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# Field Manual

Federal and State  
Aid Road and  
Bridge Work

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State Highway Commission  
Ames 1926 Iowa

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Bridge Work

Iowa State Highway Commission  
Ames 1926 Iowa

# FIELD MANUAL

## FEDERAL STATE AID ROAD AND BRIDGE WORK

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## INTRODUCTION

### To the Field Engineer:

This manual is prepared to assist you in so discharging your duties that your work will harmonize with the methods and requirements of the general office. You should first become familiar with the regulations herein outlined. Next you should master the details of the particular piece of work to which you have been assigned.

When you show up on a job, you are, in the eyes of the local people, the State Highway Commission. If you make good, the Commission makes good. If you fail, the Commission fails. You may be a hundred miles or more from the district headquarters and twice that distance from the general office. You are, largely speaking, your own boss. This places on you entire responsibility for your conduct. You must often be your own judge of the propriety of any given course of action.

Your first duty is to efficiently, accurately, and honestly perform the duties assigned to you. Your next duty is to make friends of all those with whom you come in contact. If you fail in either of these, you have not made good. The people along the road will appreciate information relative to the improvement proposed. They will ask many questions. Answer them courteously. Go out of your way to give them the information they want. We have no place on our force for the man who gives a smart or insolent reply to any inquiry that may be made of him. Get acquainted with the editors of the local papers. Get them interested in your work. Take them out to see the job. Make friends of them. Get in close touch with the county board, the county engineer, and the auditor. They can help you when you need it. Remember that if you make good, we will hear about it, and if you fail we will hear about that also, even thou you are a long way from the office.

The resident engineer or party chief is responsible for the actions of those under him, as well as for his own actions. If you have a man under you who assumes that he is a superior sort of individual because he is working for the state, fire him. We have no place for such men.

Always assume that your work is wrong until you have checked and re-checked it to such an extent that you have eliminated every possibility of error. Never ignore a suggestion by anyone on the job, even though he be the lowest laborer. He may be right and you may be wrong. I remember an incident that came to my attention some years ago. An engineer was staking out a pier for a viaduct. The foreman of the pile driver doubted the accuracy of the measurement, and expressed his doubts to the engineer. The engineer's reply was, "I'm doing this measuring." "All right," said the



foreman, "and you are responsible if it isn't right." Later, after a considerable quantity of work had been done, it was proven that the engineer was wrong. It cost the company many thousands of dollars. It cost the engineer his job. His refusal to listen to the foreman's doubts and to check his own measurements, meant the difference between success and failure.

Another thing. Avoid all appearance of loafing on the job. Never let the members of your engineering force take guns, base balls, bats, or other sporting paraphernalia out to the work with them. You will get "in bad" if you do. We understand, of course, that when there are enough men on your force to do the work promptly and efficiently, there are times when in the natural progress of the work, one or more of your men will be idle for a short time. But the public does not understand these things. They are looking for something to criticize. Don't give them the chance. Arrange your work so as to keep each man busy a maximum percent of the time. Get your men on to the job promptly in the morning and keep them there until a full day's service has been rendered. This will avoid much talk and criticism from the local people.

F. R. White,  
Chief Engineer.

# PRELIMINARY SURVEYS

## ORGANIZATION

### General

All surveys on the primary road system will be made by parties furnished by the Highway Commission. The regular parties assigned to this work for a full season will usually consist of seven men, as follows:

- 1 Chief of Party
- 2 Instrumentmen
- 4 Rodmen

The regular parties should be kept up to full strength thru the entire field season, and vacancies should be filled by the district engineer or party chief if possible. In all cases of discharge, resignation, change of assignment or employment of new help Form No. 282 must be filled out and sent to the general office AT ONCE.

In some cases surveys may be made during the winter by special parties made up of men from other departments. The organization of such parties will generally be handled by the district engineers, and the work done shall be in accordance with the requirements of this manual.

### Equipment:

Each regular survey party is supplied with the following equipment:

- 1 Berger transit and tripod
- 1 Berger wye level and tripod
- 2 Level rods
- 1 hand level
- 3 100' steel tapes
- 3 50' metallic tapes in cases
- 3 flag poles
- 1 set chaining pins
- 1 25' chalk line
- 2 hand axes
- 1 chopping axe
- 2 chaining plumb bobs
- 12 tape splices
- 1 8-lb. hammer
- 1 pick
- 1 shovel

Stakes, nails and cloth used for marking the centerline may be obtained by the party chief thru the purchasing department, or may be purchased locally or elsewhere when authorized to do so. The party chief is to be reimbursed for expense of this nature as provided by the fiscal regulations.

The attention of all members of the party is directed to the instructions relating to the use and care of equipment, as printed elsewhere in this Manual. These are to be consid-

ered as a part of the specific instructions to preliminary survey men. Their careful observance will operate to the mutual benefit of the Commission and all employees concerned.

#### **General Supervision:**

Before a survey party is started in his district each district engineer will be advised of the surveys to be made in his district, and he shall keep the general office advised as to progress made and any changes in the program which appear advisable.

The survey party shall be under the district engineer's supervision. The chief of party shall take up with the district engineer all questions concerning the surveys and shall look to him for instructions. The chief of party shall make out each day duplicate copies of the daily report, Form No. 307, and send one copy to the district office and one to the general office. These reports are to be sent in at least **twice each week**, and more often if necessary to keep the office properly advised of the movements or progress of the party. The district engineer or his assistant shall visit the county frequently during the survey so as to keep closely in touch with the work.

#### **General Plan of Survey:**

The district engineer shall go over the general plan of each survey with the chief of party and agree as to:

1. Datum to be used.
2. Point of beginning of survey and system of stationing to be used.
3. Points governing alignment.
4. Relocations.

Each district office has been supplied with all available information relative to U. S. G. S. bench marks and other existing level circuits referred to sea level. Wherever possible, sea level datum should be used.

It is desirable that there should be only one station zero on each project. In general the survey on east and west roads should begin at the west end and on north and south roads should begin at the south end.

Important bridges, cemeteries, streams and other topographical features often constitute points which will control the alignment and must always be given consideration in locating the center line of the survey.

The district engineer shall investigate fully all relocations that may appear feasible and shall instruct the chief of party to make such relocation surveys. If in doubt as to the feasibility of any relocation that presents itself, a survey should be made. **It is much better to survey a number of relocations that are later abandoned than to fail to survey one which later proves desirable.**

The district engineer is responsible for outlining all relocations and having surveys made. This does not relieve the

chief of party from his obligation to at all times look for opportunities to take advantage of conditions and improve the general quality of the surveys. If at any time it should appear that the district engineer has overlooked any feasible relocations or other features of the project, the chief of party should call this fact to the district engineer's attention.

**The district engineer shall report fully to the general office relative to all relocations which are to be surveyed. These reports shall contain sketches of all such relocations.**

Sketches should be approximately to scale so that a good idea of the proposed alignment may be obtained therefrom.

### DETAILED INSTRUCTIONS

#### General:

The chief of party should constantly bear in mind that the office man who works up the notes may have no first-hand knowledge of field conditions; he must necessarily base the design on the information contained in the notes, and the value of the completed plans will depend entirely upon the care with which the survey is made and recorded.

In the instructions which follow, a great many points have been covered, but it is impossible to anticipate all conditions. The chief of party will doubtless encounter many situations not mentioned here. To make sure that nothing important is omitted, get **everything** that will have any bearing on any phase of the improvement. Unnecessary information does no harm, but lack of information will mean delay in completing the plans and another trip into the field to secure the missing data.

To fully appreciate the needs of the designers, the field man should familiarize himself with the details of completed plans. The fullest co-operation between field and office forces is necessary. Under no other conditions can the best results be obtained.

#### Keeping the Notes:

The notes in each book must be completely indexed, and the first few pages shall be reserved for this purpose. Care should be taken in indexing alternate lines to refer to the same letters or numbers by which the various lines are designated on the sketch map.

The notes shall show (preferably in the first alignment book) a sketch map of the entire project, drawn approximately to scale with the line or lines as surveyed plainly marked. All relocations or alternate lines shall be indicated by a system of lettering. If the chief party so desires, he may use a print of any suitable map instead of drawing a sketch map, and if this is done the print is to be pasted in the first alignment book.

The note books shall be numbered. They shall bear a serial number and also show the total number of books in the set. For example, 1 of 6, 2 of 6, 3 of 6, etc.

			<i>Deflec.</i>		
+23.5	<i>P.T.</i>	9° 10'			
137		8° 35'			
+50		7° 20'			
136		6° 05'		<i>P.I. Sta. 135+41.6</i>	
+50		4° 50'		$\Delta = 18^\circ 21'$	
135		3° 35'		$D = 5^\circ R$	
+50		2° 20'		$T = 185.1$	
134		1° 05'		$L = 367.0'$	
+56.5	<i>P.C.</i>	0° 0'		$E = 14.85'$	
133					
+61			<i>Sec. Line</i>		
132					
131					
130					
+51.7			<i>N. End br.</i>		
129					
+91.4			<i>S. End br.</i>		
128					
127					
+51			<i>⊥ Cross Road</i>		
126					

PLATE A.

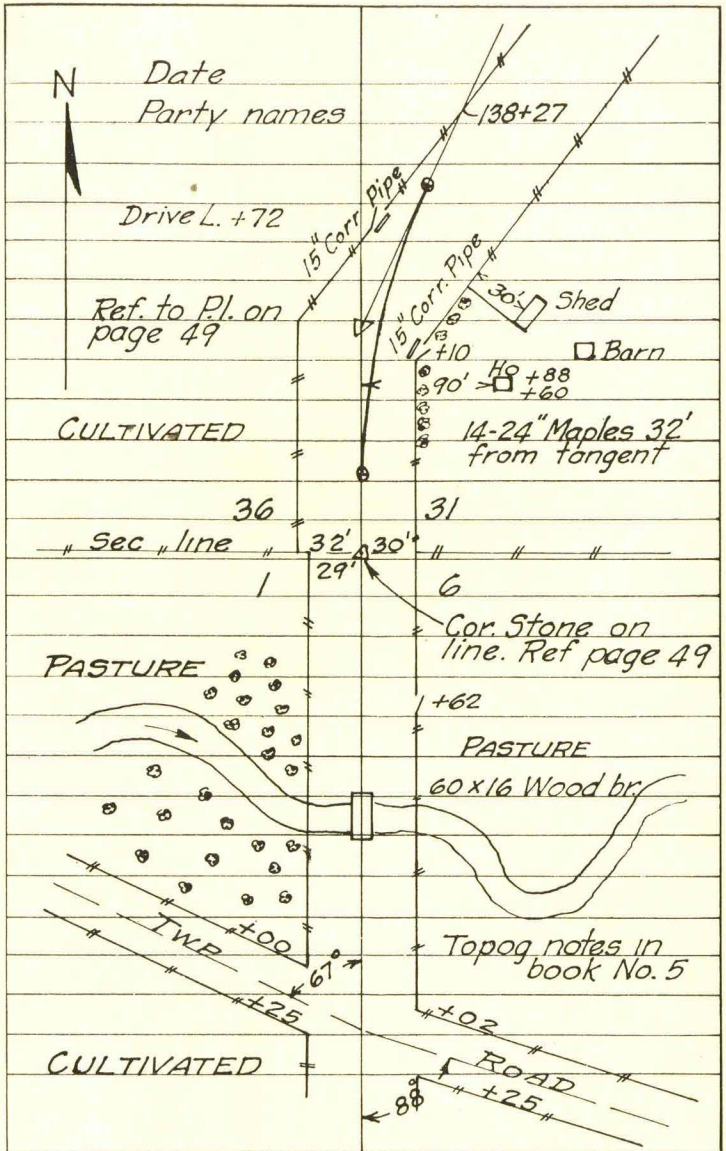


PLATE B.

In keeping the notes of the transit survey the arrangement shown on Plates A and B shall be followed. Here the sketch appears on the right-hand page plotted up from the bottom. The station numbers with additional notes appear on the left-hand page. It is not necessary that any fixed length of road be covered on a double page; sufficient space should be allowed that the notes will not be crowded.

The form for keeping the level notes is shown on Plate C. These are carried up from the bottom of the page, which leaves no doubt as to which side of the road the notes refer. Always leave a line between the stations so that when the notes are reduced there will be ample room to write in the elevations.

The names of the party, dates, weather conditions, etc., should appear at intervals thru the notes, so that the work of the different men and the conditions under which the work was done can later be identified.

#### **Staking the Line:**

The following method should be followed in staking the line:

- I. Set all hubs on the center line in their true positions.
- II. Set adjacent hubs at such stations that each can readily be seen from the other. This will usually be on the tops of hills or ridges.
- III. In no case should hubs be more than one-half mile apart even though it may be possible to see further than that distance.
- IV. For all hubs use 2"x2"x18" hard wood stakes.
  - V. Drive all hubs down until the tops are three inches below the ground surface.
- VI. All hubs shall be referenced to four points so located that a line drawn between the diagonally opposite reference points will intersect at the hub. Give the distance from each reference point to the hub. (Plate A.) Note: If the chief of party so desires he may set aside several pages of the notebook on which detailed reference data for all hubs is recorded.
- VII. The reference points shall in all cases be located far enough away from the center line to be well outside of the limits of the cuts or fills. If possible, at least two of the reference points shall be located on trees, buildings, or other permanent objects. The other two reference points should be located so that an instrument can be set up over them.
- VIII. Where no other suitable reference points are available stakes should be used. These stakes shall be of the same size and quality as the hubs. All reference stakes shall be driven flush with the ground surface,

Sta.	B.S.	H.I.	F.S.	Elev.	Date	Party names
133					4.2 5.3f 5.8 8.4 6.9 33 29f 22 78 72 65	6.7 8.7 6.0 6.1f 6.0 77 77 77 77 33
132					10.1 10.4f 11.8 10.1 8.2 34 29f 20 73 70 84	8.5 10.6 10.8 11.0f 11.0 76 74 70 30f 32
131					11.6 12.0f 13.2 12.6 9.0 34 29f 21 76 70 92	9.2 12.0 12.2 12.7f 12.0 75 75 70 30f 32
130					10.9 12.7f 12.7 8.7 33 29f 76 70 83	8.8 12.5 12.7 12.6f 12.1 78 76 72 30f 32
+62	Ends of wings				Str. Bd. 176 12.6 12.2 11.8 7.8 700 29f 20 75 9 70	7.5 12.1 12.7 12.7f 11.6 8 76 72 30f 33
T.P.	8.34	97.40	2.21	89.06	BM#8 E1.8904	
+51.7	End of br.				10.4 8.9f 8.9 8.6 0.2 35 29f 75 9 8 02	0.2 8.9 9.2 10.4f 11.5 8 78 72 30f 37
+25	Str. bed				11.5 30	11.6 11.9 30
129	Str. bed				11.3 30	11.9 30
+91.4	End of br.				8.1 9.9 9.4 8.9 0.1 35 29f 26 97 8 01	0.1 8.6 9.9 10.2f 10.7 8 7 23 30f 37
+80	Ends of wings				8.4 8.3f 8.6 0.6 33 29f 23 70 03	0.2 9.0 9.0 9.6 7 22 30 32
128					9.1 7.9 6.7 6.1 3.0 35 29f 77 75 70 29	3.3 6.3 6.8 8.2f 8.0 9 72 22 30f 33
127					7.2 7.9 7.1 3.8 34 29f 71 9 35	4.0 6.7 7.0 7.9f 7.0 8 72 21 30f 33
126		91.27			6.6 7.2 5.8 4.5 3.8 33 29f 70 72 7 38	4.2 6.1 6.8 7.4f 6.7 7 71 20 30f 33

PLATE C.

and the location shall be indicated by suitable guard stakes.

- IX. On tangents or on curves set a centerline stake on each side of each watercourse where a bridge or culvert is required. These stakes should be back thirty or forty feet from the stream bank so as to not be disturbed by the excavation. Such line stakes shall be driven until their tops are three inches below the ground surface, and shall be referenced to convenient points, such as corners of old bridges, trees, telephone poles, etc. If no such convenient reference points exist, then stakes shall be used for reference points. On curves these centerline stakes can be located at convenient stations which will be located in the ordinary process of running out the curve. It is not necessary to set special points on the curve for these stakes.

Note: In setting line stakes at bridges or culverts, use small stakes, that is stakes about 1½"x¾"x12" to 15". Do not use the 2"x2"x18" hub stakes as the small stakes will serve the purpose and are less expensive.

