A Sufficiency Rating System for Secondary Roads

by

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I. Introduction

Needs for improvements on any state, county, or urban road system in this country are perennially greater than can be satisfied with the funds, at any time, currently available. This situation has persisted throughout the history of the nation. In modern times, the ever increasing numbers and amounts of usage of motor vehicles have made the satisfaction of these needs appear to be an all but impossible task requiring enormous expenditures of public funds, herculean efforts by highway officials, administrators, contractors, material producers and other highway personnel, and a long period of time for its accomplishment.

In these circumstances, the highway officials responsible for and concerned with the administration of the highway system of any state, county, city or town, must select periodically from the whole group of the needs for improvement in the system under their jurisdiction those needs which appear to them to be most urgent and for which satisfaction would be of greatest benefit to the community. In this act, these officials undertake one of the most important and most difficult operations of modern highway administration.

In connection with this operation, they are constantly under pressure from numerous individuals, groups of individuals, and special interest groups, each citing or proclaiming the urgency of some specific need for improvement of some section of the highway system of particular interest or benefit to them but either ignoring or belittling the needs of all other sections of the system. As each differs from every other, the combination of these requests, demands, petitions, and proposals for improvements is a summation of the needs

of the system as a whole with which officials responsible for its administration were confronted at the beginning of the operations. Nothing but variations in the volume of clamor for satisfaction of these needs indicates that any one is more urgent than another.

During the past fifteen years, highway officials in general have sought more objective and scientific means or prccedures for the evaluation and comparison of needs of the various sections of the highway system under their respective jurisdictions to serve as guides in making selections for improvement programs. As a consequence, a great variety of sufficiency or adequacy rating systems have been developed and adopted for that purpose.

Arizona, in 1946, became the first of 36 states now employing a rating system for the evaluation and comparison of needs of the various section of its state highway system for improvement. Seventeen of these 36 states also make ratings on urban primary road extensions and two of this 17 make ratings on urban federal-aid road system extensions only. Thirteen of the 36 states make ratings on urban secondary roads and two of these on federal-aid road extensions only. Usage of such systems are now prescribed by law in seven states including Iowa.

Rating systems for evaluation and comparison of needs for improvements on secondary road systems have been developed and adopted in 27 of the 36 states. Ratings are made in 12 of these 27 states on the federal-aid secondary system only.

II. Sufficiency Rating Systems

As may have been implied from several of the statements made in the preceding paragraphs of this paper, sufficiency or adequacy rating systems are procedures for the evaluation and comparison of the relative needs of the various sections of a given highway system for improvements.

They are employed either alone or in combination with other procedures as guides in the selection of the sections of the system for improvement and in the determination of the type of improvements to be made in each instance.

Most of the rating procedures designed for usage on the state primary road systems follow the general pattern of the one developed by the Arizona State Highway Department but many of them include variations of such nature as to render them almost unrecognizable as descendants of that system. While they all tend to emphasize the features of the highway associated with its safety, service, or structural condition, the treatment of these features among states varies greatly. Collectively, these state road rating systems deal with about 55 different factors. A given system may include ratings of as few as 15 to as many as 30 factors. All of the systems attempt to measure and compare the sufficiency or adequacy of a highway to render a given traffic service, which although similar in nature throughout the United States, requires differences in facilities due to differences in climate, soils, economic conditions, and local traditions in construction standards and maintenance practices, and in local administrative policies of such nature as to indicate differences in emphasis among the factors included in the rating system and on the choice of factors deemed advisable in each instance for inclusion in the rating system. As time passes, it is likely that a trend toward similarity of the system will develop. This could lead eventually to the adoption of a national standard rating system. None of the rating systems for primary roads is at present, suitable for application to more than a small portion of the mileage of the secondary roads of the nation.

Lack of time for the presentation of the paper has prevented any review or analysis of the rating systems employed in the 27 states for secondary road systems.

III. Iowa Highway Research Board Project HR-50

To this point, this paper has dealt with sufficiency or adequacy ratings in general as a background for a progress report on Iowa State Highway Commission, Iowa Highway Research Board, Highway Research Project No. HR-50, which constitutes the balance of the paper.

