road conditions, three levels of distress severity were considered—severe, moderate, and slight.

TABLE 1 LIST OF HIGHWAY MAINTENANCE ACTIVITIES INVESTIGATED

Code	Description
201	Shallow Patching
202	Deep Patching
203	Premix Leveling
204	Full Width Shoulder Seal
205	Seal Coating — Chip Seal
206	Sealing Longitudinal Cracks and Joints
207	Crack Sealing
208	Sand Seal
210	Spot Repair of Unpaved Shoulders
211	Blading Unpaved Shoulders
212	Clipping Unpaved Shoulders
213	Reconditioning Unpaved Shoulders
231	Clean and Reshape Ditches
234	Motor Patrol Ditching

A simple calculation shows that there are 14 × 3 × 3 = 126 entries to be priority rated. Simultaneous rating of all 126 entries was out of the question. Pairwise comparison was theoretically possible but not practical due to the large number of possible combinations. To reduce the problem to a manageable size, the contributing factors were partitioned into two categories and examined independently. Figure 2 shows the flow diagram of the survey. Part 1 of the survey dealt with assigning priority scores to individual routine maintenance activities in accordance with their relative importance in preserving highway pavement conditions at a desired level. In Part 2, priority scores were assigned to different pavements of various highway classes by road distress severity level according to the relative urgency of the need for maintenance work.

To aid raters in arriving at priority scores more quickly and efficiently, the following measures were taken:

1. A two-stage rating procedure was adopted. Raters were first asked to rank the entries with all potential ties considered. Keeping the order of the ranks, the raters were next asked to assign a priority score to each on a 10-point scale.
2. Instead of using tables or forms, a set of cards with a different maintenance activity written on each was given to each rater. By allowing each rater to place the cards in rank order and then move them into relative positions above or below each other along the 10-point scale, realistic priority scores could be assigned fairly quickly.

The experience of the survey indicated that this rating procedure was well received by raters, and satisfactory results were obtained in an unambiguous manner. Figure 3 shows the priority rating scale along with rater instructions used for Part 1 of the survey. An identical scale and similar rater instructions were used for Part 2 of the survey.

An alternative procedure would have been to adopt a tree-like survey structure, as shown in Figure 4. The raters would first rate all maintenance activities as in Part 1 of the survey in Figure 2, then proceed to repeat N_1 number of times the Part 2 rating process in Figure 2. However, this procedure is highly time consuming. Consequently, the survey procedure in Figure 2 was used in this study. The computational and analytic techniques discussed in the subsequent sections of this paper are, however, applicable to both procedures.

ANALYSIS OF SURVEY DATA

This section presents the results and computes the final priority ratings of routine maintenance activities by highway class and road condition severity level. In addition, this section shows that the data gathered in this form of study can be analyzed further to provide other useful information on routine maintenance practice. As an illustration, an analysis is presented which compares the maintenance practice of the north and south regions of Indiana.