- X. The ordinary station points between hubs need not be staked in a permanent way. Where the line is in



the traveled portion of the road, it will often be found convenient to use spikes with a small piece of cloth attached for marking stations. In such cases small stakes bearing the station number should be set at the side of the road opposite the station point. On relocations and on portions of the road where the center line is off the traveled way, the stations may be marked by small stakes at the station points.

### Alignment and Right of Way

#### Location of Center Line:

One of the most difficult features of the field survey is the determination of right of way limits and the proper location of the center line. In flat or gently rolling country where the roads follow land lines and where re-locations are not necessary, the problem is very much simplified. In hilly country and on angling roads, the most mature judgment on the part of the chief of party is required. In many such cases the location of the road as shown by the records does not in any way conform to the road as now traveled. The following general instructions should be followed as closely as possible, but many cases not covered by these instructions will be encountered:

- a. Get copies of all records in the courthouse relative to the location, establishment, and right of way of the road included in the project.
- b. Run center line before running bench levels.
- c. If the established location follows the present road, and the location and alignment are desirable, follow the established location.
- d. If the established location does not follow the present road, the choice as to which to follow will depend on a comparison of the two lines as to:
  1. Topography
  2. Alignment
  3. Improvements on or along the present road.

Unless there is a decided advantage in favor of the established location, the survey should in general follow the present road. It should be noted that whichever alignment it is determined that the survey should in general follow, relocations may be made to take advantage of the topographical features, to better the alignment or to make the line conform to existing permanent improvement on or along the road.

- e. In cases where the alignment follows land lines, or where a land monument is located on or near the alignment chosen, a diligent effort should be made to find the monuments, and the line should be tied to all such monuments that can be found. If a monument cannot

be found, no elaborate land surveys should be made to locate it.

- f. Many existing bridges and culverts will not conform to the center line of the road on which they are located. In the case of important permanent structures the line may be varied so as to conform, but this is not always advisable. The chief of party must use his judgment in this matter, taking into consideration the amount of variation of line necessary, the size and importance of the structure, and all other facts in the case. In many instances it would be poor practice to make such variation in the alignment.
- g. Where the records show the right of way lines, the notes shall show the position of these right of way lines with reference to the center line.

#### Relocations:

Before making relocation surveys the district engineer or chief of party shall always look up the land owner or tenant and acquaint him with the intentions of the party. A little consideration thus shown, previous to the survey, may do much to avoid friction with owners of private property.

Relocations may be divided into five classes, namely, relocations to improve:

- a. Grades,
- b. Alignment,
- c. Railway crossings,
- d. Stream crossings,
- e. Location.

No fixed rule can be set forth under which the selection or rejection of a relocation can be definitely determined upon. The solution of such problems must be left to individual judgment. The location of a highway is its most lasting feature and it is, therefore, imperative that all alignment or location problems receive very careful attention from the most experienced men available.

It will often be found that a relocation will fall in more than one of the above classes, and it also often happens that a relocation which would improve the road in one respect may prove to be detrimental in other respects; i. e., a relocation to avoid steep grades may require the use of alignment not as good as the original. In such cases recommendations should be made by the district engineer only after careful consideration has been given to the need for the relocation and the advantages and disadvantages of all alternate routes. In making such a study it will often be found that a much better idea of the layout as a whole can be obtained by plotting on the same sheet and in their true relation to each other, the alignment sketches and profiles of the various routes in question. Several sketches of this kind have been prepared in the central office and sample prints will be sent to the district engineers on request.

In the past, much trouble and delay have resulted from unsatisfactory alignment. In many cases it has been necessary to send the party back for additional relocation surveys before the project plans could be completed. It is seldom that such extra work should be necessary and it is believed that strict observance of the following rules will result in its elimination:

- A. Send in alignment sketches of all projects showing all proposed relocations.
  - a. In considering the necessity for relocation surveys the district engineers must take into consideration their past experiences with the general office as well as their own personal judgment. It is well to remember that we are now making relocations which probably would not have been made a year or two ago.
  - b. Sketches should be approximately to scale so that a good idea of the layout can be had.
  - c. Sketches should reach the central office some time before the party completes the survey so that if it is felt that additional surveys should be made it will not be necessary to bring the party back from some other job.
- B. In case of doubt as to the feasibility of any relocation a survey should always be made.
- C. In general where relocations are surveyed a survey shall also be made over the old road. The necessity for this will depend upon local conditions. If it is at all likely that a relocation would meet with local opposition a complete survey must be made over the old road. If, however, all parties concerned agree on a relocation a survey over the old road would not be necessary. The district engineers must consider each case separately and decide accordingly.

In all cases where relocations sever the connections between secondary roads and the primary road complete surveys must be made for connections which will properly serve tributary traffic.

In all cases where relocations do not leave the old road over, say 800 feet, and where a complete survey is not made, the notes shall show the alignment of the old road either by offset ties from the survey center line or by a separate traverse.
- D. In running relocation surveys the chief of party shall set substantial stakes at all points where the center line crosses fences. The center line shall also be tied in to nearby objects, such as prominent trees, buildings, field gates, fence corners, etc. Such stakes and ties are of much value when tracing the course of a line on field examination.
- E. In locating a line near a stream or watercourse great

care must be exercised lest the earthwork on the proposed line encroach on the adjacent stream in such a manner that the latter cannot be properly handled. Unless it is plainly evident that no trouble would occur the chief of party should never pass over such places without first plotting the cross sections at the critical points and also plotting on the template lines to an assumed grade line, in order to assure himself that the proposed line is feasible. In many cases it will be necessary to locate the course of a stream or ditch for some distance outside the right of way lines, for example, when it appears desirable to make a channel change in connection with bridge work or to prevent a stream from encroaching on the road. The district engineer should become sufficiently familiar with the topography and needs of the road that he can outline such special surveys to the field party early in the survey so that the chief of party may plan his work to better advantage.

- F. It is often found desirable for various reasons to shift the center line a few feet after the plans have been prepared. This applies to existing roads as well as relocations. District engineers should keep this in mind while going over a project with a party chief and should instruct him to extend the cross sections beyond the usual limits wherever it appears that such information might be useful.

#### **Intersection Angles:**

Intersection angles, however small, shall be measured and recorded. All intersection angles shall be measured by the repetition method.

#### **Horizontal Curves:**

At all points of intersection where the intersection angle is greater than 2 degrees, horizontal curves shall be run in, and the stationing shall be carried continuously around such curves. In running in curves the data given in the HARGER & BONNEY HIGHWAY ENGINEER'S HANDBOOK shall be followed.

Curves sharper than a 6-degree curve shall not be used except at right-angled turns and in other special cases where sharper curves must be used.

A 6-degree curve is not to be considered as standard for all curves except at right-angled turns. On relocations the degree of curve used may occasionally depend upon the central angle, but in general it is desired to hold to a 4 or 5-degree curve as the maximum where conditions will permit. Under some conditions it might be advisable to use even a flatter curve than 4 or 5 degrees. For example, when following an existing road laid out with curves flatter than those mentioned above, when running a relocation parallel to a rail-

road track, or when the profile or general location at the curve might be improved by throwing the center line a greater distance in from the P. I.

When conditions will allow it a 10-degree curve shall in general be used at right-angled turns. In many cases buildings, orchards, cemeteries, etc., will necessitate the use of curves sharper than 10 degrees. In such cases the flattest curve possible should be run in.

## Drainage

### Bridges and Culverts:

The chief of party is required to secure and record the following data for each existing bridge and culvert or site where a drainage structure is required:

(a) Size. Determine length of each span and width of roadway. Clear roadway is the distance measured at right angles to the center line of the highway between hand rails or parapet wall on culverts, or between inside of hub guards or curbs on bridges. Where no hub guard or curb exists, record the distance between hand rails or truss members.

The span or opening of culverts should be the clear opening measured at right angles to the center line of the barrel. On trusses, I-beams, etc., give the c. to c. of bearings. For arches the distance between spring lines measured at right angles to the barrel, should be given.

(b) Type and Condition. Indicate type of structure with probable date of erection or construction if known; also the condition or state of repair of existing structure.

(c) Number of Spans. For multiple span culverts or bridges show the arrangement of spans and approaches.

(d) Drainage area. The party chief is required to walk or drive around all drainage areas of approximately 1300 acres or less and to plat the location of the divide and stream location on Form I-C (Pink Sheet). He shall indicate on this sketch the section, quarter section, and quarter-quarter section lines.

(e) Elevation of Highwater. In giving the elevation of highwater, the Chief of Party shall indicate the source of his information, date of occurrence, and whether the elevation shown is considered by local residents as being ordinary or maximum highwater. On the larger structures great care should be exercised to determine this information accurately, and the notes should preferably show highwater elevations at several points in the vicinity of the bridge. The low water elevation at the bridge site at the time of the survey should be recorded.

(f) Elevation of present grade over culverts.

(g) Elevation of present grade at each end of bridge.

(h) Elevation of inlet and outlet ends of culverts.

(i) Elevation of stream bed at bridge site. The elevation of stream bed at the bridge site as recorded should be

the normal elevation of the stream bed in the immediate vicinity of the bridge. Readings should be taken, however, in holes or depressions adjacent to the bridge to indicate probable depth of scour.

- (j) Stream Characteristics. The Party Chief should record all available information on the nature and amount of drift and ice carried by the stream at high-water as well as data indicating whether the stream is cutting or filling.
- (k) Profile elevations of stream bed each way from bridge or culvert. A profile is required to be furnished by the Chief of Party showing the stream bed elevations for 100 feet each way from each culvert, and for a distance of at least 500 feet each way from each bridge.

In taking notes to show the slope of the stream bed each way from the bridges and culverts, three cases will be encountered:

- \* a. Where the general direction of the stream is at right angles to the road.
- b. Where the general direction of the stream is not at right angles to the road.
- c. Where there is a combination of "a" and "b."

In the first case, a cross section taken at the center line of the stream and extending out the necessary distance each way will give the desired data. The notes should show that this cross section is taken to show stream bed elevation and is not to be used for computing quantities.

In the second case, the cross sections on either side of the bridge or culvert should be extended far enough to show an elevation on the stream bed the necessary distance both above and below the road. These cross sections will be taken at right angles to the road in all cases. The elevations on the stream bank and stream bed should be indicated in the notes by suitable letters. It should be noted here that on a skew culvert the elevation of headwall and flow line at both ends cannot be shown on the same cross section. Two cross sections will be required.

In the third case the elevations on stream bed will be secured by a combination of the methods used in the other two cases. It should always be remembered that elevations on stream bed should always be taken the same way as any cross section; i. e., in a practically straight line and at right angles to the road.

When a stream or ditch is not at right angles to the road, the cross section notes shall show accurately the location of such stream so long as it remains within 200 feet of the center line of the road.

- (l) Elevation and location of existing headwalls on culverts.
- (m) Soundings. Where data is obtained of value in indicating the existence of rock ledges or the condi-

tion of foundation material, give the source of information and the exact elevations at which these foundation materials will be found.

- (n) Topographic Surveys. Detailed instructions will be found elsewhere in this manual covering topographic surveys.

The district engineer, county engineer, and the chief of party will complete the bridge and culvert survey, and make definite recommendations as to size, type and elevation of grade for each structure.

For structures to be remodeled, the district engineer shall indicate to the party chief the additional field data required in the preparation of the design by the bridge department.

A field manual of instructions for making bridge and culvert surveys has been issued by the Commission. Copies of this manual will be supplied the chief of party from the district office.

Don't forget that the suitability of the design which is prepared will depend largely upon the completeness and correctness of the notes which you supply. The designer will not have seen the site and he must depend wholly upon the record of field conditions furnished by the chief of party.

#### **Tiling:**

The notes should show the size and location of all tile and intakes which have been laid on or across the road. This data can best be obtained from the county engineer or local drainage engineer. Where local drainage districts have been constructed the party chief should, if possible, secure blue prints of the plans used in constructing the district. These are particularly useful in determining outlets for additional tile to be placed along the road. If such blue prints cannot be secured as much of the data as is necessary should be copied in the notes.

#### **Drainage of Intersecting Roads and Driveways.**

The direction of flow of surface drainage at intersecting roads shall be indicated in the notes by arrows. The drainage area, size, type and condition of all cross road and driveway culverts is also to be shown.

#### **Miscellaneous Data**

##### **Pluses:**

As the transit party proceeds they should take plus measurements to the following:

- a. Corner stones.
- b. Section and quarter section lines.
- c. Division fences.
- d. Side roads. Angle between side roads and center line of survey shall be shown.
- e. Buildings, giving exact distance from center line if within or immediately adjacent to the right of way lines.

- f. Rows of trees—kind, usefulness, size, and distance from center line.
- g. Existing tile lines, size and outlet.
- h. Field and yard driveways.
- i. Sidewalks.
- j. All culverts and bridges. Pluses to center line of culverts is sufficient, but for bridges give plus to both ends.
- k. Telephone and transmission lines, distance from center line.
- l. Guard rails and retaining walls, showing length.
- m. Gravel pits.

#### **Property Owners:**

A separate sketch or skeleton map to a small scale should be prepared, showing the names of the various land owners along the road. This information may be secured from residents, but perhaps may be obtained easier and quicker by referring to the county auditor's records.

#### **Unusual Soil Conditions:**

The occurrence and extent of sand pockets, gravel knobs, solid or loose rock, springs, swampy places, or any other unusual soil conditions should always be noted.

#### **Railroad Crossings:**

On federal and state aid projects all railroad grade crossings will be eliminated if possible. If it is not possible to eliminate a grade crossing, such crossing will be improved in the best manner possible. The district engineer will outline to the chief of party the surveys that shall be made at each crossing.

In many cases it will be found that the railway and highway grades have already been separated. In cases where the highway passes under the railroad the crossing is known as an undergrade crossing and where the highway passes over the railroad the crossing is known as an overhead crossing. For undergrade crossings the notes shall always show the following information:

- a. Type of structure.
- b. Horizontal clearance at right angles to center line.
- c. Vertical clearance.
- d. Elevation of top and base of rail.
- e. Number and location of pile bents, if any.
- f. Number of tracks.
- g. Length and position of wing walls, if any.
- h. Drainage.
- i. Angle between center line of railroad and center line of highway.
- j. Sketches, both in plan and elevation.

For overhead crossings the notes shall always show the following information:



- a. Type of structure.
- b. Width of roadway.
- c. Vertical clearance over track.
- d. Ground profile across track.
- e. Road profile elevation at the end of the structure and at each bent.
- f. Angle between center line of railroad and center line of highway.
- g. Sketches as noted above.

The district engineer will outline any additional notes that are necessary.

#### **Railroad Bridges and Culverts, and Location.**

When a railroad comes within 500 feet of the highway the following data on such railroad shall be secured:

- a. Location of center line of railroad with respect to the center line of the highway.
- b. Elevation of base of rail at intervals not exceeding 500 feet.
- c. Location, size and type of all bridges and culverts on the railroad, the waterway, and the elevation of flow lines of waterway structures.

#### **Bench Marks**

##### **Selection of Datum:**

Sea level datum is to be used wherever the same can be obtained. If this is not available, the county datum should be used. If no county datum has been adopted, it will be necessary to assume an arbitrary datum, but care should be taken to assume the elevation of the original bench mark at such height that all elevations will be plus.

##### **Establishing Bench Marks:**

Bench marks should be established at least every 1500 feet and at closer intervals in rough country, particularly at high and low points. Bench marks should be established at each bridge and culvert that will probably be rebuilt. They should not be established on objects which are likely to be disturbed previous to or during construction, but rather on such points as bridge seats, wingwalls, headwalls of culverts, stone or concrete steps, etc. If such points are not available, use pieces of gas pipe or bar iron about four feet in length, driven nearly flush. Such bench marks should be so placed as to be visible in both directions along the road. In all cases they should be carefully and accurately described so that they may be readily found for future use.

All bench marks shall be numbered consecutively beginning at one.