This project was instigated late in 1956 at the request of the Commission to develop a sufficiency rating system for secondary roads as a basis for the determination of the priority and type of improvements for the various portions of the secondary road system in Marion County as a guide to the Board of Supervisors and a group of local citizens in the formulation of a highway improvement program for which the nature and content was at that time a matter of considerable controversy. Upon adoption by the Iowa Highway Research Board and final approval by the Commission, the project was extended in scope to provide for the development of a sufficiency rating system suitable for the secondary road system of Iowa as a whole.

Lack of research personnel delayed start of work on the project until June, 1959 during which month the design of a tentative rating system was completed and an inventory of the farm-to-market road system was made. Some months previously a preliminary design for a sufficiency rating system had been prepared by the Research Department and discussed in an all day session with the Executive Committee of Iowa County Engineers Association. In the course of this discussion, several revisions were made by individual members of the committee. Concensus of the meeting was that the proposed system was worthy of trial on an experimental basis.

Lack of research personnel again delayed further work on the project until October, 1960. During October and November, 1960 the rating system as revised in the meeting with the Executive Committee was brought to its present stage of development, which is essentially its final form unless more extensive usage

may indicate the advisability of further revision. Tabulation and analization of the Marion County data are in process of completion. Final report on the system and its application in Marion County will be completed in the Spring of 1961.

The sufficiency rating system for secondary roads that has been developed in this project is a wholly new and original product. It has been developed without reference to any other rating system for secondary roads and reference to those for primary roads has been limited to a review sufficient in extent to disclose that they were unsuitable for application to secondary roads in Iowa. A traffic adjustment procedure common to both primary and secondary road rating systems generally was borrowed from the Iowa primary road rating system and adjusted for use on Iowa secondary roads.

In this secondary road rating system, emphasis is placed on the evaluations of the physical characteristics of the highway such as the dimensions of the roadbed, the roadway surfacing, the roadway base, the roadway subbase, the shoulders, and the ditches and upon the condition of these various structural features of the highway. Significance of the service of the highway to the community is also evaluated in ratings involving the number of houses along the road and the presence of mail routes, and the presence of school bus routes on the road. Provision is also made for the evaluation of the adequacy of the geometric capacity of the road to serve the volume of traffic carried by the road. Ratings are also provided for nature of the topography through which the road is located and for the general alignment of the road.

The choice of these factors is based on their close association with the principal reasons for improving a road such as, (1) to obtain a greater width of roadbed or roadway surfacing, (2) to obtain better drainage, (3) to replace a worn out roadway surfacing with a new one of the same kind, (4) to provide

a roadway surfacing of a higher type, (5) to provide more adequate snow storage capacity, and (6) to provide traffic service to a community in proportion to its needs for such service.

Objectivity of procedures and reproducibility of results are insured within narrow limits because the ratings on which the greatest emphasis is placed are based on measurements of structural features of the highway and on counting of things, such as, houses, mail or school bus routes, and volumes of traffic. Judgement values are confined to the condition of the structural features of the highway, evaluation of snow storage capacity, description of topography and description of alignment. Ratings by different observers of comparable intelligence, judgement, and alertness are confined by the objectivity of the procedures to a relatively small variation in values of the final rating. This is a highly desireable feature of a rating system which is to be applied over a wide range of conditions by a great number of operators. Also confinement of major emphasis to physical characteristics is an advantage in gaining the confidence of the public in the soundness and in the fairness of the sufficiency rating values obtained for these are the characteristics of the highway that they can see and measure and judge conditions for themselves.

The elements of the highway and of the features associated with the reasons for the existence of the highway are classified into three groups:

1. The structural characteristics of the highway,
2. The condition of the structural elements of the highway, and
3. The items of service to the community.

The range in dimensions and conditions of the elements of the highway included in the rating system and their corresponding ranges in values of basic rating are shown in Table No. 1. The total basic rating is the sum of the basic ratings

of the three groups of elements included in the rating system. It is to be noted that the maximum basic rating of 107 can be only attained for a road with maximum width roadbed and pavement with all structural elements in excellent condition and without either houses, a mail route or a school bus route. This is a situation occasionally encountered but with such a low probability of occurence that it has appeared inadvisable from a statistical viewpoint to hold it to a basic rating of 100 because to do so would unbalance certain interior ranges of the basic rating scale.