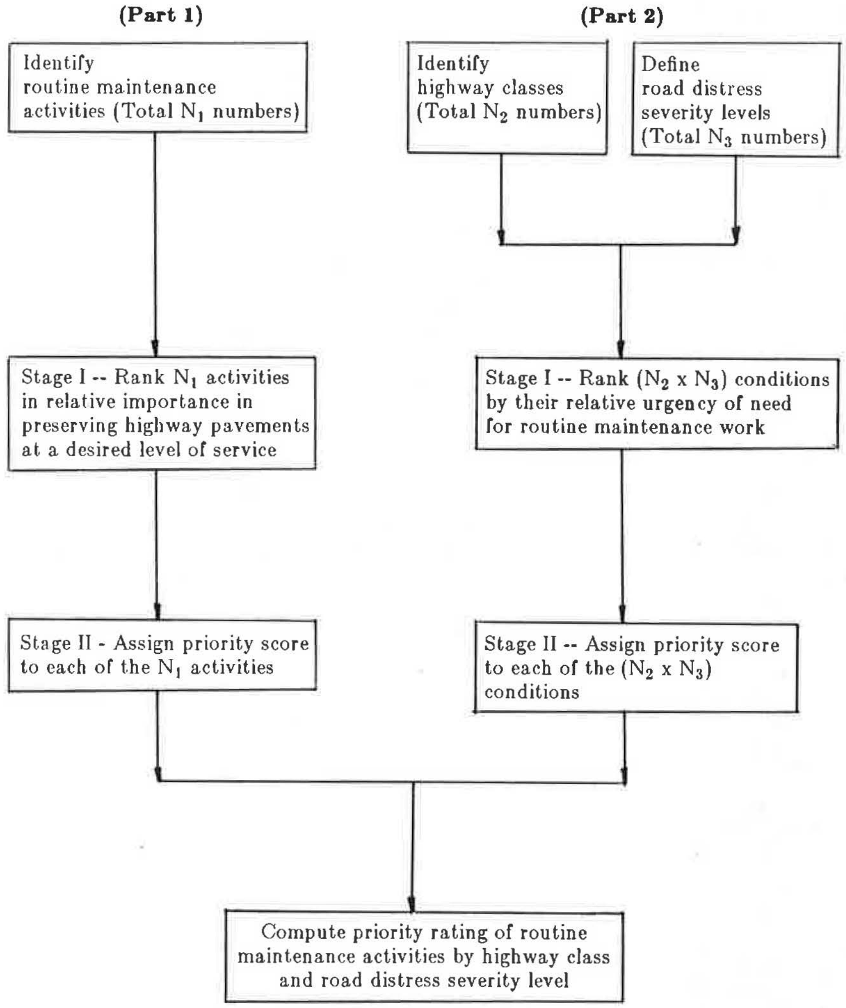


FIGURE 2 Activity flow chart for the partitioned two-stage survey procedure.

Computation of Final Priority Ratings

The data collected from Parts 1 and 2 of the survey (see Figure 2) are presented in Tables 2 and 3. Let f_1 and f_2 represent the priority scores obtained from the two parts. The final priority ratings of all routine maintenance activities can be computed as follows:

$$F_{ijk} = (f_1)_i \times (f_2)_{jk} \qquad i = 1, 2, \ldots, N_1, \quad j = 1, 2, \ldots, N_2, \; k = 1, 2, \ldots, N_3 \qquad (1)$$

where

F_{ijk} = priority rating for routine maintenance activity i on highway class j with distress severity level k, $1 \leq F_{ijk} \leq 100$,

$(f_1)_i$ = priority score for routine maintenance activity type i in relation to all other routine maintenance activity types, $1 \leq (f_1)_i \leq 10$,

$(f_2)_{jk}$ = priority score for combination of highway class j and distress severity level k in relation to all other combinations of the two factors, $1 \leq (f_2)_{jk} \leq 10$,

N_1 = total number of routine maintenance activity types,

N_2 = total number of highway classes, and

N_3 = total number of distress severity levels.

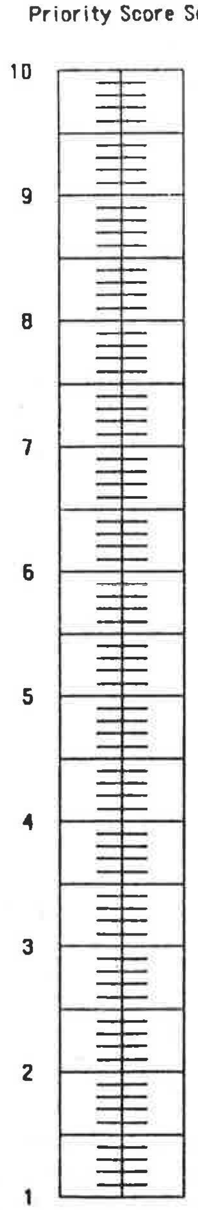
In Equation 1, the rating score $(f_2)_{jk}$ can be considered to be a weighting factor applied to each maintenance activity. The priority ratings thus computed are recorded in Table 4. Priority scores for both the north and south regions are presented in the same table. These priority ratings provide the necessary information on the relative importance of various maintenance activities by highway class and distress severity level.

It should be mentioned that, instead of taking the product of f_1 and f_2, a slightly different set of priority ratings, F'_{ijk}, may be computed by adding f_1 and f_2 in the following manner:

$$F'_{ijk} = \frac{10}{(W_1 + W_2)}[W_1(f_1)_i + W_2(f_2)_{jk}]$$

$$i = 1,2,\ldots,N_1, j = 1,2,\ldots,N_2, k = 1,2,\ldots,N_3 \qquad (2)$$

where W_1 and W_2 are numeric weighting factors and all other symbols are as defined in Equation 1. The factor 10 is included



Instructions for Rater

Step 1. You are given 14 routine maintenance activity types, each written on a small card. Go through and read the activity types carefully.

Step 2. (Ranking Assignment) Rank the cards on your desk in accordance with the importance of each activity type in preserving pavement condition at a desired level. Put the most important activity at the top, followed by other activities in the order of decreasing importance. Ties are allowed.

Step 3. Carefully review the ranking in Step 2. Make changes if necessary.

Step 4. Move the top priority card to the top (i.e. a score of 10) of the scale on this instruction sheet. Next, move one card at a time, in sequence of decreasing importance, to the score and assign a score to each by comparing with the activity immediately above it. Continue until all the cards are placed on the scale.

Step 5. If the last card does not have a score of 1, adjust the scores (except the top score) so that the lowest priority activity has a score of 1.

Step 6. Carefully review the priority scores assigned. Make changes if necessary.

FIGURE 3 Priority rating scale and rater instructions.

so that F'_{ijk} will have the same range as F_{ijk} (i.e., $1 \leq F'_{ijk} \leq 100$).