##### **Running and Checking Bench Mark Levels:**

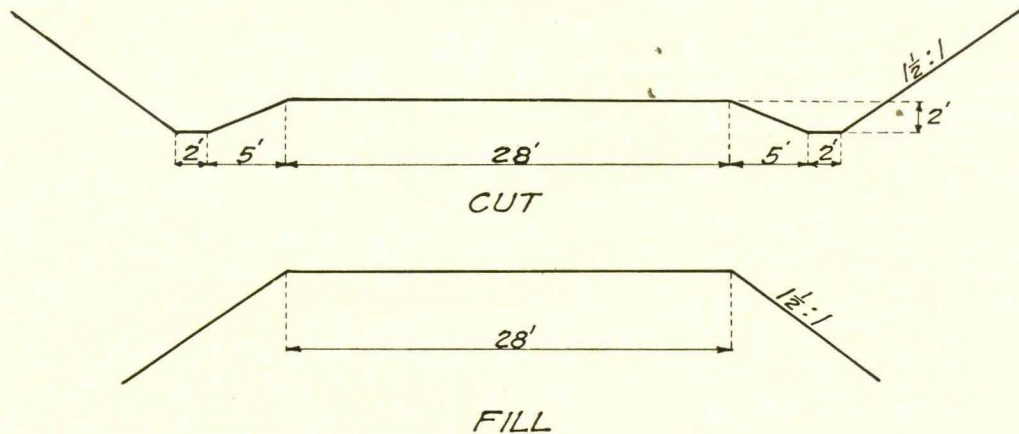
Bench levels on any portion of the road shall be checked prior to running the cross section levels on that portion. In

B.M. No.	Sta.	Descrip- tion in	Original B.M. Elev. and Diff.	1 <sup>st</sup> Check Elev. and Diff.	2 <sup>d</sup> Check Elev. and Diff.	3 <sup>d</sup> Check	4 <sup>th</sup> Check	5 <sup>th</sup> Check	6 <sup>th</sup> Check	Adjusted		
										Diff.	in Elev.	Corrected Elev.
1	0+38	2-4	841.25	841.25							841.25	
			+18.90	+18.88						+18.89	860.14	
2	28+15	2-14	860.15	860.13						+12.08	872.22	
			+12.04	+12.02							872.17	
3	51+99	2-22	872.19	872.15	872.15					-1.16	871.01	
			-1.98	-1.14	-1.17						871.01	
4	80+00	2-28	870.21	871.01	870.98					+13.15	884.16	
			+13.14	+13.17							884.16	
5	105+89	2-34	883.35	884.18						+8.05	892.23	
			+8.05	+8.04							892.21	
6	131+74	2-38	891.40	892.22						-10.96	891.25	
			-10.98	-10.95							891.25	
7	158+62	2-46	880.42	881.27						-7.85	873.40	
			-7.83	-7.86							873.40	
8	185+00	2-50	872.59	873.41	873.41					-10.77	862.63	
			-10.79	-10.68	-10.76						862.63	
9	209+34	2-56	861.80	862.73	862.65					+6.19	868.82	
			+6.21	+6.18							868.82	
10	234+91	* 2-60	868.01	868.91							868.82	
											868.82	
										Total Plus	+58.31	check
										Minus	-30.24	
										Net Diff.	+27.57	
										841.25 + 27.57 =	868.82	

PLATE D.

running check levels each bench mark must be taken as a turning point in order to get a true check. The maximum allowable variation in the difference of elevation between any two bench marks is  $0.05 \sqrt{\text{distance in miles}}$ .

Should the variation in the difference of elevation between two adjacent benches exceed this amount, the check levels shall be re-run between these benches until two differences of elevation between these benches check within the above limits. The chief of party shall then make up a bench mark adjustment sheet (see Plate D) on which the benches are listed. In the first column show the bench mark numbers. In the second column show the station of the bench mark. In the third column show the book and page numbers where description of the bench will be found. In the fourth column show the elevation of each bench and the difference in elevation between each two adjacent benches as obtained by the first bench levels. In the succeeding columns show the corresponding elevations and differences of elevations as obtained by succeeding check levels. In the column next to the last show the adjusted difference in elevation between each two benches, and in the last column show the corrected or adjusted elevation for each bench. This corrected elevation shall be used in running cross section levels.



STANDARD CROSS SECTIONS FOR EARTH ROADS

## Cross Sections

### Cross Sections on the Main Road:

Cross sections are to be taken at every 100-foot station, and at plus stations where breaks occur in the center line profile. Sections are also to be taken at points where the cross section breaks, even though the center line profile may continue on a uniform grade. This refers particularly to existing 0.0 points where changing from cut to fill. Sections are always to be extended at least 33 feet on each side of the center line, and in rough country where there is any reason to suppose that the proposed improvement will extend beyond the right of way limits, the sections must be extended accordingly. In the case of level cross sections a 66-foot right of way will permit a center cut of 6 feet and a center fill of 12 feet, using the standard primary road cross section with  $1\frac{1}{2}:1$  side slopes. (See Plate E.)

Knowing this and taking into consideration the existing grades on the road, the field chief can roughly determine if it will be necessary to extend the cross sections beyond the 33-ft. limit. Additional sections should always be taken at both ends of bridges and at the ends of the wingwalls. Center line elevations should be taken at the end and at all intermediate supports. Similar sections should be taken at culverts. In the case of permanent culverts the distance back to back and elevations of headwalls must always be taken. Without this information it is impossible to determine the height of grade that the culvert will carry. Each cross section shall show the distance to the fence line on each side of the road.

Any abbreviations appearing in the cross section notes shall be explained by suitable notations or a key on the page where such abbreviations first occur. This key will be construed to apply to any further use of the same abbreviations on that project survey.

### Levels on Branch Roads:

The center line profile of branch roads should always be taken and continued a sufficient distance to enable the designers to establish the grade lines to fit both roads. In level or gently rolling country, the profiles for branch roads shall be continued a minimum distance of 300 feet from the intersection point. Where there is a hill on the side road near the main road, the profile of the side road shall be continued far enough to enable the designer to establish a grade on the side road to fit the grade on the main road, and to balance the cut and fill on said side road.

Whenever it seems possible that the proposed improvement will necessitate the grading of branch roads for a short distance in order to make proper connections with the main roads, the branch roads must be cross sectioned far enough to permit the computation of the necessary earthwork.

Date	Party names
Elev.	Description
1280.83 B.M.#6	
Hl.Rod=5.13	Hl.Elev=1285.96
Contour Shot (C.S.)	
C.S.	
"	
"	
⊕ Ravine from S.	
C.S.	
"	
"	
"	
"	
"	
"	
"	
"	
"	
"	
⊕ Ravine from E	
C.S.	
"	
⊕ Ravine from S.	
C.S.	
"	
"	

Sta.	Azim.	Hor.	Dist.	Vert L	Diff
Inst. Obs		Obs.	Corr.	or Rod	in El.
C					
B	0° 00'	5.30 5.13 4.97			
1	193° 12'	5.97 5.13 4.30			-8° 43'
2	286° 02'	5.30 5.13 4.97			+1° 22'
3	225° 08'	9.75 9.13 8.51		on 9.13	-13° 07'
4	269° 57'	5.97 5.13 4.30			-5° 15'
5	223° 41'	6.09 5.13 4.18			-13° 05'
6	252° 53'	5.92 5.13 4.34			-8° 01'
7	226° 20'	6.29 5.13 3.97			-9° 18'
8	244° 36'	6.10 5.13 —			-7° 40'
9	276° 45'	6.47 5.13 3.79			-8° 20'
10	250° 04'	6.84 5.13 3.42			-3° 31'
11	238° 10'	6.60 5.13 3.67			-6° 26'
12	258° 52'	6.87 5.13 3.39			-1° 48'
13	238° 11'	— 5.13 3.23			-6° 40'
14	267° 34'	6.96 5.13 3.31			+1° 33'
15	257° 51'	7.24 5.13 3.02			-1° 28'
16	248° 01'	12.59 10.13 —		on 10.13	-4° 52'
17	253° 13'	10.35 8.13 3.91		on 8.13	-2° 51'
18	248° 03'	9.44 7.13 4.82		on 7.13	-2° 35'
19	254° 53'	15.47 13.13 —		on 13.13	-2° 38'
20	256° 37'	7.74 5.13 2.52			-1° 16'
21	251° 04'	7.75 5.13 2.50			-3° 25'
22	261° 32'	7.76 5.13 2.50			+0° 20'

### Levels on Driveways:

When passing farm or field entrances, side shots are to be taken out in the driveway about 100 feet from the center line, or at such other distance as will show how the existing grade of the driveway will be affected by the proposed improvement.

### Working Profile:

As the work of taking cross sections progresses, the chief of party shall plot up a center line profile of the road cross sectioned. This profile will be plotted on a roll of cross section paper eleven inches wide, using the scale of 1" = 100 feet horizontally, and 1" = 10 feet vertically. Supplies of this cross section paper will be secured from the district engineer, or main office.

The working profile shall be available for the use of the district engineer or engineers from the main office who may have occasion to visit the party. On completion of the survey it shall be sent to the main office with the remainder of the notes.

## TOPOGRAPHIC SURVEYS

It will often be necessary, particularly at stream and railroad crossings, to amplify the usual notes by topographic surveys. Plates F and G show the form to be followed in keeping such notes. If the traverse is not closed the angles should be checked by the repetition method. If the traverse is closed the party chief should plot the notes and make certain that the traverse will close when placed on paper. Plot to a scale of 100 feet equals 1 inch. This is the scale used on road plans, and any tracings made later on of the topographic map will fit in with the road plans.

The traverse will always start from the center line of the road survey. The azimuth of all contour or stadia shots is to be measured clockwise from the last course, and with each new setup the azimuth of the last course, or back tangent, is to be considered as  $0^{\circ} 0''$ . (See Plate G.) The first column indicates that the instrument occupies point C. Point B is first observed with the plates reading  $0^{\circ} 0''$ . With the lower motion clamped and the upper motion free the successive shots are taken, the azimuth being measured clockwise from B.

It will be noticed that two HI's are carried; one, the HI Elev., is the height of instrument with respect to the level datum, and the other, HI Rod, is the height of the telescope above the ground. When the side shots can be taken with the telescope level the reading of the middle wire subtracted from the HI Elev., gives the elevation of the point in question, as in ordinary level work. When it is necessary to use the vertical circle, as will usually be the case, the middle wire is set to read the HI Rod. In either case the readings of all

three wires are placed in the third column. The fourth column is filled out later to show correct horizontal distances. The fifth column shows vertical angles or rod readings. Note that in some cases the middle wire because of obstructions cannot be set on the HI Rod. It should then be set on some reading an even number of feet more or less than the HI Rod. When this is done it should be noted in column five as shown on Plate G. The difference between the reading recorded and the HI Rod is taken into account in computing elevations.

Field men are expected to follow the form of notes for topographic surveys as shown by Plates F and G. Other methods may be just as good, but for the sake of uniformity and ease of handling in the drafting room where the men are familiar with the form as shown, it is highly desirable that the method outlined above be followed on all work of this character.

## **MATERIALS AND CONSTRUCTION**

### **ORGANIZATION**

#### **General Plan**

The construction work on each project will be under the direct charge of a resident engineer. The resident engineer will be under the supervision of and shall report to the district engineer in whose district the project is located. The district engineer is under the supervision of and shall report to the Construction Engineer, and Engineer of Materials and Tests, whose headquarters are at Ames.

The Construction Engineer and Engineer of Materials and Tests are assisted by general inspectors who will inspect all construction work at frequent intervals. These men represent the General Office and have full authority to act for their respective departments.

In some cases the resident engineer will be a man assigned to the project by the Commission. In other cases the county engineer may act as a resident engineer. This point will be determined for each individual project. Where the county engineer is designated as resident engineer, he will be under the supervision of the district engineer as fully as though he were employed by the Commission. This is the only basis on which the Commission will approve of the county engineer's acting as resident engineer.

The Construction Engineer will have full supervisory charge of federal aid and state road and bridge work. District engineers will report to him, and will take up with him all construction questions concerning which the district engineer may be in doubt.



The Engineer of Materials and Tests will have full supervisory charge of the quality of the materials used upon all primary road and bridge work, and of the proportioning of concrete materials therefor. He will exercise such supervision over the measuring devices as is necessary to insure accurate proportioning of concrete materials.

#### **Duties of Resident Engineers:**

The resident engineer is responsible for carrying on the work in strict accordance with the plans, specifications, and the instructions of the district engineer. He shall,

1. Properly mark detours and maintain detour markings in good condition.
2. Make sure that the work is staked out at the proper time and in a proper manner, and right of way provided.
3. See that the specifications and plans are fully complied with.
4. Recommend to the district engineer any change in plans or deviation from the specifications that may seem necessary.
5. Inspect all materials and work, or make sure that that such materials and work are being properly inspected.
6. Report fully and promptly to the district engineer any faulty work or any failure of contractor to comply with any plans, specifications, or instructions.
7. Make such progress reports and other reports as are hereinafter required.
8. Make up the estimates of work performed.
9. Have full supervision of all inspectors, instrumentmen, or assistants placed on the work.
10. Make no acceptance of work.

The resident engineer will have no authority to change, alter, or modify the plans or specifications except where it appears that such plans or specifications are obviously in error, and where such changes and corrections must be made at once, in which event he will immediately notify the district engineer regarding such changes or corrections.

Where changes, alterations or modifications might be made for the benefit of the work, the resident engineer will call this to the attention of the district engineer, who will instruct the resident engineer regarding such changes.

All instructions will be given to the contractor by or through the resident engineer.

The Federal Aid Law places all federal aid road and bridge work under the direct supervision of the Commission. The resident engineer must at all times be courteous toward county road officials, but he is under no obligation to obey orders of county officials. County officials have no authority to make any change in the plans or specifications, or to give any instructions to the contractor. If the county officials

should request a change in the plans or specifications, such request should be referred to the district engineer.

The resident engineer must always remember that he is the man on the job and that he is primarily responsible for the proper execution of the work. He must be the eyes and ears of the Commission and its various employees. He must make friends with the local officials and local people with whom he comes in contact. His value to the Commission depends on his ability to get good work and make friends.

#### **Duties of District Engineers:**

The district engineer will have full supervision over the resident engineer. He shall,

1. Choose detours and make arrangements for their proper maintenance.
2. Give the resident engineer such instructions as are necessary to secure the completion of the work in accordance with the plans and specifications.
3. Inspect the work at frequent intervals and make sure that the work is being done in accordance with plans, specifications and instructions.
4. Confer with and adjust matters with the board of supervisors relative to the progress and method of prosecution of the work.
5. Approve or disapprove minor changes of the plans promptly, where such changes require prompt action, and report such approval immediately to the road construction engineer.
6. Refer important changes of plans or specifications to the construction engineer.
7. Check and approve estimates.
8. Make such reports as are hereinafter required.
9. Comply with all instructions of the construction engineer and engineer of materials and tests.

#### **Duties of General Inspectors:**

1. To inspect all construction work at frequent intervals, and if accompanied by the district engineer, to give instructions to him only. If alone, written instructions will be given to the resident engineer, a copy of such instructions to be mailed to the district engineer.
2. Keep the main office advised as to the progress being made on all construction work.
3. See that reports are filed at proper intervals.

#### **Duties of the Construction Engineer:**

The Construction Engineer shall,

1. Have general supervision of all road and bridge construction work on federal aid and primary road and bridge projects.
2. Make decisions on construction questions submitted by the district engineer.

3. Inspect the work occasionally and instruct the district engineer as to any corrections or modifications which should be made in the methods, equipment, or manner of prosecuting the work.
4. Approve all major changes in the plans.

#### **Duties of Engineer of Materials and Tests:**

1. Have general supervision of the materials used upon all primary road and bridge work, and over the combining of materials for the various uses.
2. Make decisions on questions affecting materials, submitted by the district engineer.
3. Make occasional inspection of testing laboratories, sources of material supply and construction work.
4. Approve the source of supply for all materials used on primary road and bridge work.

The Assistant Engineer of Materials and Tests has full authority to act in the absence or at the direction of the Engineer of Materials and Tests.

### **INSTRUCTIONS TO RESIDENT ENGINEERS**

#### **GENERAL**

##### **Introduction:**

The intent of these instructions is to furnish the resident engineer on Federal Aid and Primary Road and Bridge projects with such information as has already been found valuable in handling construction work.

It is not proposed to burden any person with unnecessary detail, but the instructions contained herein are considered sufficiently important to warrant their study and use and it is earnestly urged that all engineers study them carefully and handle their work in accordance with them.

Many of our engineers are from outside the state and are frequently sent out to take charge of important work with no other instructions than can be given in perhaps a half hour's conversation with the district engineer or some engineer from the general office. It is hoped that these instructions will be sufficiently clear and complete to prevent any misunderstanding as to their requirements.

All instructions pertaining to the work will be given by the District Engineer.

##### **Notification of Address:**

Upon arriving on the residency the resident engineer will immediately notify the district engineer and the Highway Commission at Ames of his post office and telegraph address, also telephone number.

Suitable office room will be provided either with the county engineer or in another convenient location.