Table No. 1

Summary of Basic Ratings

Item	Description of item	Range in value: Rating Element	Basic Rating
	I. Structural Characteristics		
1.	Roadbed, width	36-22 feet	13-06
2.	Roadway pavement, width	24-16 feet	12-04
3.	Shoulder, width	8-0 feet	05-00
4.	Ditches, depth	3-0 feet	05-00
5.	Road, pavement thickness	8-0 inches	12-04
6.	Roadway base thickness	10-3 inches	12-05
7.	Roadway subbase treatment	10-0 inches	08-00
8.	Snow storage potential	good to bad	05-01
9.	General gradient situation	flat to very hilly	03-00
10.	General alignment situation	straight to sharp turn	02-00
	Subtotal		77-20
	II. Structural Condition		
1.	Roadbed condition	good to bad	05-01
2.	Roadway pavement condition	good to bad	05-01
3.	Shoulders, condition	good to bad	05-01
4.	Ditches, condition	good to bad	05-01
	Subtotal		20-05
	III. General Services		
1.	Number of houses in section	0-5	05-00
2.	Mail route	No or yes	02-00
3.	School bus route	No or yes	03-00
	Subtotal		10-00
	IV. Basic Rating in Total of groups I, II, and III		107-25

5 Point ratings		3 Point ratings		2 Point ratings	
Condition, Excellent	- 5	Gradient, flat	- 3	Alignment, straight	- 2
Condition, good	- 4	Gradient, rolling	- 2	Alignment, curve	- 1
Condition, fair	- 3	Gradient, hilly	- 1	Alignment,	- 0
Condition, poor	- 2	Gradient, very hilly	- 0		
Condition, bad	- 1				

Mail route - yes 0
Mail route - No 2

School bus route - Yes 0
School bus route - No 3

Dimensions of the elements of the roadway as shown in Table I of the Farm-to-Market Road Design Standards of January 1, 1960 were used as the basis for the assignment of rating values and ranges of rating values. For example, the recommended minimum width of roadbed of 30 feet for traffic volumes from 400 to 1000 vehicles per day was assigned a rating value of 10; the recommended minimum pavement width of 20 feet, a rating value of 10 and the recommended standards for other dimensions were treated similarly by the assignment of a rating value which in combination with all others in the series employed in the system would add to 100 if all features were in excellent condition. A range of rating values was provided to cover the range of dimensions which might be encountered in the field in the application of the rating system. For dimensions less than given at the recommended minimum value the values ranged downward from 10 in proportion to difference from that value and for dimensions greater than given as the recommended minimum they ranged upward similarly. Par for sufficiency of each element was therefore the dimension given in the farm-to-market road standards. Any other dimension was either above or below par from a sufficiency viewpoint.

Rating values for other elements of the rating system were assigned on a basis of equal influence on the value of the total basic rating.

Table No. 2

Secondary Road Sufficiency Rating System

DATA SHEET

Road System _____

County _____ Township _____ Section _____

Road No. _____ Surface type _____ Length miles _____

- -

I. Structural Characteristics of Roadway

1.	Roadbed	Width feet	_____	Rating	_____
2.	Roadway	Width feet	_____	"	_____
3.	Shoulder	Width feet	_____	"	_____
4.	Ditch, X-section or depth in	feet	_____	"	_____
5.	Roadway Surface, Thickness,	inches	_____	"	_____
6.	Roadway Base Thickness,	inches	_____	"	_____
7.	Roadway Subbase, Thickness,	inches	_____	"	_____
8.	Snow Storage Potential, Estimated		_____	"	_____
9.	General Gradient Description		_____	"	_____
10.	General Curvature Description		_____	"	_____

Subtotal of Rating - - - - - - _____

II. Structural Condition

1.	Roadbed	Estimated	_____	Rating	_____
2.	Roadway Surfacing	"	_____	"	_____
3.	Shoulders	"	_____	"	_____
4.	Ditches	"	_____	"	_____

Subtotal of Rating - - - - _____

III. General Services

1.	Number of Houses	_____	_____
2.	Mail Route (yes or no)	_____	_____
3.	School Bus Route (yes or no)	_____	_____

IV. Summary and Conclusion

1.	Basic Rating	Total Rating _____
2.	Traffic Volume	_____
3.	Traffic Adjusted Rating	_____
4.	Road Surface Type Adjustment Factor	_____
5.	Road Surface Type Adjusted Rating	_____
6.	Quality of Traffic Service Factor	_____
7.	Quality of Traffic Adjusted Rating and Final Rating	_____