In comparing the multiplication model of Equation 1 and the addition model of Equation 2, the absolute values of individual priority ratings do not carry much physical meaning. It is their relative magnitudes in the entire set of priority rating scores that makes the difference in routine maintenance programming and scheduling analysis. It is therefore of interest to examine the ability of the two models to differentiate relative priorities of routine maintenance activities.

Consider two maintenance activity–highway class–distress severity combinations, A and B. Let f_{a1} and f_{a2} be the priority scores of A from Parts 1 and 2 of the survey, respectively, f_{b1} and f_{b2} the corresponding priority scores of B, and F_A, F_B, F'_A, and F'_B be the respective final priority ratings for A and B computed from the two models. The following relationships can be shown (*15*):

Case 1. $\min(f_{a1}, f_{a2}) \geq \max(f_{b1}, f_{b2})$, $f_{a1} \neq f_{a2}$ or $f_{b1} \neq f_{b2}$ or both. We have $F_A > F_B$ and $F'_A > F'_B$. The two models agree.

Case 2. $\max(f_{a1}, f_{a2}) \leq \min(f_{b1}, f_{b2})$, $f_{a1} \neq f_{a2}$ or $f_{b1} \neq f_{b2}$ or both. We have $F_A < F_B$ and $F'_A < F'_B$. The two models agree.

Case 3. $f_{a1} = f_{a2} = f_{b1} = f_{b2}$. We have $F_A = F_B$ and $F'_A = F'_B$. The two models agree.

Case 4. $\max(f_{a1}, f_{a2}) \geq \max(f_{b1}, f_{b2}) \geq \min(f_{a1}, f_{a2}) \geq \min(f_{b1}, f_{b2})$. We have $F_A \geq F_B$ and $F'_A \geq F'_B$ The two models agree.

Case 5. $\max(f_{b1}, f_{b2}) \geq \max(f_{a1}, f_{a2}) \geq \min(f_{b1}, f_{b2}) \geq \min(f_{a1}, f_{a2})$. We have $F_A \leq F_B$ and $F'_A \leq F'_B$ The two models agree.

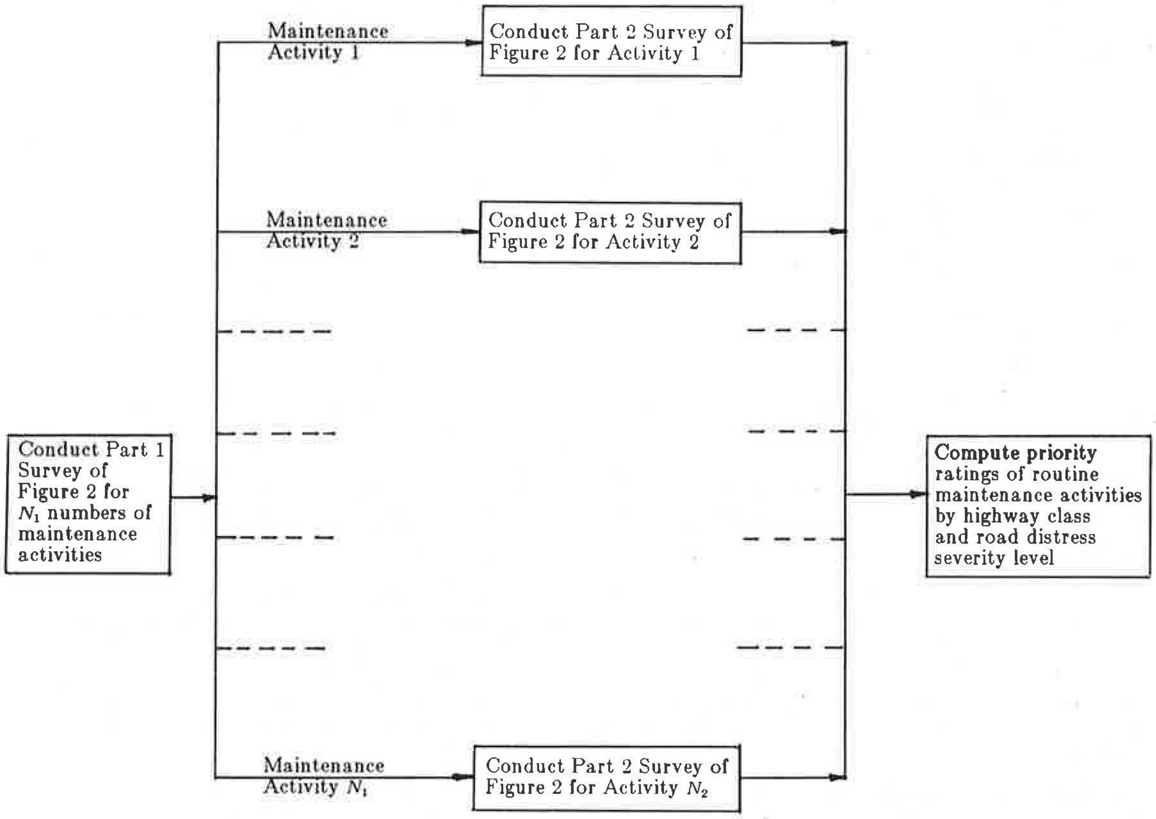


FIGURE 4 Activity flow chart for alternative survey procedure.