##### **Diary:**

The resident engineer shall keep or cause to be kept a

daily record of everything done on the project. This record to show weather conditions, work accomplished, delays, and cause of same, together with any other information pertaining to the work. An ordinary field book may be used for this record and should be turned in to the district office with the balance of the records when the work is completed.

#### **Cooperation with County Officials:**

No one will be considered eligible to the position of resident engineer who cannot work on a friendly footing with the county engineer and Board of Supervisors.

It is absolutely essential that friendliest relations with county officials be maintained at all times and that this relation should in no wise interfere with the integrity of the work.

### **DETOURS**

#### **Introductory:**

When a primary road or bridge construction project is started, it is absolutely necessary that adequate provision be made for the traffic desiring to use the highway. Either the construction work shall be carried on so that the traffic is not seriously inconvenienced or the road shall be closed and the traffic carefully detoured around the construction.

It shall be the duty of the resident engineer to see that proper detour signs and barricades are placed when roads are closed to traffic. It shall also be his duty in case the road is not closed, to see that the contractor carries on his work in such a way that the traffic is not endangered or seriously inconvenienced. He will consult with the district engineer and be advised by him as to which roads are to be closed and which are to be kept open for traffic. He will also be advised by the district engineer as to which roads to mark for a detour.

#### **Responsibility:**

When Primary road construction is started the district engineer becomes responsible for the detours due to such construction. The Commission will hold each district engineer accountable for four items in connection with this work, as follows:

First —He shall determine whether or not a detour is needed.

Second—He shall cooperate with the local officials in choosing the location of the detour.

Third —He shall provide for the proper marking of the detour, the maintenance of the signs, and for the removal of all detour signs when the construction is opened for traffic.

Fourth—He shall provide for the maintenance of the detour.

#### **Determination of Necessity:**

In deciding whether or not a detour is necessary, the dis-

district engineer should be guided by the fact that both the public and the contractor are greatly inconvenienced when an attempt is made to carry traffic over construction work. If a detour is at all available, it is nearly always desirable to direct the public away from the construction work, even though it might be possible to carry the traffic over the road. Where paving is being constructed, it is self-evident that the road must be closed and detours provided. People living along the highway which is closed must be allowed to get in and out along the road. This problem should be handled by the resident engineer. Rural mail carriers should temporarily change their routes rather than try to travel a closed road.

If the construction is to be kept open for travel sign No. 6 (see Plate I) must be erected at both ends of the work.

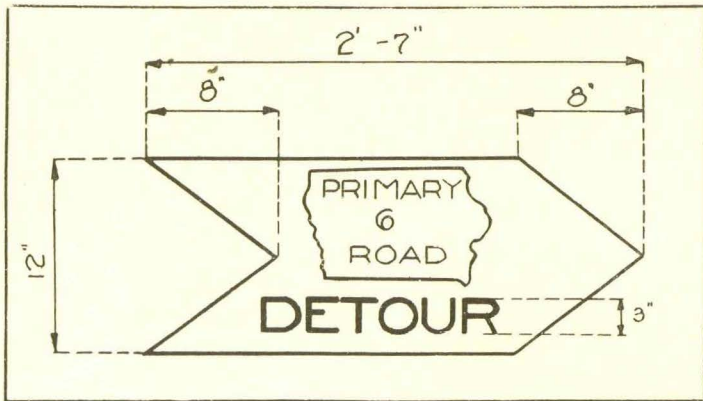


PLATE L.

#### Choice of Detours:

After it has been determined that a detour is to be used, the district engineer should confer with the board of supervisors and county engineer and choose a route which will best serve the traveling public. The district engineer should be mindful that the detour will be forced to carry a much heavier traffic than it has in the past. Care should be taken to select as good roads as possible for the detour. The public would rather detour two or three extra miles over a good road than save that mileage by traveling over a poor one. It is ordinarily better to detour over a county road than over a township road. In some cases in order to divide heavy traffic, it may be advisable to select two detours, one to carry the traffic in one direction and the other to carry it in the opposite direction.

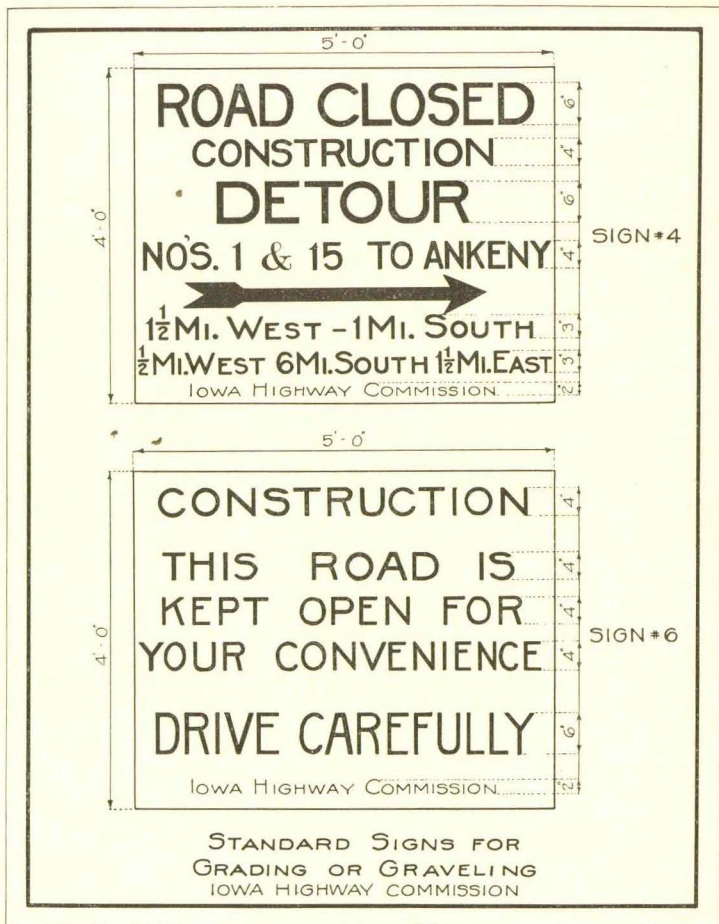
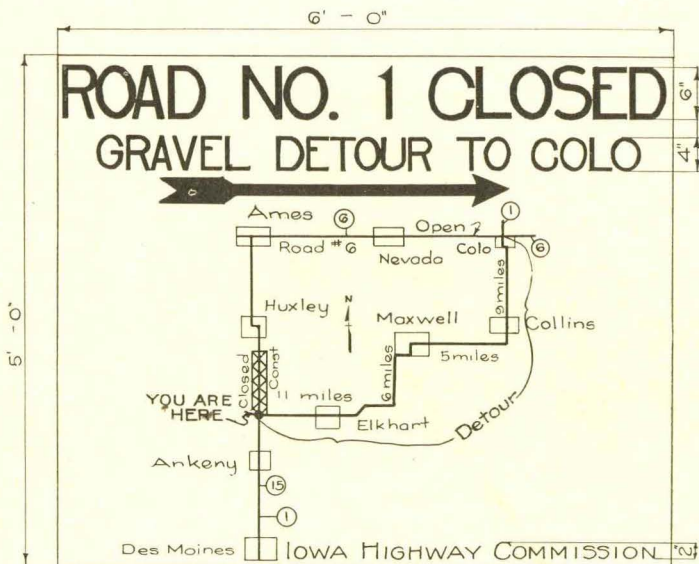


PLATE I.

**Closing Road and Marking Detour:**

In every case where a road is barricaded, a "Road Closed" sign shall be erected by the resident engineer. Plate "I," sign No. 4, is a typical road closed sign. This sign and also sign No. 6, Plate "I," should be substantially constructed of 1" clear lumber and should be given two coats of white paint, after which it should be lettered in black by a sign painter.

In case of complicated detours it is desirable to show a map



Sign #2.

PLATE J.

of the detour on the "Road Closed" signs. (See Plate J.) This sign is of similar construction and painted the same as signs Nos. 4 and 6.

The "Road Closed" sign should be erected at the barricade, securely fastened to two heavy posts with the top of the sign 5½ ft. from the ground. The barricade closing the road should be substantial and should extend from shoulder to shoulder. It should always be placed at the intersection where the detour leaves the main road. Barricades should be made of 3"x12" plank spiked to substantial posts set solidly in the ground. Two red lanterns should be displayed on every barricade at night. In order to slow traffic down and warn them of the presence of a barricade, it is desirable to place a "Slow Down" sign about 400 ft. back from the intersection. This sign should be placed close to the shoulder line of the road, and should read "Slow Down, Road Closed." This warning sign should be lettered in black on a yellow background.

Detours shall be marked with standard wood detour signs painted white and lettered in black. Plate "L" shows a typical wood detour sign cut from a 1"x12" board.

These signs should receive the same paint treatment as specified for the road closed sign. In all cases they should be fastened to individual posts set just outside of the shoul-

der line of the road. They should be placed beyond the intersection at an angle of about twenty degrees to the center line of the road, so that they will point in the direction which the traffic is to take.

Great care should be used in placing the detour signs. They should be so placed that anyone, no matter how unfamiliar he may be with the location of the roads, will be able to follow the detour around the obstruction without delay or confusion. No road should be closed until all detour signs have been placed. As the traffic will use the detour in both directions, the detour signs should be placed accordingly (this does not hold true if two detours are to be used as in this case it is usually best to direct the traffic in opposite directions over the different detours).

#### **Maintenance of Detour Signs:**

Responsibility does not end with the erection of signs and barricades, but the resident engineer will be held responsible for their proper maintenance.

In the past detour signs have been left in place long after the necessity for them has ended. The resident engineer will see that these signs are removed at the proper time. Neglect of these duties on the part of the resident engineer will be cause for removal.

#### **Maintenance of Detour Roads:**

Roads used as detours around primary road or bridge construction will be maintained by the state as primary roads, and all rules and regulations pertaining to the maintenance of the primary system will apply.

## **GRADING**

### **Stakes.**

The resident engineer shall make an estimate of all stakes required on the project and notify the district engineer of his requirements at an early date. Ordinarily center, grade and slope stakes can be made of soft pine, wedge shaped, from one-inch dressed lumber fifteen inches long. The hub stakes should be 2"x2"x18" hardwood.

### **Plans and Location Notes:**

The resident engineer should study carefully all plans and records, noting any changes from the originals, before starting checking in the field.

### **Alignment:**

The first field work done on the project by the resident engineer should be the checking of the alignment notes. Hubs for future use should be set while checking location hubs. All hubs at curve points, P. I.'s, and bridge openings should be carefully referenced.



### Center Stakes:

It is suggested that center line stakes be set at the time the alignment is checked. These stakes to be offset at some convenient distance as at the fence line.

When the alignment follows an old roadway, a 40-d nail marked with a red rag makes a suitable marker for the center line, is easily found, and not often disturbed.

Where the line is a relocation and does not follow an old road stakes may be used, driven where they rightfully belong. All curves should be checked for alignment and distance before cross-sectioning is started.

After the construction work is complete all P. C.'s and P. T.'s are to be referenced with permanent reference points located between the right of way fences. These reference points are to be established as follows: Set up a transit over the point to be referenced and locate two intersecting lines establishing not less than two points on each line. Where possible these points should be tied in by both measurements and angles.

Permanent concrete markers are to be set at these points. These markers to be at least four inches (4") in diameter by four feet (4') long with a steel rod running the entire length through the center. These markers may be pre-cast and set as one would set a fence post or by making a hole with a post auger and filling with concrete.

The field notes should contain a sketch showing the exact layout at every curve point so referenced.

At the point of intersection drive a one-inch gas pipe twelve or eighteen inches in length.

Where corner stones are to be disturbed they must be referenced out so that they may be accurately re-set. The law provides a penalty for failure to do this.

Small errors in chainage, not exceeding one foot, may be carried ahead to the next P. I. All other errors shall be corrected at once and an equation made so that the station set will have the same relation to the ground line as shown on the plans.

### Right of Way:

Before contracts for either road or bridge work are approved by the central office all necessary right of way will have been arranged for. This work is handled by the Right of Way Engineer from the Central office. No payments for right of way claims will be paid unless approved by the Right of Way Engineer.

The resident engineer shall go over the line in advance of the contractor's forces and take note of the following:

1. Width of right of way between fences and stations between which fences are to be moved.
2. Location of pole lines.
3. Buildings to be moved and any other obstacle that it

it necessary to move in order to clear the way for the contractor's forces.

Right of way stakes should be carefully set and marked on the face "R of W" and on the back with the station number. No changes in alignment will be made unless first approved by the district engineer.

#### **Note Books:**

Each leaf in the note books must be numbered and paged, dating the beginning and ending of each day's entries, carefully indexing on pages in the front of the book each separate piece of work. Indexing and paging should be done as the work is performed. Four or five pages should be left in the front of the book for this purpose. Field entries of notes on paper or in memorandum books will not be tolerated.

Notes for more than one project should not be entered in the same book.

#### **Cross Sectioning:**

Cross section work should be started well ahead of the time the contractor's crew actually starts work. An entirely new set of cross sections should be taken at the time the slope stakes are being set and comparison made with the original. The quantities should be figured promptly in order that yardage in each cut or fill may be accurately determined before the work is opened by the contractor.

On even ground cross sections taken every one hundred feet will be ample, but where the ground is uneven additional sections must be taken at intermediate points to insure an accurate determination of the quantities.

In the past various methods of setting slope stakes have been used. In order that one method might be adopted as standard practice, a conference of the nine district engineers was called for the purpose of adopting such a method. As a result of this conference the following method is recommended for standard practice:

1. Slope stakes for fill sections are the stakes set at the toe of the slope and will show the height of the fill measured from center grade to the ground at the point where the stake is driven. These stakes shall be set for grades and width of roadway as shown on the plans. In no case shall slope stakes in fills be set to include shrinkage.

2. Slope stakes in cuts are the stakes set at the top of the back slope and will show the depth of cut from a point on the ground where the stake is driven to the bottom of the ditch grade.

In taking cross sections and in setting slope stakes the following method should be used:

A level reading is taken at the center and the amount of cut or fill recorded. If on a relocation or an unused roadway a stake should be set at the center line and marked, but if on

a used roadway the cut or fill should be marked on an offset stake, or center cut or fill given to the contractor.

Readings at right angles to the center line shall be taken and recorded, at all breaks in the ground out to where the slope stake is to be set.

The slope stake is set by taking trial readings until one and one-half times the cut or fill plus one-half the width of roadway equals the distance from the center.

In cuts the width of roadway is considered the distance between the outer bottom lines of the two ditches. In fills the width of roadway is the distance between shoulders.

In addition to the regular cross sections a cross section should be taken at 0.0 points. Three of these should be taken in going from cut to fill, one on each side and one in the center. Without these the proper estimate of quantities cannot be made.

The depth of a cut or fill shall be marked on the face and the station number on the back of the slope stake, which shall be driven vertically.

The cut ditches at the mouth of the cuts should be turned away from the embankment to guard against wash. The ditch should be extended well beyond the 0.0 point of the cut ditch.

#### **Finishing Stakes:**

The resident engineer should keep in close touch with the construction work and be ready to set finishing stakes on all work which has been roughed in ready for finished grade.

Finishing stakes should be set at all stations, or closer if necessary, and marked with blue keel on the top. On both fills and cuts these stakes are to be set on the shoulder line at the elevation of the center grade. This means that the road bed in both cut and fill is finished to a level section.

Finishing stakes on fills are to be set so as to provide for shrinkage which ordinarily will be one-tenth of a foot for each foot of fill.

The engineer should insist that the contractor keep his work finished up as close as possible to his roughed-in work. This is important to both county and contractor, for as a mile of road is finished to the satisfaction of the engineer, the same is taken over and maintained by the county.

The shoulder line of the finished roadway should conform to the line of finishing stakes.

#### **Re-measurement:**

Attention is called to Div. II, Sec. 1, paragraph 7, Standard Specifications, which reads as follows:

"Grading shall be paid for by the cubic yard at the price specified in the tender. Measurements of quantities will be made by cross sectioning **before** and **after** excavation and the volumes determined by the average end area method." Bear in mind that the work is to be measured by actual cross sec-

tions when completed. The field party should endeavor to re-measure the work as fast as it is completed, thereby avoiding rush work at the time the final estimate is due. Prompt re-cross-sectioning also eliminates errors in quantities due to the filling of borrow pits.

Care should be taken in the remeasurement of all work to take cross sections at the same location the original sections were taken. •

#### **Cross Sections at Bridges:**

Extra care should be taken at all bridge and culvert locations to get enough cross sections to insure an accurate determination of quantities.