MARION COUNTY
TRAFFIC VOLUME ADJUSTMENT
OF BASIC SUFFICIENCY RATINGS

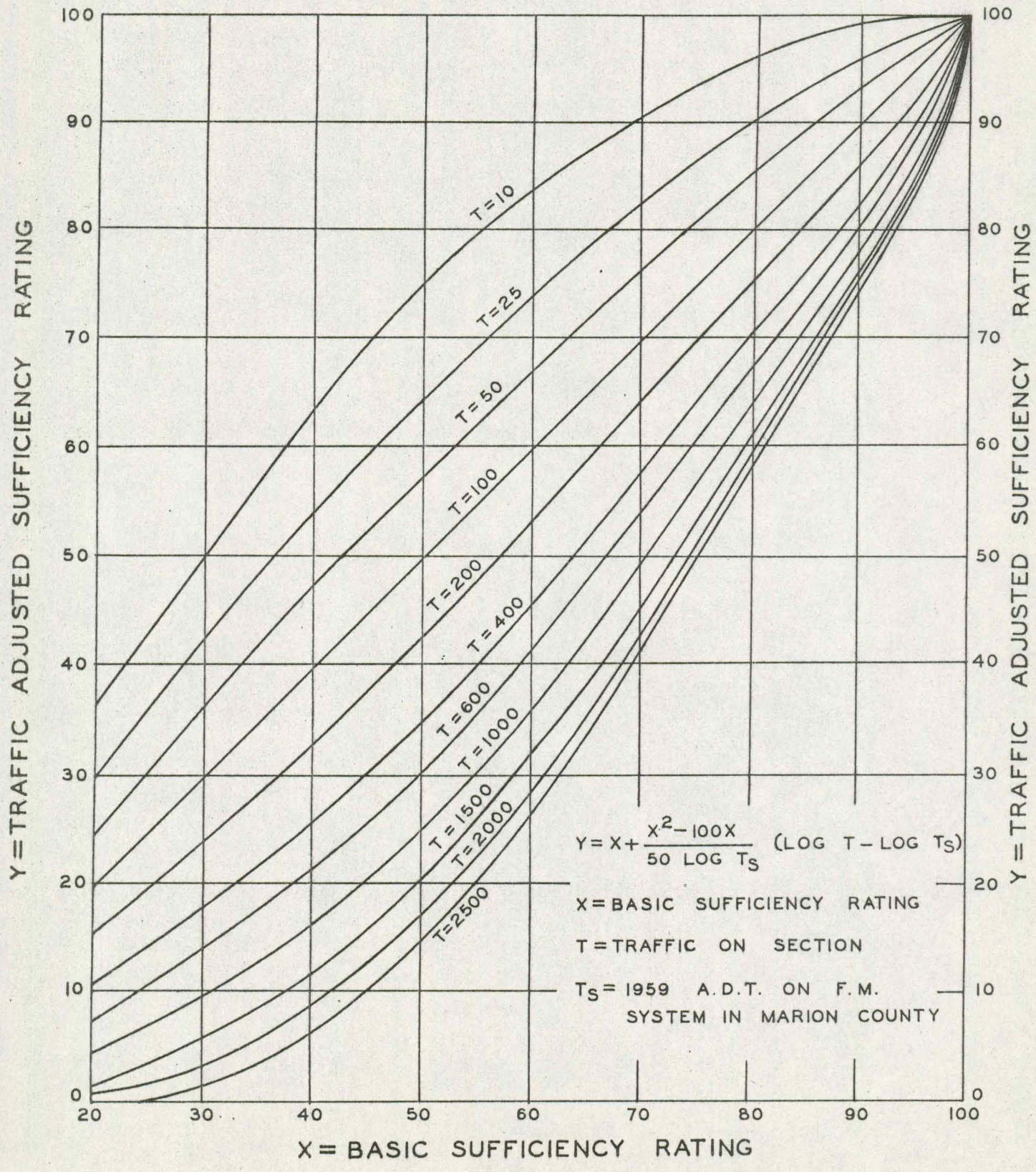

Table No. 2 consists of the sufficiency rating system data sheet which provides spaces for the entry of the field data and their ratings and for entry of the basic rating. This sheet also provides space for the entry of:

1. The traffic volume on the road,
2. The traffic volume adjusted rating,
3. The road surface type adjustment factor,
4. The road surface type adjusted rating,
5. The quality of traffic service factor, and
6. The quality of traffic service adjusted rating, which is also the final sufficiency rating of the road for which the data sheet was prepared.