TABLE 2 RESULTS FROM PART 1 OF PRIORITY RATING SURVEY

Maintenance Activity Code	North Region			South Region		
	Average Rank	Priority Score		Average Rank	Priority Score	
		Average	95% Conf. Interval		Average	95% Conf. Interval
201	1	9.9	9.8 - 10.0	2	9.4	8.8 - 10.1
202	2	9.6	9.2 - 10.0	1	9.6	9.1 - 10.0
203	6	7.2	5.5 - 8.9	8	5.4	2.9 - 7.9
204	10	4.9	3.2 - 6.6	12	3.5	2.1 - 5.0
205	8	6.4	5.4 - 7.3	11	4.4	2.8 - 6.0
206	7	6.7	5.3 - 8.1	8	5.7	4.1 - 7.3
207	7	6.8	5.3 - 8.4	7	6.5	4.6 - 8.4
208	9	5.6	3.8 - 7.3	12	2.9	1.7 - 4.2
210	5	7.8	6.1 - 9.6	7	7.1	5.8 - 8.4
211	6	7.0	5.1 - 8.8	9	5.9	4.2 - 7.5
212	10	4.6	2.8 - 6.4	8	5.8	4.2 - 7.4
213	11	4.2	2.7 - 5.6	7	6.5	4.4 - 8.6
231	10	3.7	1.6 - 5.9	5	7.8	6.7 - 8.8
234	3	1.9	0.3 - 3.5	7	6.6	4.9 - 8.4

TABLE 3 RESULTS FROM PART 2 OF PRIORITY RATING SURVEY

Highway Class	Distress Severity Level	North Region			South Region		
		Average Rank	Priority Score		Average Rank	Priority Score	
			Average	95% Conf. Interval		Average	95% Conf. Interval
Interstate	Severe	1	10.0	10.0 - 10.0	1	10.0	10.0 - 10.0
	Moderate	3	8.7	8.2 - 9.2	4	8.1	7.3 - 8.6
	Slight	6	6.3	4.7 - 7.8	7	4.1	2.8 - 5.4
High Volume OSH	Severe	2	9.4	8.9 - 9.9	2	9.6	9.5 - 9.7
	Moderate	5	7.8	7.2 - 8.3	5	7.3	6.8 - 7.9
	Slight	8	4.3	3.0 - 5.6	7	3.7	2.2 - 5.1
Low Volume OSH	Severe	5	7.4	6.4 - 8.3	4	7.6	6.0 - 9.3
	Moderate	7	4.9	3.6 - 6.4	7	3.8	2.2 - 5.5
	Slight	9	1.0	1.0 - 1.0	9	1.0	1.0 - 1.0