#### **Channel Changes:**

The earth work involved in channel changes is frequently quite large and where contemplated should receive the same careful attention as the grading proper. Cross section stakes should be set and the quantities carefully determined. Material excavated should be used in the embankment where the length of haul will permit.

#### **Surface Ditches:**

The Standard Specifications, Div. II, Sec. 1, paragraph 11, provide that in cuts along side-hills or where there is a possibility of surface water causing damage to the side slopes by flowing into the cut, an intercepting ditch shall be constructed at the top of the slope to prevent this water from flowing into the cut. These ditches, where necessary, should be built before the excavation in the cut has started.

#### **Side Borrow and Borrow Pits:**

Where side borrow and borrow pits are necessary, the right of way for the same will be purchased in such dimensions as is best suited to the type of equipment that is to be used.

In purchasing borrow pits for elevating grader work the pits will be sufficiently wide to allow the contractor to load both ways. These borrow pits should, if possible, be located so as to eliminate overhaul.

All borrow pits are to be cross sectioned before and after excavation is made, and all excavation quantities paid for are cut quantities.

The contractor is required to leave all borrow pits in a neat presentable condition, well drained if possible.

#### **Waste:**

Waste banks are unsightly and are not to be tolerated. Where there is an excess of material, this excess shall be used in uniformly widening embankments or if advisable adjust the grades to care for the excess material.

## TILE

### Location:

Where definite information regarding outlets is known, the grade line will, as a rule, be shown on the plans. Frequently the work of determining outlets and establishing grades will be done in the field. When such is the case the engineer should take level readings along the center of the proposed ditch to insure that the grade of the tile line will fit the outlet location.

### Staking:

Stakes should be set every 100 feet or at shorter intervals, depending on the nature of the ground.

Inasmuch as the price paid the contractor depends solely on the depth of the ditch, great care should be exercised by the engineer in staking and marking.

Ordinarily the depth of ditch for which the contractor is paid is not measured from the top of the hub to the bottom of the ditch. It is recommended that after the hubs are set and cuts marked an additional level reading be taken on the ground on the high side of the ditch. This reading should be recorded to be used for pay quantities.

The contractor will be furnished with a "cut-sheet" showing the cuts at every station.

### Outlets:

It is essential that suitable outlets be provided for all tile drains. Prior to commencing actual tiling operations the question of outlets should be gone into carefully by the county officials and property owners, and methods for outletting definitely settled.

Frequently the necessary outlets are found within the right of way at some convenient stream or at a bridge opening. On other occasions it will be necessary to secure right of way across privately owned property. Very often property owners will profit by the outlets provided, and are frequently willing to share in the expense of constructing the same.

Remember that the outlets should not be located so that the discharge from the tile will damage adjacent property, without first making definite arrangements with the owner.

Where the tile outlet is placed at a culvert or bridge opening the tile should be carried to the down stream side of the road. This prevents ice from forming in the culvert during the winter.

### Inspection:

No tile should be laid until the necessary tests provided by the specifications are made.

Cooperate with the testing department in arranging for the necessary sample taking.

## BRIDGES

Since bridge specifications can insure satisfactory bridge construction only when they are written fully and in detail, these same specifications constitute the best guide for resident engineers and inspectors.

We will therefore mention here only some of the more important features of bridge construction and bridge inspection.

### Staking:

The first consideration when staking out a bridge is to keep your mind on the business in hand, and allow no distraction to divert you. Bridges have been staked with the skew the wrong way, long sloping culverts under deep fills have been built with the short end of the barrel down stream, and abutments have been constructed too close together, all because the man at the instrument was not keeping in his mind a mental picture of the completed structure. So glaring have some of these mistakes been that serious consideration has been given to the question of whether we should not require all bridge staking to be done twice by different men in order to provide against such possibilities. The bill for damages is not always limited to the price of the materials and labor to correct the mistake. It sometimes costs us hundreds of dollars in lost confidence and the good will of the public who pay the bills.

1. Alignment: Run out a piece of center line for the road project sufficiently long to eliminate errors. Do not hesitate to send a flagman back to a known point on the line even at the cost of some shoe leather. Run it out forward till it checks on another known point ahead. Nothing is so displeasing on a completed highway as bridges that do not line up with the road. Once the alignment is determined, monument it. These monuments need not be elaborate, but should be chosen to serve the purpose in mind. For a small culvert, set on center line in the immediate vicinity of the structure, two or more good stakes, solidly driven, in locations where they will not be covered up by materials or disturbed by traffic or construction operations. On larger bridges, some of which may be under way for a year or more, put more effort on your location work. Choose heavier stakes, set them deep, select their position carefully and check your work. Remember that once the work is started you cannot alter the location. Keep in mind that it is not always possible to see from one side of the stream to the other on center line during the course of the construction due to equipment or material piles. Therefore it is good practice to have two points on center line on each side of the stream from which to take back sights.

2. Stationing: Take pains that your chaining is accurate enough to locate the bridge exactly on the station where the plans show it, unless you have had authority for change. On

small culverts a few feet may make no difference, and may even improve the drainage. But on larger structures across difficult streams it may land your bridge on foundations of a considerably different character than those for which it was designed. Above all, measure the spacings of abutments and piers enough times and by enough different methods to be sure they are the correct distance apart. Abutments that will not receive the steel, or archfootings that change the span of an arch are serious matters.

3. Elevations: Check your level work. Get your bridge to come out in the end at the elevation it was designed to have. Grades on the highway or city street may be already laid, and the pavement may be already built to within a few feet of the new structure. There is often very little leeway in which to make corrections.

4. Skew Angles: Where skews are required set your angles with care. One attempt to erect steel on abutments improperly skewed would demonstrate to almost anyone the importance of this part of the staking.

#### **Materials:**

Methods of proportioning and mixing concrete materials, important details of construction, are clearly outlined in the Standard Bridge Specifications, which should be carefully studied. Close compliance with the provisions of these specifications is required.

#### **Cofferdams:**

Careless methods of driving cofferdams or the use of inferior or inadequate sheeting should not be permitted. The specifications provide that the engineer's authority covers methods and materials to be used by the contractor.

Where wooden sheeting is used, matched lumber is recommended except in locations where the foundations are sunk in firm soil.

Ordinarily the best practice is to keep the sheeting driven a foot or two below the bottom of the excavation, the sheeting to be driven in place before the excavation is started. When finally driven the bottom of the sheeting should be not less than two feet lower than the excavation, except in case the points of the sheeting encounter rock or other impenetrable strata. This insures full width at the bottom as well as providing means of handling the leakage in the case of porous foundations. Par. 51, Div. IV of 1925 Standard Specifications provides for payment of excavation 6" beyond the neat lines of the concrete.

#### **Piling:**

A large percentage of the bridges built in the State are on pile foundations.

Inasmuch as the type of equipment used in pile driving is necessarily light, precaution must be exercised in the driving

operations. Except in cases where batter piling are specified care must be used to insure the pile being driven as nearly plumb as possible. Greater penetration can be secured when driven plumb.

Frequently boulders or other obstructions are encountered which deflect the course of the pile or prevent its driving entirely. The driving should be stopped when it is apparent the pile is brooming or failing. Piling are made ineffective by continued driving after the pile has been driven to refusal.

The inspector should be required to keep a very complete pile driving record. This record should show the following:

- a. Kind and length of pile in leads,
- b. Length in ground,
- c. Length cut off,
- d. Weight of hammer,
- e. Penetration last five blows,
- f. Height of fall last five blows.

The above together with any other remarks may prove useful information later on.

The engineer's attention is called to Paragraph 27, Section 2, Division III of the 1925 Bridge Specifications. By careful study of this section it may be easily determined whether the penetration obtained is sufficient to carry the load required.

Paragraph 28, Section 2, Division III requires the engineer to decide on the length of piles the contractor is to supply. This in the greatest number of cases must be done before any excavating is done and requires the best of judgment to avoid ordering piling too long, thus incurring unnecessary expense, or the still more expensive mistake of getting them too short, thus requiring another complete set of greater length. The Engineer should exhaust all resources of information that are available before deciding on the length of piles. These include:

1. Soundings taken on the site at time of survey.
2. Supplementary soundings taken at beginning of construction.
3. Comparison of data from former structures built in immediate vicinity, either highway or railroad.
4. Information as to soil conditions obtained from residents of the vicinity.
5. Consideration of the geologic formations known to exist.
6. Test piles.

The last mentioned source of information is the surest as well as the most expensive, but should be resorted to when necessary to secure the information. The advice of the district engineer should be sought as to the advisability of driving test piles.

#### **Concreting Footings:**

Before any concrete is poured, the foundation should be



pumped free from water and be kept so during the concreting of the footing.

If the cofferdam is built extra long and wide as described above a better opportunity is offered for handling the water with little damage to the concrete.

Care must be taken to prevent water running over or boiling up through freshly deposited concrete as water carries away cement and damages the concrete.

Pipes or tile may occasionally be employed to good advantage in conducting springs or streams of water from beneath the concrete to sumps located outside the lines of the footings where pumps may be kept running continuously until after the concrete is all poured and finished.

Where the soil is of such a nature that the cofferdam cannot be pumped dry a seal coat may be permitted. This seal coat to be placed below the elevation of the bottom of the footing. In placing this seal coat the cofferdam may be allowed to partially fill with water and the concrete placed in accordance with methods outlined in Division III, Section 3, Paragraph 46 of the 1925 Bridge Specifications.

The seal coat when placed is paid for as extra concrete as is also the excavation required, usually at a rate that will make the cost run high. Therefore unusual care should be taken to secure satisfactory work and a seal coat that really seals. Otherwise a large expenditure is incurred with no accompanying value received. A contractor's plea of unusual difficulties is not a satisfactory substitute for good results in foundation work. The high prices he bids on such work are his guarantee against loss in such cases.

Possibly the placing of this seal coat would be unnecessary if the contractor is required to use proper materials in constructing his cofferdam. The use of inadequate materials or inadequate methods should not constitute an excuse for paying for a seal coat. Perusal of Par. 4, Division III, and Par. 41, Division IV, will show that the engineer has almost complete control over the design and adequacy of cofferdams and if this control is exercised together with good judgment many foundation troubles will be eliminated.

#### Forms:

The 1925 specifications are written with the idea of securing an acceptable surface with the minimum amount of bricking or rubbing. This is mainly accomplished by good forming and adequate ramming and spading. It is possible to so construct forms and place concrete that no rubbing will be necessary. We require a clean smooth surface free from porous spots, fins, scales or projecting wires. There is no objection to seeing the imprint of the form boards in the finished surface provided the finished surface is a smooth one.

It is desirable to remove forms as soon after initial set as possible, due consideration being given to the requirements of Par. 52, Division III of the Specifications. When the con-

crete is green the faults in the surface may be corrected with the least expense and much more satisfactorily.

Contractors are very apt to charge porous surfaces to the engineer's requiring a mix "too dry."

We ask that the engineer and inspector give careful attention to consistency with which concrete is mixed, and exercise good judgment. Remember that narrow walls full of reinforcing steel make it difficult to properly ram and spade. When such situations are unavoidable sufficient water must be used to insure the concrete flowing into place without too great efforts at ramming and spading. However, much of the trouble usually encountered in the spading of faces can be avoided by seeing that the forming is properly planned to avoid these inaccessible spots. The practice occasionally seen of forming the full height of a large wall or abutment before any concrete is poured should be prohibited. In such a case the gain to the contractor can be but slight for he seldom is able to pour the full height in one run, due to small capacity of mixing equipment, and in most cases even if the equipment is large the pressure of the concrete at the bottom of the forms would be dangerous to their stability.

The handrail of a bridge or culvert is the most conspicuous part of the structure. Handrails are not designed to add strength; a wetter mix on hand rails may be permitted if necessary to secure a proper finish, but even here a very sloppy mix is to be avoided or the finished surface will be full of water bubbles.

#### **Steel Erection:**

Attention will be called here to a few important points in the erection of steel spans.

Ordinarily crews which erect these spans are experienced men handled by experienced foremen and superintendents—capable of turning out a satisfactory piece of work, but even so it is highly advisable that this class of work be given careful inspection.

Before spans are shipped to the job they are usually inspected at the fabricating shop by an engineer from the Bridge Department at Ames. This shop inspection comes nearly meaning an assurance that the various members will fit when assembled in the field.

The following points in steel erection are of special importance and frequently the cause of trouble. Each will therefore be discussed briefly.

1. Careful handling of steel.
2. Securing proper camber.
3. True alignment of trusses.
4. Properly driven rivets.
5. Painting both in shop and field.
6. Smooth riding concrete floor.
7. Straight hand and hub rails and curb.
8. Rockers.

## 9. Masonry plates.

### Careful Handling of Steel:

Because steel is hard and tough is no guarantee that it cannot be injured by rough handling and neglect. From the railway station to the job the steel is necessarily under the supervision of the resident engineer as much as when it is on the job. Rolling heavy members off of cars and permitting them to drop onto hard ground or onto trucks or wagons may spring the whole member out of true. It may bend some of the large gusset plates or deform the flanges of angles or channels. Heavy lifting with bars or steel cables may do the same. On the job steel must be stored on skids to avoid deterioration of the single coat of shop paint. Allowing it to lie where it becomes splashed and coated with mud makes needless work and expense in cleaning afterward.

### Securing Proper Camber:

A camber diagram is provided on the plans as a guide for blocking up the bottom chord members when erection begins. Should the false work settle or the blocking be compressed by the load the blocks should be raised to their proper places. Specifications require that all field connections be drift-pinned and bolted before any riveting is done, and that important connections have at least 50 percent of the holes filled. Important connections shall be construed to mean truss connections, but not necessarily those in the floor system. The drift-pins are supposed to draw the members into their proper relative positions and maintain them there till the rivets are placed. The bolts are to hold the members in close contact laterally so that rivets may be driven with no space between the plates. A safe proportion will be to require that the 50 percent of holes be filled by about 25 percent drifts and 25 percent bolts.

While the shop erection mentioned above may insure that the steel will go together when assembled in the field it does not insure that the trusses when swung clear of the false work will necessarily maintain their proper camber. Little inaccuracies which do not prevent assembly while the truss is lying flat on the floor of a bridge shop may show up in settlements at certain panel points when the truss is swung. It is therefore the practice of the Commission to demand that the entire span be swung clear of the false work after the above mentioned drift pins and bolts have been placed and before any riveting has been done. This permits an inspection of the camber and a correction of any inaccuracies before the steel has been fixed rigidly by the riveting.

### True Alignment of Trusses:

The above mentioned swinging of the span also permits a checking up of the alignment of the trusses under load and before it is too late to make corrections. Bridges are known to exist on our highway system in which the top chord of the trusses is out of alignment by an inch or more. This is not

considered satisfactory from the standpoint of either appearance or safety. The top chord of a truss is merely a horizontal column, and a crooked or excentrically loaded column is being stressed to a degree for which it was not designed. A circumspect use of jacks, steamboat ratchets, or block and tackle, and occasionally the slight loosening of the bolts in a floorbeam connection, or the running of a hack-saw thru a top chord joint that was not milled square will do much toward truing up the alignment of the trusses, after which the riveting may be done with some hope that the alignment thus secured will be held.

#### **Rivets:**

Rivets must be tight with properly formed heads. A first-class riveting crew will cut out a poorly driven rivet while it is still hot without waiting to be so ordered by the inspector. The work of the riveting crew should be inspected from day to day rather than wait for a final inspection when the crew is done and ready to move away. Bear in mind that rivets do not tighten with age, but tend to work loose instead.

Field connections contain 20 percent more rivets than shop connections carrying the same load. This is to take care of the fact that conditions for driving rivets in the field are not as perfect as in the shop. In testing the rivets on any connection the inspector should have this in mind. A loose rivet in any joint or connection might be overlooked if the balance of the rivets are good. Sometimes cutting out one poor rivet will loosen several others that were acceptable. Overheated or burned rivets should be removed even tho they are tight. If sparks are thrown from the rivet while driving, it is a sign of overheating. A burned rivet may be detected even after it is driven, by its pitted surface or the presence of heavy iron oxide scale.

For testing rivets a light machinist's hammer should be used. Where both ends of the rivet are easily accessible at the same time a good practice is to hold a nail punch or something similar on one end and tap lightly with the hammer. Some inspectors merely hold their fingers on the opposite end from the hammer. Any looseness can be readily detected.