The traffic volume data used should be the latest available on a system wide basis.

The traffic volume adjustment of the basic rating is made in accord with the formula:

$$Y = X + \frac{X^2 - 100X}{50 \log TS} (\log T - \log TS)$$

where Y = Traffic volume adjusted rating
X = Basic rating
T = Traffic volume on road
TS= Latest average annual daily traffic of the highway system as a whole of which the road being rated is a part

The effect of this adjustment is to produce higher values than the basic rating for roads having an average daily traffic less than that for the system as a whole and lower values for roads have an average annual daily traffic greater than that for the system as a whole.

The sufficiency of a gravel roadway surfacing diminishes more rapidly with increases of traffic volume than does that for higher types of roadway surfacing. In other words, the range of traffic volumes for which gravel is suitable is much less than that of the higher types of surfacing. To provide for the greater task of loss of sufficiency with increase in traffic on gravel roads it is necessary to reduce the traffic adjusted sufficiency rating of these roads by amounts proportional to the volume of traffic on them. The factors as determined for that purpose in this research are given in Table No. 3.

Table No. 3

Gravel Roadway Adjustment Factors

Average Annual Daily Traffic	Amount to Reduce Traffic Adjust Rating
750	31
700	29
650	27
600	25
550	23
500	21
450	19
400	17
350	15
300	13
250	11
200	09
150	07
100	05
75	03
50	01
25	00

Earth roadway adjustment facts are, for 50 vehicles per day, 15 and for 25 vehicles per day, 10.

A rating range of 100 points is insufficient for evaluation of the degrees of quality of traffic service represented by the full range of possible conditions of the roadway surfacing without serious imbalance in the emphasis of other factors included in the basic rating. This can be overcome by applying an adjustment factor to the traffic adjusted rating value. The factors for

that purpose as determined in this research are given in Table No. 4.

Table No. 4

Quality of Traffic Service Factor

Condition of Roadway Surfacing or Pavement	Factor to Apply to Roadway Surface Adjusted Rating
Excellent	+05
Good	00
Fair	-10
Poor	-20
Bad	-30

The value obtained after the application of the quality of traffic service factor is the final sufficiency rating. These values will range from near 00 to 100. Values for particular ranges bear special significance as to the sufficiency or adequacy of the road to provide the service demanded of it. These ranges and their significance are given in Table No. 5.

Table No. 5

Degree of Sufficiency Represented by Final Ratings

Rating Value Range	Degrees of Sufficiency of Road
92.5 to 100.0	Superior
80.5 to 92.5	Excellent
65.5 to 80.5	Good
50.5 to 65.5	Tolerable
35.5 to 50.5	Poor
0.0 to 35.5	Critical

Sufficiency rating values are always integers in this system. Consequently they fall positively in some one group of degree of sufficiency. The terms for degree are self explanatory except perhaps those for "Tolerable", "Poor", and, "Critical". "Tolerable" signifies a situation which can be tolerated if funds are unavailable for significant elevation of the quality of improvements on the road to which the term applies; "Poor" signifies that the road is in need of improvement in near future programs; and "Critical" signifies that the road is in need of immediate improvement.

These ranges of degree of sufficiency are derived from the Farm-to-Market Road Standards of January 1, 1960 and the sufficiency rating system developed in this research is based on the recommended minimum standards for the three ranges of traffic volumes for which these standards apply.

Application of the rating system to roads built in accord with these standards and found in excellent condition will have the sufficiency ratings shown in Table No. 6.