TABLE 4 PRIORITY RATINGS OF ROUTINE MAINTENANCE ACTIVITIES BY HIGHWAY CLASS AND DISTRESS SEVERITY LEVEL

Routine Maintenance Activity Code	Interstate			High Volume OSH			Low Volume OSH		
	Distress Severity Lev.			Distress Severity Lev.			Distress Severity Lev.		
	Severe	Moderate	Slight	Severe	Moderate	Slight	Severe	Moderate	Slight
201	99 (N)	86 (N)	62 (N)	93 (N)	77 (N)	43 (N)	73 (N)	49 (N)	10 (N)
	94 (S)	76 (S)	39 (S)	90 (S)	70 (S)	35 (S)	71 (S)	36 (S)	9 (S)
202	96 (N)	84 (N)	60 (N)	90 (N)	75 (N)	41 (N)	71 (N)	47 (N)	10 (N)
	96 (S)	78 (S)	40 (S)	92 (S)	70 (S)	36 (S)	73 (S)	35 (S)	10 (S)
203	72 (N)	63 (N)	45 (N)	68 (N)	56 (N)	31 (N)	53 (N)	35 (N)	7 (N)
	54 (S)	44 (S)	22 (S)	52 (S)	39 (S)	20 (S)	38 (S)	21 (S)	5 (S)
204	49 (N)	43 (N)	31 (N)	46 (N)	38 (N)	21 (N)	36 (N)	24 (N)	5 (N)
	35 (S)	28 (S)	14 (S)	34 (S)	26 (S)	13 (S)	27 (S)	13 (S)	4 (S)
205	64 (N)	56 (N)	40 (N)	60 (N)	50 (N)	28 (N)	47 (N)	31 (N)	6 (N)
	44 (S)	36 (S)	18 (S)	42 (S)	32 (S)	16 (S)	33 (S)	16 (S)	4 (S)
206	67 (N)	58 (N)	42 (N)	63 (N)	52 (N)	29 (N)	50 (N)	33 (N)	7 (N)
	57 (S)	46 (S)	23 (S)	55 (S)	42 (S)	21 (S)	43 (S)	22 (S)	6 (S)
207	68 (N)	59 (N)	43 (N)	64 (N)	53 (N)	29 (N)	50 (N)	33 (N)	7 (N)
	65 (S)	53 (S)	27 (S)	62 (S)	47 (S)	24 (S)	50 (S)	25 (S)	7 (S)
208	56 (N)	49 (N)	35 (N)	53 (N)	44 (N)	24 (N)	41 (N)	27 (N)	6 (N)
	29 (S)	23 (S)	12 (S)	28 (S)	21 (S)	11 (S)	22 (S)	11 (S)	3 (S)
210	78 (N)	68 (N)	49 (N)	73 (N)	61 (N)	34 (N)	58 (N)	38 (N)	8 (N)
	71 (S)	58 (S)	29 (S)	68 (S)	52 (S)	26 (S)	54 (S)	27 (S)	7 (S)
211	70 (N)	61 (N)	44 (N)	67 (N)	55 (N)	30 (N)	52 (N)	34 (N)	7 (N)
	59 (S)	48 (S)	24 (S)	57 (S)	43 (S)	22 (S)	46 (S)	12 (S)	6 (S)
212	46 (N)	40 (N)	29 (N)	43 (N)	36 (N)	20 (N)	34 (N)	23 (N)	5 (N)
	58 (S)	46 (S)	23 (S)	55 (S)	42 (S)	21 (S)	43 (S)	22 (S)	6 (S)
213	42 (N)	37 (N)	26 (N)	39 (N)	33 (N)	18 (N)	31 (N)	21 (N)	4 (N)
	65 (S)	53 (S)	27 (S)	62 (S)	47 (S)	24 (S)	50 (S)	25 (S)	7 (S)
231	37 (N)	32 (N)	23 (N)	35 (N)	29 (N)	16 (N)	27 (N)	18 (N)	4 (N)
	78 (S)	63 (S)	32 (S)	75 (S)	57 (S)	29 (S)	59 (S)	30 (S)	8 (S)
234	19 (N)	17 (N)	12 (N)	18 (N)	15 (N)	8 (N)	14 (N)	9 (N)	2 (N)
	66 (S)	53 (S)	27 (S)	63 (S)	48 (S)	24 (S)	50 (S)	32 (S)	7 (S)

Note: (N) stands for North Region, and (S) stands for South Region.

Case 6. $\max(f_{a1}, f_{a2}) \geq \max(f_{b1}, f_{b2}) \geq \min(f_{a1}, f_{a2}) \geq \min(f_{b1}, f_{b2})$, or $\max(f_{b1}, f_{b2}) \geq \max(f_{b1}, f_{b2}) \geq \min(f_{a1}, f_{a2}) \geq \min(f_{b1}, f_{b2})$. The two models may agree or differ, depending on the magnitudes of f_{a1}, f_{a2}, f_{b1}, and f_{b2}, and the relative values of W_1 and W_2 in Equation 2.

The two models produce the same order of relative magnitude in priority ratings for Cases 1 through 5, but discrepancies are found in Case 6. This means that (a) regardless of the computation method used, the top and bottom portions of the priority rating list are likely to stay unchanged; and (b) the discrepancies would lead to some differences in the order of priority ratings in the middle portion of the list. In the context of the present study, the computation selected is unlikely to affect much the relative priority ratings of important maintenance activities on Interstate or high-volume OSH with high distress severity levels. These are the activities that are of major concern in a routine maintenance programming analysis. To quantitatively assess the difference between the models, a statistical correlation analysis was performed *(10)* to compare the set of priority ratings in Table 4 and one computed from Equation 2 with $W_1 = W_2$. The coefficient of correlation found was 0.966, showing an excellent positive association between the priority ratings obtained from the two methods. The impact of the choice of computation method is, therefore, not likely to be great on priority ratings used for routine maintenance planning purposes.

While the multiplication model is used in this study, one should not overlook the potential usefulness of the addition model. A highway agency may to some extent influence the results in favor of certain policy preferences through the use of weighting factors W_1 and W_2. The values of W_1 and W_2 are, however, not expected to be very different from the simple case of $W_1 = W_2$ in normal conditions.

Analysis of Priority Rating Data

An analysis was conducted to compare the maintenance practice of the north and south regions of Indiana. Plotted in Figures 5, 6, and 7 are data obtained from Table 4 for routine maintenance activities on Interstate, high-traffic-volume OSH, and low-traffic-volume OSH, respectively. Because of the large number of data points in the table, three plots instead of one were prepared for clarity of presentation.