#### **Painting:**

It is essential that a first-class job of painting be secured. Specifications provide that when completed a span will have three coats of paint, one shop coat and two field coats. When shop inspections are made this inspection will include the shop painting. If for any reason the steel is delivered to the job with an inferior coat of paint, the inspection should see that the defects in the shop coat are corrected even before the span is erected. All exposed surfaces must be protected by paint.

### **Floor:**

Too frequently contractors are permitted to get by with a poor riding surface on the concrete floors. We expect the inspectors to use all the precautions necessary to secure a good riding surface—just as we do on a paved road. No concrete floor should be left as finished until it has passed the straight edge test.

### **Hand and Hub Rails and Curbs.**

The whole appearance of a perfectly good bridge may be spoiled by a poorly constructed hand rail and hub rail, and curb. There is absolutely no reason for not securing true alignment on these.

We ask that our engineers be exceptionally "Hardboiled" in the matter of securing good workmanship on this part of the structure.

Concrete rails and curbs which are not satisfactory should be torn off and rebuilt at once.

Defects or kinks in steel hand rail can be easily corrected.

### **Rockers:**

The rockers under the expansion end of a steel span deserve mention. Keep in mind that the steel expands in hot weather and contracts in cold. In the medium temperatures of spring and fall the masonry plate and anchor bolts should be so located that the rocker will sit almost vertical. Rockers set in winter should lean toward the stream and those set in the hottest of summer weather should lean somewhat toward the abutment.

### **Masonry Plates:**

The specifications require the masonry plates to be bedded down on canvas saturated with red lead. The ideal way to set these would be to locate the masonry plates and pedestals accurately by instrument, bed them down and place the anchor bolts, before steel erection begins.

However, practical considerations seem to demand that we accept a less perfect method. The slight inaccuracies unavoidable in the fabrication of structural steel make it almost impossible to be sure that there will not be some slight variations from the theoretical length of the steel between supports after it is erected. Any such variation would necessitate moving part of the masonry plates. Therefore the general practice is to set the masonry plates dry and erect the steel on them. After the span is riveted it is moved slightly if necessary to locate it correctly. After this it is jacked up sufficiently to permit of the insertion of the canvas soaked in red lead, which process is followed by the drilling and setting of the anchor bolts. Care used in this process will give satisfactory work, but the following are points to be watched:

1. That both plates on any given abutment or pier are jacked up simultaneously. Jacking one corner

only of a span should not be permitted because of danger of racking the rivet connections.

2. That the raising is high enough to permit the canvas to be placed smoothly and accurately.
3. That the jacks are applied close up to the shoe on the sole plate where it is supported immediately above by the gusset plate. Bottom chords of the first panel have been badly bent by permitting the jacks to be placed too far out. The bottom chord is a tension member and not designed to withstand cross-bending.

## GRAVEL ROAD CONSTRUCTION

All material used in gravel road construction shall pass thru a screen having a one-inch square opening or an inch and a quarter round opening.

Grizzly screens are not permitted.

All oversize is to be crushed unless ordered otherwise.

All gravel roads built in Iowa are by the feather edge method.

The standard section calls for 1560 cubic yards per mile.

The best results are obtained when the gravel is spread full width between the shoulders and so thin in the center that traffic is very little inconvenienced. From time to time a little material is dragged from the outside to the center as the gravel becomes packed.

Under no condition is the gravel hauler to be allowed to leave his day's hauling unspread over night. This is a dangerous practice and under no condition to be permitted.

### Screens:

No screen will be considered satisfactory that does not separate the coarse from the fine. All material under an inch is to go on the road. All over an inch to be wasted or crushed.

## PAVING

### General:

Detailed instructions regarding the different steps in a paving operation will not be given in this manual. Inspectors and resident engineers are required to make a careful study of the standard and special specifications before actually going on the work in order to become perfectly familiar with their requirements. These requirements are in the specifications to be followed, and no clause in the specifications is to be regarded as a dead letter, without special instructions to that effect from someone in authority. Any points about which there is doubt, or which admit of more than one interpretation should immediately be taken up with the district engineer, or others authorized to make decisions, and the standard practice of the Commission secured. Accepted in-

terpretations and methods of procedure on many such points have been developed without any necessity having arisen for writing them into the specifications. These form a valuable supplement to the stock in trade of the man coming into direct contact with the contractor and he should avail himself of them before an emergency calling for their use has arisen.

Some of these points which have embarrassed the uninitiated resident engineers or inspectors in the past are as follows:

#### **Stakes:**

Procedure regarding staking as already laid out for other work is to govern on paving projects, also, so far as it applies. Extra lines of stakes for the paving itself are recognized as a requirement of all paving jobs. The number of these stake lines, whether single or double, the location, as regards distance out from the center line or edge of pavement, the elevations used, whether edge or crown elevation, the stake interval, whether 50 or 25 feet, etc., are usually matters which are taken up with the contractor's superintendent and a definite agreement reached before the staking is begun. It must be recognized by those in the field that it is the contractor who must work to the stakes; the instrument party has merely to set them. This being the case the contractor is entitled, within reason, to have them as he can best use them.

In general it has been found sufficient to set a single line of hub stakes 2"x2"x18" on one side of the pavement at the contractor's convenience, giving him edge grade, spacing the stakes 50 feet apart on tangents and straight grades, and changing to a 25-ft. interval on either vertical or horizontal curves. On very sharp curves this latter interval may be shortened to suit the occasion. In the interest of economy, in both stakes and time, a serious effort should be made to secure the contractor's agreement to a staking program that will not exceed the above, and with full explanations this will usually be possible.

In the matter of staking out new work for the contractor to open up, misunderstandings may arise. A length of line fully staked out ahead that seems adequate to the resident engineer may not fit in with the contractor's plans. It is to be remembered in cases of this sort that it is for the contractor's use that the stakes are set, and that, therefore, he is to be the judge. An unusual length of line completely staked is at times required in order to show balance points for earth; to provide employment for grading crews on light earth-moving; to complete earthwork before it is necessary to haul over it; to lay industrial tracks, etc. Delays for stakes in such cases save nothing to the Commission, but do often serve to irritate the contractor to a degree that weakens the engineer's position with him materially. Danger that the stakes will be

knocked out or lost does exist, but the care of all stakes set is made mandatory on the contractor in the specifications, and any appreciable amount of extra work put on the instrument party by carelessness with stakes can be equalized by a charge for resetting same.

#### **Embankments:**

When a resident engineer takes charge of a job where paving is to be placed on a road already brought to permanent grade, it is necessary to assume that the fills have been properly built or else are sufficiently stabilized by settlement during wet and freezing weather. However, if upon opening up the work evidence develops to the contrary, steps should be taken to correct defects. This may take the form of careful and heavy rolling, draining of seepy spots, replacement of spongy material that will not compact, etc. The advice of the district engineer should be invoked frequently until the standard of excellence required is well understood.

When new fills are to be built on which to place pavement the specification requiring that they will be built and rolled in lifts will be rigidly adhered to. The rolling of a narrow strip the width of the pavement is not sufficient compliance. Each lift is to be rolled from slope to slope. However, it is not necessary to ditch the road-roller in order to secure substantial compliance with this provision. Slopes and shoulders thus brought up full width at the same time as the center of the fill attain a degree of solidity that is impossible in those built separately or not rolled, and will act monolithically with the center of the fill. Once satisfactorily built in this manner they should be left undisturbed. The practice of gouging shoulders and slopes to secure earth for subgrading or covering of concrete is not to be tolerated. Loose material placed later to fill such cavities in the shoulders and slopes is separated by natural planes of cleavage from the solid material of the embankment and there is a reasonable doubt whether it ever knits thoroughly with the main body.

#### **Rolling of Subgrade:**

Rolling of the subgrade must be done before forms are set in order to obtain any compaction under the edge of the pavement slab. The extra width specified must be secured as a guarantee of this solidity under the edge. It is also practically the only way a solid foundation for side forms can be secured. The amount of rolling cannot easily be made a matter of specification. Experience, or the advice of those who are experienced, is about the only safe guide. In general, it should be continued until the subgrade is uniformly compacted.

#### **Subgrading:**

The ideal way of bringing the subgrade to proper elevation is, of course, to place an amount of material that when thor-



oughly compacted with a roller will leave the subgrade at the correct height. The impossibility of estimating this amount of material exactly necessitates a certain amount of reshaping after the heavier rolling is done. Toleration of a small amount of this reshaping after rolling and the setting of forms is recognized as necessary under practical working conditions. Doing the rolling on a rough uneven surface, varying from several inches below to a similar amount above correct subgrade elevation is not satisfactory. The removing or filling in of any such quantities will call for an additional rolling. This additional rolling may be done satisfactorily on that part between the forms after these are set, but under the forms it could not be done. It has been the practice, therefore, to require that under the forms the subgrade be brought up to within an inch or so of correct elevation if it is low, or possibly a somewhat larger amount above, in case the subgrade has to be trimmed off in order to set the forms. Only within some such narrow limits are we assured that the subgrade under the forms will be sufficiently solid to prevent settlement under the finishing machine.

This small permitted variation under the forms practically limits the contractor to a similar variation over the remainder of the subgrade and such will usually be their practice. The removal by means of a subgrader of an inch or so of earth between the forms is not considered to eliminate the effect of the rolling and such a subgrade if left undisturbed below correct elevation is considered satisfactory without further rolling. So also with about an inch of fine earth which must be deposited on the subgrade. If, however, there are spots where a greater quantity of earth than one inch must be replaced, then additional rolling or tamping should be done. The rolling of such light lifts of earth is a delicate matter and may result in an unsatisfactory condition of thin slabs of earth lying loosely on the subgrade. This is especially true where damp earth is rolled on a dry hard surface. Light sprinkling before placing, selection of filling material that is not plastic, a reasonable amount of rolling, and possibly the use of a lighter roller than the standard will all help to avoid this difficulty.

As to when a subgrade is at proper elevation little is left to the judgment of the man on the job. Full depths as specified on the plans below the top of the side forms is the only compliance that is satisfactory. The rule of "average" or "give and take" is not considered to apply, since a pavement slab is only as strong as its thinnest section. With modern equipment it is entirely possible to secure full depth of concrete with very little waste below to be stood by the contractor.

#### **Form Setting:**

Setting of forms to an exact alignment is highly desirable though the failure to do so results in but slight actual damage

to the pavement. The unsightliness of it is its worst fault and this is partly disguised when the shoulders are built, if they are maintained at the proper elevation.

No such extenuating circumstances exist when the grade of the forms is not perfect. Every dip or bump in the forms shows up in the finished surface and is there to stay. Therefore, nothing but the most careful setting to grade is satisfactory. Accuracy of grade-staking is the first requisite. Insist that the levels, or level-boards, or whatever is used in setting forms be in adjustment. Also that the form-setters be competent to handle them correctly. See that lines are stretched to take out all sag between stakes. On vertical curves require the form-setters to adjust the forms in a manner that will secure a smooth curve rather than a broken line. Do not permit any forms to be placed until the subgrade has been brought to proper grade within the limits prescribed above and thoroughly rolled to a distance one foot outside the edge of the pavement. The setting of forms on narrow ridges or small mounds of earth compacted only by hand tamping will not be permitted under any circumstances. If a thin skim of earth is necessary to bring the subgrade to proper elevation for the forms it is to be placed before setting the form and thoroughly tamped. Do not permit forms or form pedestals to be hung on stakes and the space below to be loosely filled afterward with a shovel. If earth is to be removed to obtain proper depth for forms it should be removed only to correct subgrade elevation and not to a greater depth to be loosely filled in later. On soft spots require extra pedestals or stakes. In extreme cases of sand or loose material that cannot be compacted use plank of larger area than the bottom of the forms in order to avoid settlement. Finally, inspect the forms frequently just ahead of the mixer to avoid the chance that they may have been displaced by subgrader or trucks.

#### **Cleaning and Oiling of Forms:**

The contractor will find it to his financial interest to keep his forms clean, well oiled, straight and in good repair. His failure to recognize this does not free the field force from responsibility. Forms that are crooked on the top edge introduce waves in the finished pavement surface. Crooked forms are to be removed and straightened before use. All lumps of concrete adhering to the top of the forms are to be removed for the same reason. Cleaning and oiling of the inner face of the forms is necessary to facilitate stripping and avoid breaking of the green edges.

#### **Use of Reinforcing:**

The members of the field force have a natural hesitancy about incurring the expense of using extra steel. This care for the financial interest of the county is a laudable characteristic, but should not be allowed to become a fault.

The standard type of reinforcement is designed to care for stresses in the pavement slab where conditions are normal. It is impossible for the designing office to show what would be desirable under the special conditions that will be met, for the reason that there is no way of anticipating these conditions. On this matter, therefore, the construction force must also act as designers. It is the intent of the Commission that the men in the field shall meet these conditions and provide for them since no one else can. The use of a considerable amount of steel in addition to that specified is necessary in many places, for example, over culverts recently built and filled; on side-hill fills where there is reason to doubt the methods used to compact or stabilize a newly placed slab of embankment; old channels of streams or gullies; seepy spots only recently drained; mucky subgrade that cannot be satisfactorily compacted under a roller. Extensive stretches of road where subgrade bearing is not entirely up to normal do not necessarily require heavy doubling up on the steel. In such locations the uniformity of the subgrade material from side to side and over considerable distances may work to prevent any serious or uneven settlement even though the unit bearing is low. In such locations the advice of the district engineer is desirable. On short stretches that are in question a safe rule is "When in doubt, put in the extra steel."

#### **Proportioning:**

The proportioning methods and the related matters of measurement and checking of materials at proportioning plants should be mastered by both resident engineer and inspector before the work is begun. No detailed explanation will be attempted in this manual. The explanations of the district engineer or a representative from the central office should be sought at the earliest opportunity if there is any doubt as to the method of procedure, as on the accuracy of the proportioning may depend the strength of the pavement or the incurring of a large bill for extra cement.

#### **Finish:**

A sidewalk finish free from tool marks or discoloration helps the appearance of a pavement, but adds nothing to its serviceability. The efforts expended on finishing should rather go toward securing a surface free from waves and inequalities and at the same time well compacted and dense. The proper setting of forms and their rigidity goes a long way toward securing this.

Attention is called to the fact that a two-inch crown in the strike-board of the finishing machine does not always give a two-inch crown in the resulting concrete surface. The strikeboard should be adjusted to a slightly greater height if necessary to secure the full two-inch crown in the finished pavement. The crown of the pavement should be checked

at frequent intervals to make sure that the strikeboard has not gotten out of adjustment from wear or other causes.

The above applies with equal or greater force to the strikeboards ordinarily used in hand finishing.

When the consistency of the concrete is correct the finishing machine can without difficulty be run over the pavement a sufficient number of times to strike it to a true crown. The first trip over is rarely sufficient. Successive trips should be made, carrying some concrete ahead of the strike board each time until all depressions developed by tamping are filled and all high spots are trimmed off.

The next finishing operation after the final passage of the finishing machine is the use of the heavy longitudinal float. This clumsy looking contrivance comes nearer to giving us the desired smoothness of surface than anything else that has been tried on the Iowa pavements. But its use calls for skill by the operators as well as study and attention by the inspector and resident engineer. Concrete too wet or too dry, shortage of mortar in the concrete, inadequate striking off and tamping by the finishing machine, all prevent this tool giving proper results.

The specifications are open as to the use of this longitudinal float, permitting the contractor to use some method giving equal results. In the past many such substitutes have been tried and to date none have shown their ability to give as good work. Therefore the use of this tool has practically become standard. One circumstance that has helped to bring this about is the fact that once this float and its bridges are constructed, the time and effort necessary to secure the right finish is less than by any other means that has been tried. Therefore we feel that we can with a clear conscience require the contractor to use this longitudinal float even though he has the option under the specifications of trying other methods.

The ten-foot straight edge should be used after the first belting. The use of this straight edge is specified with the intent that it shall be used to detect uneven places **and correct them**. The use of the straight edge the next day or any time after the concrete is hardened is a needless waste of effort. The correct time is while the concrete can still be worked and any waves filled or cut off. A strict interpretation of the quarter-inch variation from a 10-foot straight edge is the rule since it is found entirely feasible. The ten-foot straight edge should be light in order that it may be mounted on a long handle to reach all parts of the pavement surface. A ten-foot reach will enable the pavement to be checked as far as the center line from either side. Light straight edges have a decided tendency to warp, but this may be lessened by using clear white pine or cypress and soaking it well in oil before using. It should be checked frequently and straightened if crooked.