Table No. 6

Sufficiency Ratings of Roads Built to January 1, 1960
Farm-to-Market Standards and in Excellent Condition

Width of Roadway Feet	ADT under 110 Roadbed 28 feet	ADT 100-400 Roadbed 24 feet	ADT 100-400 Roadbed 34 feet	ADT 400-1000 Roadbed 30 feet	ADT 400-1000 Roadbed 36 feet
1. Gravel					
24	67	--	--	--	--
2. Portland Cement Concrete					
20	80	78 - 66	83 - 74	71 - 65	74 - 69
22	80	80 - 70	85 - 76	75 - 70	76 - 71
24	84	82 - 73	87 - 78	76 - 71	80 - 75
3. Asphaltic Concrete on Base and Subbase					
20	76	74 - 63	79 - 69	67 - 59	70 - 64
22	78	74 - 65	81 - 71	68 - 61	71 - 65
24	80	78 - 67	83 - 75	71 - 65	75 - 71

These data indicates that a standard gravel road in excellent condition is barely sufficient for 100 vehicles per day; that the Portland Cement Concrete pavement ranges from barely sufficient for 1000 vehicles per day at a width of 20 feet on a road bed having a width of 30 feet to excellently sufficient for 100 vehicles per day at a width of 24 feet on a roadbed having a width of 34 feet; and that asphaltic concrete ranges from tolerably sufficient for 1000 vehicles per day at a width of 20 feet on a roadbed having a width of 36 feet to excellently sufficient for 100 vehicles per day at a width of 24

feet on a roadbed having a width of 34 feet.

Consideration is now being given to the employment of this rating system as a routine feature of the road inventory operation of the Planning Division of the Iowa State Highway Commission. If this should come to pass, sufficiency ratings of the secondary roads of the state would be made as a part of that work. These operations include about one fifth of the counties of the state in each year. At this rate sufficiency ratings for the entire secondary road system could be obtained in a total of five years.

APPENDIX

Sufficiency Rating System for Secondary Roads

Details of Basic Ratings

I. Structural Characteristics

1. Roadbed width

Width, feet	Ratings
36	13
34	12
32	11
30	10
28	09
26	08
24	07
22	06
20	05
18	04

2. Roadway pavement width

Width, feet	Ratings
24	12
23	11
22	10
21	09
20	08
19	07
18	06
17	05
16	04

3. Shoulders, width

Width, feet	Ratings
8	05
7	05
6	05
5	05
4	04
3	03
2	02
1	01
0	00

4. Ditches, depth or condition.

	Depth, feet	Rating
Excellent	5.0	05
Excellent	4.0	05
Good	3.0	05
Good	2.5	04
Fair	2.0	03
Fair	1.5	02
Poor	1.0	01
Poor	0.5	00
Bad	0.0	00

5. Roadway pavement thickness

Portland Cement Concrete		Asphaltic Concrete	
Thickness Inches	Rating	Thickness Inches	Rating
10	24	4.5	13
09	23	4.0	12
08	22	3.5	11
07	21	3.0	10
06	20	2.5	09
05	19	2.0	08
04	18	1.5	07
03	17	1.0	06
		.7	05
		.5	04

6. Roadway base thickness

Rolled Stone		Bituminous treated	
Thickness Inches	Rating	Thickness Inches	Rating
10	12	10	12
09	12	09	11
08	10	08	10
07	09	07	09
06	08	06	08
05	07	05	07
04	06	04	06
03	05	03	05

7. Roadway subbase treatment

Depth, Inches	Rating
10	08
9	07
8.0	06
7.0	05
6.0	04
5.0	03
4.0	02
3.0	01

8. Snow storage

Excellent	05
Good	04
Fair	03
Poor	02
Bad	01

9. Gradient

Flat	03
Rolling	02
Hilly	01
Very hilly	00

10. General alignment

Straight	02
Curves	01
Rt. angle curve	00

II. Structural Condition

1. Roadbed

Condition	Rating
Excellent	05
Good	04
Fair	03
Poor	02
Bad	01

2. Roadway pavement

Condition	Rating
Excellent	05
Good	04
Fair	03
Poor	02
Bad	01

3. Shoulders

Condition	Rating
Excellent	05
Good	04
Fair	03
Poor	02
Bad	01

4. Ditches

	Depth	Rating
Excellent	3.0	05
Good	2.5	04
Fair	2.0	03
Poor	1.5	02
Poor	1.0	01
Bad	0.5	00

III. General Services

1. Number of houses

Number	Rating
0	05
1	04
2	03
3	02
4	01
5	00

2. Mail Route

Present	
No	02
Yes	00

3. School Bus

Present	
No	03
Yes	00