In a priority rating comparison analysis, as mentioned in the preceding section, one is interested in the relative magnitudes of priority values within each set of ratings. For instance,

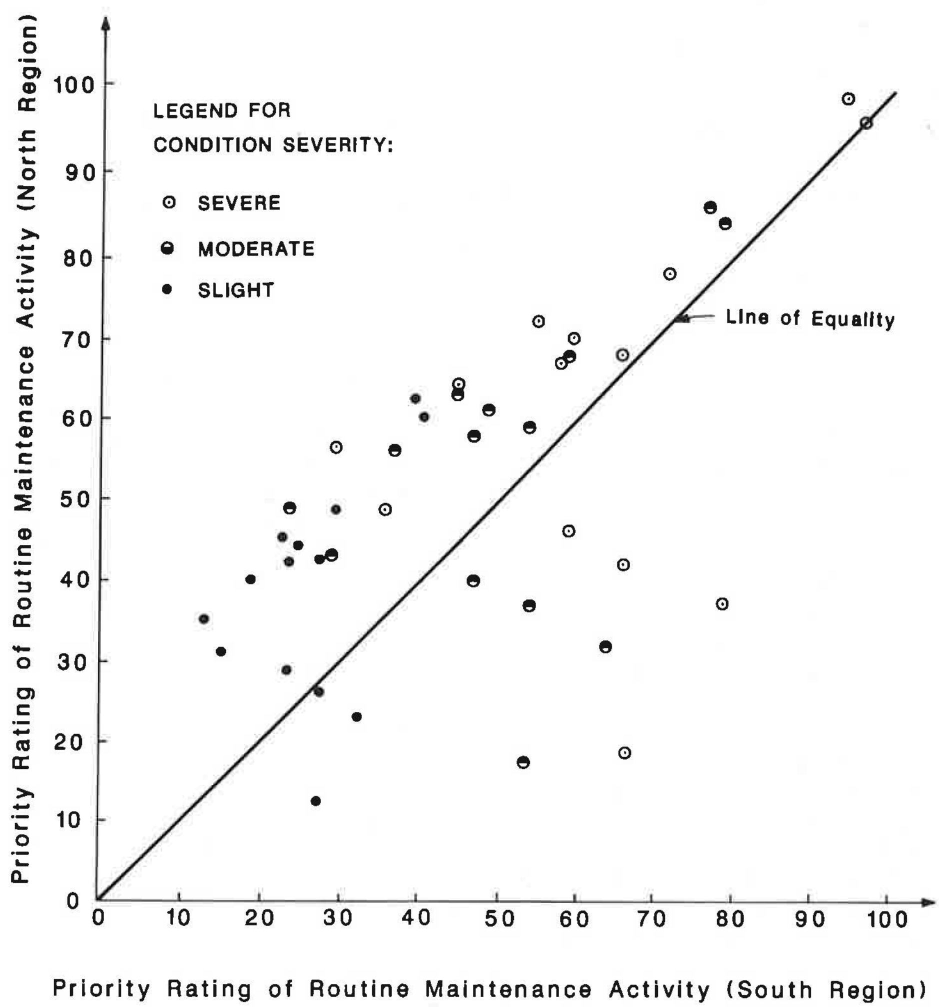


FIGURE 5 Comparison of north and south region priority ratings for maintenance activities on Interstate.