Special care should be used on transition sections, superelevated and widened curves, bridge floors, bridge approach sections, etc., as these usually require equipment different from that used on the standard sections. The attempt to place these without straight edges or templates usually results in uneven surfaces.

Inability to secure a smooth surface over the joints is the most frequent failing of the untrained inspector. Make sure first that the header board is at the correct elevation and is set vertically. Then insist that striking off be continued till the concrete is absolutely at correct grade from the header back, as shown by frequent application of the straight edge. Start the next day's run with the same care and a smooth riding joint should result.

#### **Curing.**

The various curing processes required by the specifications are to be used, as there stated, largely at the discretion of the engineer in charge of the job. The difficulty of specifying exactly what is desired, under varying conditions of material and weather, is the reason for the indefiniteness there apparent. The same difficulty exists in attempting to cover the subject in a manual of instructions. Therefore, detailed instructions are not here given further than to state that strict compliance with the specifications is the rule until instructions to the contrary are secured from the district engineer or other competent authority.

Close watch should be kept of the results obtained, and their success or failure reported at every opportunity with the object of securing indorsement of the method used or authority for change of methods in case they are unsatisfactory. The handling of setting checks, commonly called hair cracks, will require the closest attention and should be in the mind of inspectors and resident engineers alike, constantly. Here again, experience or the advice of competent authority is more valuable than any set of instructions.

#### **Concreting in Cold Weather:**

Data on file with the Commission show conclusively that concrete put down in cold autumn weather does not have adequate opportunity to develop its strength before going into the winter. Because of the damage it may suffer in consequence of this, the policy of the Commission is against placing any concrete when it will not have ample time to set. This matter is well understood by most of the contractors operating in this State and in consequence their work is usually planned to end in good time before winter. Apparent failure to so execute the work is a matter that, as a rule, will be handled directly by the district engineer or headquarters representative.

## CONSTRUCTION REPORTS AND RECORDS

### Daily Progress Report, Form 238:

The resident engineer will be supplied with a pocket field book (IHC Form 238) in which he shall daily record the number of men on each contract separately, their time distributed over the various items of work, and the amount of each kind of work accomplished.

This data is kept for the purpose of supplying an accurate record from which the monthly progress reports can be compiled, and to provide an accurate daily record of the forces employed and the work accomplished.

### Monthly Progress Report, Form 239-A (Revised)

The resident engineer is required each month to make a monthly progress report to the District Engineer. This report shall be made up for each project separately and mailed in such time that it will reach the district engineer's office not later than the 27th of the month. The information contained in this report is used in reports to the Chief Engineer and the Commission, and to be of value must be in on time. Therefore, promptness on the part of the resident engineer in starting it on its way is essential.

The report is to be made out in duplicate, the original sent to the district engineer, the carbon copy to be retained in its binder by the resident engineer. The district engineer will make two typewritten copies, sending both to the Highway Commission at Ames.

### Heading:

All blanks in the heading should be carefully filled in to enable everyone who is concerned with the report to readily identify it whether or not he is familiar with the project. Among hundreds of reports one not properly labeled can easily become a source of error or delay.

### List of All Contracts on Project:

On the ordinary project the number of items contracted for will not be greater than the number of lines provided in this table. In case it should be greater additional pages may be used, numbering each at the top to clearly identify it, and pinning all securely together.

Begin by entering the name of the earliest contractor on the project in the first column and first line. Follow his name with all the information regarding his contract that is required by the succeeding columns if same is available by any means. In case his contract covers more than one item, such as excavation, tile, tiling, paving, graveling, guardrail, etc., list such additional items and the quantities in their proper columns immediately following the first item, without repeating the name of the contractor. Proceed in a similar manner with succeeding contractors and their contracts until all items under contract, whether completed, under way, or not yet be-

gun have been entered in this table. In the case of a project being prosecuted by day labor, or of an item of major importance authorized to be handled by Force Account, such project or item shall be reported in the same manner as a contracted item, the manner of handling being specified in place of the contractor's name.

Under "Section or Division" all the identifying marks to be had are often none too many to one not familiar with the job. Under "Estimated Quantity" note immediately any revisions made in the original estimated quantities. Under "Number and Kind of Outfits" specify, as clearly as possible in the limited space, the type of equipment the contractor is using on the work, for example: "2 Elevators," "2 Fresno gangs," "1 Central Mixer," "1 Traction Ditcher," "12 Tilers," etc.

#### **Work Accomplished:**

In this table the work is separated by operations regardless of who may be the contractor. For example, if two or more contractors have contracts for Gravel Surfacing on the same project, enter the name of each on one of the lines allotted to this heading, and follow his name by his quantity for the current month, followed in the succeeding column by his total to date. In the column headed "Total of Each Operation" add together the "Total to Date" of all the contractors who have done gravel surfacing on the project.

In the next column place a percentage figure that is obtained as follows: Assume for the purpose of this report that the project consists only of the contracts let and work authorized by day labor or force account. This is true so far as the Construction Department is concerned, they having nothing to do with sections of a project not yet authorized for construction. Using estimated quantities and the unit price of the various contracts calculate what the total cost of all the work under contract will be. To this add the estimated cost of any day labor or force account work. Divide this total cost of the project into the total cost of all the gravel surfacing on the project and the result will be the percentage of the entire project cost that the gravel surfacing represents.

In the column second to the last place a percentage figure calculated by dividing the total of all gravel surfacing under contract on the project in cubic yards into the total of all the gravel surfacing that has been completed to date.

In the last column will be placed a weighted percentage figure which is the product of the percentages already calculated for the two preceding columns.

Attention is invited to the fact that in the third column from the last the total of the percentages of the cost represented by the various operations is always equal to 100 percent.

Attention is also invited to the fact that the clause covering Special Classification of earth excavation no longer exists

in the specifications and that therefore the method of reporting excavation on Form 239-A is considerably simplified.

The method for future work will be as indicated on the revised Form 239-A (revision not yet printed). That is, the quantities of earth excavation, loose rock, and solid rock moved by each contractor each month will be reported as in the past, as will also his total to date and the total of all excavation by all contractors to date for each class. These last figures (column 4th from the last) will then be totaled and this total figure will be placed beneath the red line below Solid Rock Excavation and on the line entitled "Total Excavation on Project, All Classes." The percentage in the last three columns will then be calculated for this total of all excavation on the project, in the manner described above for Gravel Surfacing.

Care should be taken to fill in the "Total Percentage of the Project Completed" at the bottom of the page.

Accuracy is necessary if this report is to be of any value. Look over your figures when the calculations are made and see if they appear logical. The central office force has frequently been compelled to recalculate an entire report because of some wild error that the most casual glance warns them must exist somewhere in the report.

Keep the estimated quantities in the several contracts up to date by revising them whenever it appears that there will be a variation from the original quantities.

All the purposes intended will be served if the percentages called for are calculated only to the nearest whole number.

Wherever a percentage figure is used write it as a percent, not as a decimal fraction. That is, eighty percent is written 80, not .80.

The entire project is to be included in the one report, not separate sections of a project each on a report of its own. In any case where the latter practice is necessary special notice will be given.

When all work under contract on a project has been completed discontinue the report. Make a notation on the face of the last report that it is "Final," or if it is impossible to send in a final report at that time due to the fact that final cross sections have not been taken, make a note that it is the "Last Report till Final Quantities are Obtained," or some other proper statement of the case. Then as soon as the final quantities are available a "Final" report should be sent in without fail.

When all work is discontinued on a project for a long period of time the report should be discontinued temporarily and an explanatory notation made on the last such as "All work closed down for the winter."

#### **Daily Inspection Reports (Form No. 224):**

On pavement construction there is to be kept by the inspector on the pavement a daily inspection report. On the pri-



mary road system at present there is being built but one type of pavement, namely, reinforced concrete. For the inspection report on this work Form No. 224 is to be used. This report is to be made up in triplicate and filed with the resident engineer each evening. It must be understood that the report is to be made for each working day whether or not any pavement was laid.

One copy of the daily inspection report shall be retained by the resident engineer; the other two copies being forwarded to the district engineer.

The district engineer shall keep one copy and forward the original to the commission at Ames.

#### **Order for Extra Work (Form 240):**

Whenever it is necessary for extra work to be performed by the contractor, the resident engineer will issue a written order, using Form I.H.C. No. 240. If the extra work is of a minor nature and needs attention promptly the resident engineer may issue the order for same promptly. If the extra work is of some importance, or involves the expenditure of any considerable sum of money, or does not require immediate attention, the resident engineer shall issue no order therefor until he has consulted with and secured the approval of the district engineer. The work may be an extra paid on an agreed unit price basis, or it may be force account work paid on a cost plus basis. In either case, specify the basis of payment as indicated on the blank form.

This form is to be made out in triplicate, the original given to the contractor, one duplicate forwarded to the district engineer, and the remaining duplicate retained in its binder by the resident engineer.

#### **Daily Force Account Records (Forms 317 and 318):**

A daily record of material and labor on each force account job shall be kept on Forms No. 317 and No. 318. More detailed instruction regarding these reports will be found under Payments.

#### **Engineer's Approval of Completed Work (Form 241):**

When some well-defined portion of a project is completed ready to be opened for traffic, the resident engineer may approve of this part of the road, using I.H.C. Form 241.

In the event of several parts or sections being approved in this manner, then on the last section the engineer should write on the blank lines provided, "This approval together with the approval of sections previously given will constitute the engineer's approval of the entire project, pending acceptance by the Board and Commission."

The original copy is to be given to the contractor, the carbon retained in its binder by the resident engineer. Before making such approval, the resident engineer shall consult with and secure the approval of the district engineer.

### **Weekly Bridge Progress Report (Form 239-B):**

This report is to be made out in triplicate, one copy retained by the resident engineer, one copy mailed to the district engineer, and one copy mailed to the general office at Ames.

### **Acceptance Blank (Form 435):**

This form is to be made out when the work is completed in an acceptable manner. Please note this acceptance is to show the signatures of the Board of Supervisors, the Highway Commission, the District Engineer and Construction Engineer.

This form is to be used on the completion of all contract work.

## **MATERIAL INSPECTION**

### **Material Inspectors—Plant:**

Inspection of materials at producing plants will be under the direct supervision of the Engineer of Materials and Tests.

### **Material Inspectors—Project:**

In so far as possible materials will be inspected and tested before arrival at the site of the work. When this is not possible definite arrangement will be made for the assignment of a material inspector to the project.

### **Quality of Materials:**

Preliminary approval of the source of supply of all materials must be secured from the Engineer of Materials and Tests.

All shipments of materials for use on federal aid and primary road and bridge work must be approved by the Engineer of Materials and Tests or his authorized representative before use or before material estimates are allowed. When materials must be inspected at the site of his work, the resident engineer will act as the authorized representative of the Engineer of Materials and Tests. In such cases a material inspector may be detailed to the project. The material inspector will report direct to the resident engineer and will be under his jurisdiction.

When materials are inspected before arrival at the site of the work, the resident engineer will receive a written notice of approval or rejection upon all shipments. It shall be the duty of the resident engineer to check all shipments against the approval notices and keep a record of all shipments showing if actually used or diverted. If shipments which should be inspected at the plant arrive without notice of inspection

they shall be held until the resident engineer can get instructions from the laboratory or testing station in charge of the shipment. Such instructions shall be secured by telephone or telegraph if necessary to avoid delays.

Rejections of material by a representative of the Engineer of Materials and Tests are not reviewable except by the Engineer of Materials and Tests.

The resident engineer shall see to it that all materials are given a thorough inspection before use, in order to guard against mistakes that may be made in inspection or damages that may occur to material in transit.

**IF MATERIAL THAT HAS BEEN PREVIOUSLY ACCEPTED BY AN AUTHORIZED REPRESENTATIVE OF THE ENGINEER OF MATERIALS AND TESTS IS FOUND BY THE RESIDENT ENGINEER TO BE DEFECTIVE HE SHALL CAUSE SAME TO BE SET ASIDE, AND SHALL AT ONCE NOTIFY THE ENGINEER OF MATERIALS AND TESTS, AND THE DISTRICT ENGINEER BY TELEPHONE OR TELEGRAPH. THE ENGINEER OF MATERIALS AND TESTS SHALL MAKE FINAL DECISION, AFTER CONSULTATION WITH THE RESIDENT ENGINEER.**

All resident engineers and inspectors charged with responsibility for acceptance of materials shall report daily to the District Engineer and Engineer of Materials and Tests upon the prescribed forms.

#### **Laboratories and Testing Stations:**

Permanent laboratories are maintained as follows:

Ames, address, Highway Commission Building.

Des Moines, address, Box 352, Highland Park Station.

Mason City, address, M. B. A. Building.

Fort Dodge, address, Court House.

District material inspectors are assigned to those districts having a sufficient volume of work. During the construction season inspectors will be stationed at the principal plants producing materials used in highway work. It is the policy of the Highway Commission to inspect materials at the source in so far as practicable. It shall be the duty of the resident engineer when starting work to ascertain the source of the materials to be used and arrange with the materials department through the district engineer for the proper inspection.

The procedure with respect to the various materials will ordinarily be as follows:

#### **Sand—Gravel—Crushed Stone:**

The resident engineer shall have all shipments examined to guard against mistakes and damage in transit. If inspection is to be made at the site of the work, the resident engineer will be held responsible for proper inspection and report.

When tests cannot be made samples shall be sent to the nearest permanent laboratory.

#### **Reinforcing Steel:**

The resident engineer shall have all shipments inspected for size and condition. Steel from warehouses at Des Moines, Clinton, Waterloo, and Ft. Dodge will be inspected at the source. Lots of 100 tons or more from points outside the state may be inspected at the source. When not inspected before arrival, two rods 24 to 30 inches long from each 10 tons of steel received shall be forwarded to the Ames laboratory. The resident engineer shall caution the contractor that unless the steel is to be inspected before shipment, extra bars of each size should be ordered for testing.

#### **Drain Tile:**

Arrangements will be made in so far as possible to inspect drain tile at the factory. If such arrangements are not made the resident engineer shall select six representative tile from each one-half ( $\frac{1}{2}$ ) mile of ditch and forward to the nearest testing laboratory. Tile represented by such samples shall not be placed until the resident engineer is notified of approval. It will be necessary for the district engineer to get instructions from the Engineer of Materials and Tests as to how each project will be handled. The resident engineer or material inspector shall inspect all tile before laying, to determine whether the tiles comply with the specifications as to dimensions, shape and freedom from visible external and internal defects.

#### **Cement:**

In general, cement will be tested or sampled at the mill. District engineers and resident engineers will be notified by Engineer of Materials and Tests of approval or rejection of all shipments. If necessary, to avoid delay in unloading cars, approval will be based upon results of 24-hour tests. Copies of complete tests will be filed with district engineers. If cars of cement arrive upon which the resident engineer does not have a report he shall communicate with the laboratory which should have made the test, by telegraph or telephone if necessary. If this laboratory has not sampled the car or cars in question, the resident engineer shall take the samples and forward to the laboratory. The shipment shall then be held until notice is received from the laboratory.

#### **Paint for Bridges and Guard Rail:**

The resident engineer shall submit promptly to the engineer of materials and tests the following information concerning each shipment of paint to be used on primary road or bridge work:

- Project number.
- Name of contractor.
- Kind of paint.

Name of manufacturer.

Name of dealer.

Manufacturer's analysis as given on the container.

Paint shall not be used until acceptance notice is received from the engineer of materials and tests. Acceptance or rejection will be made promptly upon receipt of above information, or the resident engineer will be directed to forward samples for testing.

In the case of red lead paint the engineer shall determine the weight per gallon of the paint as submitted. If the weight per gallon is less than that given in the specifications, the paint shall be rejected without further tests.

#### **Guard Rail Posts:**

Arrangements may be made for plant inspection of posts shipped from Minneapolis or Saint Paul. In all other cases the resident engineer shall make the inspection. If the posts are to be treated at the site of the work, a one-pint sample of the preservative shall be forwarded to the Ames laboratory. The resident engineer shall file a report with the Engineer of Materials and Tests and district engineer, upon the form prescribed, to cover each carload lot or less.

#### **Guard Rail Cable and Fittings:**

Resident engineer shall send samples to the Ames laboratory as follows:

- 36 inches of cable for each 5000 ft. of guard rail.
- 1 each of all fittings.

#### **Corrugated Metal and Concrete Culvert Pipe:**

Resident engineer shall secure from the Materials Department approval of source of supply and shall examine all culvert pipe for condition and visible defects.