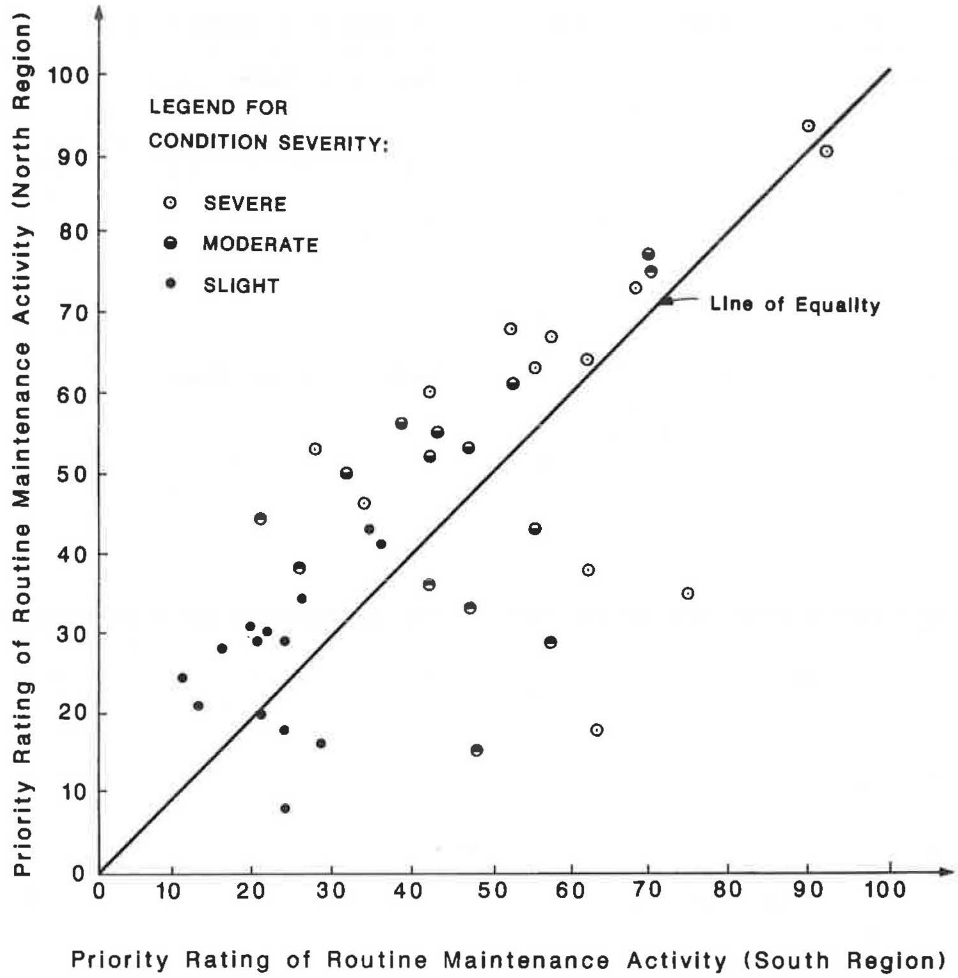


FIGURE 6 Comparison of north and south region priority ratings for maintenance activities on high-volume OSH.

Rating Panel A may award priority values of 20, 30, 40, and 50 to four different maintenance activities, while Rating Panel B awards 40, 50, 60, and 70, and Panel C awards 30, 20, 50, and 40 to the same activities. It is clear that there is no difference between the Panel A and B scores for the purpose of routine maintenance programming, but that the Panel C scores are quite different from those of the other two. The statistical coefficient of correlation, r, would again be an appropriate parameter to measure this difference (*10*). Panels A and B would give a r value of 1.0, which means a perfect linear association between the two sets of priority scores. Panels A and C or B and C produce a much lower r value of 0.60, indicating a relatively poor association between the two sets compared.

Using all the 126 pairs of priority scores in Table 4, computation gives a value of r equal to 0.74. This shows that the agreement between the priority ratings of the north and south regions was only fair. However, a closer examination of the plots in Figures 5, 6, and 7 shows that (a) all the points that lie below the line of equality belong to four maintenance activities (212, 213, 231, and 234) and (b) all other data points tend to cluster relatively closely within a straight band.

A revised computation confirms the above observation. The results are indicated in Table 5. Considering only the first 10 maintenance activities in Table 4, a r value of 0.95 was obtained. For the last four maintenance activities (i.e., Activities 212, 213, 231, and 234) the r value computed was 0.69. These results reveal that the north and south maintenance personnel were in excellent agreement over the priority ratings of most maintenance activities, except for the four activities mentioned above. These four activities are mainly drainage-related maintenance work. The south region personnel placed more priority on these activities compared with their counterpart in the north region. This is possibly due to climatic and topographical differences between the two regions. The south has steeper and more rolling to hilly terrain. It also has more rainfall, with an annual average of more than 40 in. compared with about 35 in. in the north.

A study of the priority rankings in Table 2 indicates that both the north and south region maintenance personnel gave highest priorities to pavement-related activities such as shallow and deep patching, premix leveling, and crack sealing. The main discrepancy arose when the south region maintenance personnel assigned appreciably higher priorities to the last four drainage-related activities. If these four activities are set aside, the two groups of maintenance personnel agreed closely on the relative priority rankings of the remaining activities. These observations concur with comments made in the preceding paragraph.

The pattern of the comparison plot seen in Figure 5 for Interstate is repeated very closely in the plot in Figure 6 for high-volume OSH and again in Figure 7 for low-volume OSH.

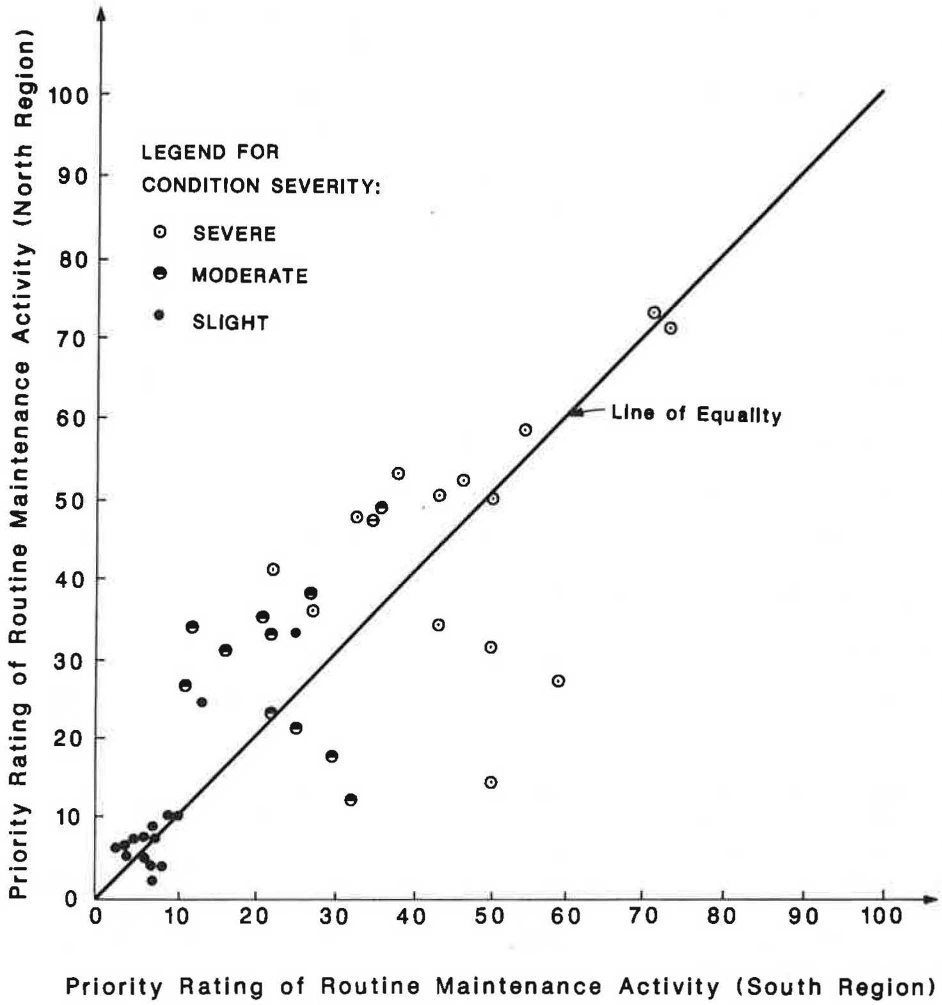


FIGURE 7 Comparison of north and south region priority ratings for maintenance activities on low-volume OSH.

This reflects indirectly a measure of consistency in the rating results. The partitioning technique and the two-stage procedure used in the survey process appeared to have produced logical, realistic ratings from the raters. The three plots also show a progressive shift in the position of general data points toward the low-priority area (at the lower left-hand corner of the plots) as one moves from Interstate to high-volume OSH and then to low-volume OSH. This roughly reflects the priority rankings of various highway classes depicted in Table 3.

Summary of Findings

The main findings of the Indiana study are summarized below:

1. The partitioned two-stage survey procedure was well received by raters. The process was found to be quick, easily understood, and easily implemented by maintenance personnel with different levels of knowledge and experience. Analyses of the data showed that logical realistic ratings were obtained from raters. The results provided a consensus view of the unwritten but important daily decision-making process governing routine maintenance practices of the highway maintenance agencies in Indiana.

2. The priority ratings from the north and south regions of Indiana showed, overall, a fair degree of agreement, although the south region maintenance personnel placed significantly higher priorities on drainage-related activities compared with their north region counterparts. The two groups showed excellent agreement on the relative priorities of other routine maintenance activities. Both assigned highest priorities to pavement-related activities on Interstate and high-volume OSH, and lowest priorities to activities on low-volume OSH with moderate and low distress severity levels.

3. The difference in the priority ratings between the two regions is believed to be related to the differences in their climatic and topographical conditions. One would therefore expect variations in priority ratings of maintenance activities among regions with different climatic and environmental conditions.

CONCLUSION

A partitioned two-stage survey scheme was implemented and found to be effective in assessing priority ratings of routine maintenance activities by highway class and road distress severity. The maintenance-activity-specific priority data were

TABLE 5 COEFFICIENTS OF CORRELATION BETWEEN PRIORITY SCORES OF ROUTINE MAINTENANCE ACTIVITIES OBTAINED FOR THE NORTH AND SOUTH REGIONS OF INDIANA

Group of Maintenance Activities	Interstate	OSH with High Traffic Volume	OSH with Low Traffic Volume	All Highways Combined
First 10 Activities in Table 4	0.97	0.96	0.94	0.95
Activities 212, 213, 231 and 234	0.44	0.61	0.78	0.69
All 14 Activities in Table 4	0.60	0.69	0.80	0.74

informative and useful in providing meaningful insight into the routine maintenance practices of highway agencies.

Since the priority ratings are influenced by seasonal factors, climatic and environmental conditions, highway maintenance policy emphasis, and pavement maintenance and repair technology, there is a need for each highway agency to develop its own set of routine maintenance priority ratings and to periodically update these ratings as a part of the continuing process of highway pavement maintenance management.

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