#### **Miscellaneous Materials:**

All materials must be inspected prior to use. For inspection of materials not covered by these instructions the resident engineer shall request instructions from the Materials Department.

#### **Sampling and Testing:**

All sampling and testing shall be done as described in the Field Manual for Concrete Inspectors or in accordance with additional instructions issued by the engineer of materials and tests. Samples shall be marked and identified as follows:

1. Some characteristic mark.
2. Kind of project and project number.
3. Name of contractor who intends to use materials.
4. Particular unit of material represented.
5. Quantity of material represented.
6. Name of producer and location of producing plant.

Forms No. 193 for identification of specimens or samples

can be secured at any time from the Materials Department at the Ames office.

## MATERIAL REPORTS

### Road Work:

All persons vested with authority to accept material shall report daily to the district engineer and the Engineer of Materials and Tests upon the prescribed forms.

Inspectors of proportioning and measuring shall prepare a daily report upon forms as prescribed by the engineer of materials and tests. This report shall be countersigned by the resident engineer and forwarded each day to the district engineer and Engineer of Materials and Tests.

### Bridge Work:

Resident engineers, unless relieved of this duty by specific arrangement, will prepare a report for each structure constructed, as prescribed by the Engineer of Materials and Tests. This report is to be filed with the district engineer and Engineer of Materials and Tests, and shall include report of test data on all materials used or reference to laboratory number under which the tests were made, and record of proportions used. If it is necessary to make any tests upon the work, the necessary equipment will be supplied by the Ames office.

## TEST SPECIMENS TO BE MADE IN THE FIELD

### Paving

#### Responsibility for Test Specimens:

On each paving project under construction, test specimens are to be made each day from the concrete as it is being placed in the pavement slab. The inspector supervising the placing of the concrete shall make the specimens and record the data hereinafter itemized.

The daily test specimens required are two 6x12 cylinders.

#### Location:

Each day at irregular times, the paving inspector shall make these specimens and keep an accurate record of the stationing and the distance right or left of the center line looking in the direction of the survey, of the location of the batch from which the concrete was taken. Make both cylinders at one time.

#### Molding:

The specimens shall be molded by placing the concrete in the forms in layers approximately 4 inches in depth. Each layer shall be puddled with 25 to 30 strokes with  $\frac{5}{8}$ -inch round steel bar about 21 inches in length having a rounded point on the end placed in the concrete. This method of molding is of special importance and care should be taken

that the operation may be properly performed as outlined. After puddling the top layer, the surplus concrete should be struck off with a wooden float or a similar tool and an effort made to obtain a smooth surface without using a trowel. A small board drawn back and forth across the cylinder and in contact with the mold will with care provide a satisfactory surface. The mold should be placed on a board to insure a smooth surface on the lower end.

#### **Washed Concrete Sample:**

At the time of molding the cylinders eight or ten pounds of concrete shall be taken from the same batch as that from which concrete for the cylinders was obtained. Place this concrete in an ordinary 14-qt. pail. When the cylinders have been taken care of, move the pail to some location whereby a constant stream of water may be turned into it. Adjust the flow so that the cement will be floated off as the mass is stirred. Continue this process until no cement appears in the overflow water. In this method care should be used in regulating the force and flow of the water so that fine sand may not be driven off with the cement.

#### **Storage:**

The cylinders shall be removed from the molds approximately 24 hours after they are made. They shall be buried in earth at the edge of the pavement slab, in the ground near the fence line, or placed on the pavement slab and completely covered with dirt. In any case they are to be kept in the same moisture condition as the pavement slab and for the same period of time.

#### **Marking:**

Each pair of cylinders constitute a set. Each set shall be numbered consecutively, beginning with number one. In addition to the set number, each cylinder shall be marked with the letter assigned to the inspector for that purpose. The most satisfactory method of marking is to use black paint directly on the side of the cylinder shortly after the form or mold has been removed. The assignment of letters to projects is on the last page of this memorandum.

#### **Data to Be Recorded:**

The following data shall be recorded in the paving inspector's notebook and on the card from I. H. C. No. 466.

1. Sender's mark and number.
2. Date.
3. Kind of project.
4. Project number.
5. Stationing of batch from which cylinders were made.
6. Distance and direction from center line.
7. Proportion of mix by weight.
8. Maximum and minimum temperature.
9. General weather conditions.

10. Slump of concrete by cone method.
11. Sources of materials.
12. Brand of cement.

After recording this information, the paving inspector shall enclose the card bearing it, with the sample obtained from the washed concrete and forward either to his plant inspector or to the nearest Iowa Highway Commission laboratory.

The plant or the laboratory will place on the back of the card the following information:

1. Sieve analysis.
2. Percent and kind of rotten stone.
3. Percent shale.

In running the sieve analysis, the whole sample as received from the paving inspector shall first be split on the number 4 sieve, and the percent passing the sieve recorded on the blank space at the bottom of the card. Then a complete sieve analysis shall be run on all that portion of the sample retained on the No. 4 sieve. A smaller sample, say 1000 grams, will suffice for the analysis of the material passing the number 4 sieve. Each analysis shall be recorded as run, separately on the card. Do not combine them.

#### **Assignment of Letters:**

For the identification of test specimens when assembled for testing in Ames, a letter or symbol is assigned for each mixer on the project during construction. If a mixer moves on to a project of a different number, another letter should be given it.

#### **Object:**

A study of the results obtained from tests of these field specimens has yielded valuable data in the determination of the effect of different materials and of different methods of construction upon the strength of the concrete in our pavements.

Reliable data obtained in this way is of great assistance in the revisions of specifications from time to time for the improvement of the pavement. The results of tests has been found to be a valuable part of the permanent records of the road.

#### **Bridge Work**

Unless otherwise ordered, two test specimens of concrete are to be made from each culvert and from each abutment, pier and floor slab of other structures. The inspector supervising the placing of the concrete shall make the specimens and record the data hereinafter itemized.

Molds for the specimens shall be secured from the Highway Commission, or elsewhere as directed.

#### **Molding:**

The specimens shall be molded from the concrete as it is poured in accordance with the instructions given above for molding specimens for paving work.



**Storage:**

If fiber molds are used, the molds shall be left on the specimens. If metal molds are used, they shall be removed when the concrete is 24 hours old. The specimens shall be so stored on the job as to receive the same curing treatment as structure receives. At a date not later than the date of final inspection of the structure, the specimens shall be taken to the headquarters of the resident engineer and stored out of doors. When the project is finished, the specimens shall be shipped by freight to the Highway Commission, Ames, Iowa.

**Marking:**

Each pair of cylinders constitutes a set. Each set shall be numbered consecutively beginning with number one. In addition to the set number, each cylinder shall be marked with a letter or other symbol assigned by the Department of Materials and Tests for that purpose. The most satisfactory method of marking is to use black paint directly on the concrete. If fiber molds are used, the marking may be done on the mold in some way to insure against erasure.

**Data to Be Recorded:**

The following data shall be recorded in the inspector's note book and on the form furnished by the Highway Commission:

1. Sender's mark and number.
2. Date cylinders were molded.
3. Project number.
4. Item number.
5. Description of structure.
6. Part of structure.
7. Contractor.
8. Date of contract.
9. Proportions.
10. Brand of cement.
11. Sources of sand and coarse aggregate.

The card bearing this information shall be forwarded to the Highway Commission with the weekly construction report. If fiber molds are used, a duplicate of the card shall be enclosed in the envelope tag attached to the side of the mold.

**STATE PARK AND STATE INSTITUTION ROADS, LAKE SURVEYS AND IMPROVEMENTS AND LAND SURVEYS****Surveys, Plans and Construction****General:**

The instructions relative to surveys, plans and construction on primary roads shall apply in general, modified or explained by the following notes. This phase of the work is generally handled from the central office under the direct supervision of the engineer assigned to this work.

## Park Road Surveys

### Datum:

Use U. S. G. S. or some other Government Datum if B. M.'s for such be anywhere near the work. County Engineers can probably be of considerable assistance in giving information regarding this. On Lake Surveys there are B. M.'s established for the meandered lakes as shown on plats thereof. B. M. levels are to be checked.

### Alignment:

In the park work straight alignment is not as necessary as on regular primary road work. We wish to preserve the natural features of the park in so far as possible without sacrificing safety too much to obtain this. Valuable trees and other features are to be avoided if possible. Circular curves are not altogether necessary, although it may be easier to run such as a base line for the survey, and alignment may be adjusted on construction. In general we wish the alignment to fit the contour of the ground as much as possible.

### Grades:

Our maximum grade so far has been 10 percent in work which we ourselves have planned. If 8 percent or 6 percent maximum grades can be obtained, however, by relocations or shifts in alignment without too much cutting and filling, we prefer that this be obtained.

### Topography:

Cross sections should be taken far enough out to permit of shifts in alignment, and natural features such as streams, etc., near the road, should be located so they can be platted. Ties to park corners or boundaries should also be obtained.

### Notes:

The alignment should be platted as the work progresses, from computed latitudes and departures, and checked for closures if possible. If time is available the work should be platted on a scale "1 inch equals 100 ft." so that when the data comes to the office it will be of aid in working up the final plans. Working profiles should be kept up, drainage areas obtained, and in general such data as is required on primary work should be obtained.

### Blazing Trees:

A minimum amount of tree blazing and line cutting will be permitted. We do not wish to destroy or mark trees too much, as the roads may never be built, and in any event this should be kept to a minimum. Paper roofing discs with 6d nails and red rag under disc with slight blaze in bark is offered as a suggestion for referencing out points.

### Clearing and Grubbing:

The preliminary survey should show information as to the

probable amount of clearing and grubbing. Frequently bids are asked for this work on the square rod basis, all trees under 3-inch diameter being classed as brush. Obviously the preliminary data will be approximate, but a statement of the approximate number of square rods of clearing and square rods of clearing and grubbing, grouped according to the probable sections of road into which the project may be divided will be of value.

#### **General:**

The above are merely a few points to be kept in mind. Notes should be complete enough to depict conditions as they are without leaving anything out or to be guessed at. Classification of material to be excavated should be shown in notes and on working profile, together with probable shrinkage or swell. Suggested grades or control points should be shown on working profile. Drainage data, highwater marks, and classification of watershed are important.

#### **Lake Surveys**

The surveys frequently needed at the various lakes are of a miscellaneous character and detailed instructions will be given in each individual instance. However, where the work is at a lake which was platted and included in the "Iowa Lake Bed Survey Report—1917," an endeavor should be made to "tie in" subsequent surveys with work previously done. Most of such former lake survey plats show monuments which serve both for level datum and alignment. These monuments are sometimes difficult to find, but generally at each lake it will be possible to find some of them.

#### **Boundary Surveys**

No phase of field work probably calls for more judgment, skill and patience than land surveys and subdivisions. The party chief should be familiar with the rules, regulations and methods used in the original government survey, and also the later regulations of the Government Land Department. Before starting on the field work, copies of the original government survey notes should be obtained for the territory involved. Usually this can be obtained at the county seat or from the records at the State House in Des Moines. In the case of areas obtained for state parks, the deed descriptions should be obtained. In addition, all records of surveys made subsequent to the government survey in the territory involved, which may pertain to the survey in question or give aid in making it should be obtained. These records are frequently obtainable at the county seat. Valuable information can often be obtained at the county seat. Valuable information can often be obtained from residents in the territory involved. Sometimes this is misleading and confusing, but may be of great value.

In any survey it is of prime importance that all corners established or found be referenced so that they may be found

or restored at a later date. In the case of all corners established, permanent monuments are to be set, preferably of stone, iron or concrete, firmly planted. Where trees are near by, at least two witness trees should be used, properly marked and described in the notes. If there are no trees available, other natural or artificial features may be available. Every effort should be made to establish some kind of reference points.

Volumes could be and have been written on the various problems that may be encountered and the method of solution, but such will not be attempted here. If possible, any survey made should be run to a closure and in any event some kind of a check should be secured on the work done. In the case of area surveys, closure of the work will be insisted upon.

In searching for corners in the field, every effort should be made to find any corners that may exist. They frequently exist, but often require more than a cursory search to find. However, if a half day or so of digging and search results in a corner being found, the result is certainly more satisfactory and binding, and probably more economical than to survey to re-establish it.

The main thing is to exercise common sense, be accurate and make such a survey that it can be re-traced in the field from the notes, even if many of the corners should be destroyed.

## **PAYMENTS**

### **PRIMARY ROAD CONSTRUCTION**

#### **General**

All bills, estimates, and force account statements for Federal Aid and Primary Road work shall be prepared on forms furnished by the Commission and in accordance with these instructions and such special instructions as may be issued in connection with individual projects. Care in keeping of records and rendering of estimates will facilitate payments.

These instructions shall supersede and render void the instructions set forth in Part Nine of the "Field Manual, Federal and State Aid Road Work" issued in 1922.

#### **Assessment District the Unit**

On all projects on which a part of the cost of construction is to be paid from special assessments, the assessment district shall be considered the unit in preparing estimates and vouchers for payment of cost of construction. This is necessary in order that the total cost of the improvement in each road assessment district may be shown.

On all projects involving special assessments the Resident Engineer shall show the number of road assessment districts on the upper right-hand corner of the vouchers, estimates and force account statements, and in preparing same care shall be taken to see that only one assessment district is involved in each voucher, estimate and force account statement.

#### **Authority for Expenditure**

No vouchers or estimates covering expenditures of any nature whatsoever shall be incurred unless the same shall have been previously authorized by an authority for expenditure (A. F. E.). Each estimate and voucher must show upon its face the A. F. E. number against which the expenditure is to be charged.

The resident engineer should keep a record of all estimates and vouchers drawn against each A. F. E. and if it should appear that the amount of the A. F. E. as originally issued will be insufficient to cover the cost of the work, advise the district engineer to the end that additional A. F. E. be obtained.

#### **Forms Used**

The following named forms shall be used:

- No. 308, Voucher or bill.
- No. 314, Estimate Sheet.
- No. 315, Force Account Statement, Material, etc.
- No. 316, Force Account Statement, Pay Roll.
- No. 317, Daily Material Report, Force Account Work.
- No. 318, Daily Time Report, Force Account Work.

#### **Classification of Work**

With reference to manner of payment, all work shall be divided into two classes, namely: "Contract Work" and "Extra Work."

##### **Contract Work:**

Contract work shall consist of two classes:

- (a) Work contracted at unit prices based on quantity of production.
- (b) Work contracted on a force account or other special basis.

Contract work based on unit prices shall be reported on Form No. 314, as hereinafter directed under the heading "Monthly Estimates." Contract work let on a force account or other special basis shall be reported in the same manner as "Extra Work" referred to below.

##### **Extra Work:**

Extra work shall be recorded and reported in accordance with the instructions directly following:

Extra work shall consist of two classes:

- (a) Extra work which is being done on the basis of unit prices or a lump sum.

- (b) Extra work which is being done on the force account basis.

#### Daily Force Account Record

Force account work is one of the most fruitful sources of difficulty and disagreement between engineers and contractors. This difficulty can be largely avoided by keeping the records each day complete for that day's work. For this purpose Forms No. 318, Daily Time Report, and No. 317, Daily Material Report, have been prepared. Each day the resident engineer or inspector should make out in duplicate the material and time reports for each force account job separately. These sheets should be signed by both the resident engineer or the inspector and by the representative of the contractor, one copy being retained by each.

All of the information required by the blanks should be given. Under "Employment" should be listed the class of employment which a man is performing; that is, "laborer," "hoisting engineer," "foreman," "teamster," etc. The attention of the engineer is directed to the specifications which outline the items that may be included and the division of time which is to be made for foreman, timekeepers, or superintendent on the work. Should the engineer's representative be unable to agree with the contractor on any point, notes stating the difference shall be added on the reverse side of the sheet.

#### Statement of Force Account

At the end of each two weeks, the daily time and material records shall be transferred to Form 315, Statement of Force Account—Materials, Supplies, etc., and to Form 316, Statement of Force Account—Pay Roll. One copy of each of these statements of force account shall be prepared and shall be certified by the resident engineer and checked and approved by the district engineer.

#### Monthly Estimates

The monthly estimates are to be prepared on Form No. 314. All data required by this form shall be added thereto. The data required by the various columns is as follows:

"Item No." The numbers entered in this column should be the same as those shown in the proposal form, for the item of work being listed.

"Items." State briefly in this column the nature of the work such as "Earth excavation," "monolithic brick pavement," "guard rail," etc.

"Rates." List the unit prices for which work is being constructed.

"Sum of previous estimates." Show the quantity and amount of estimates which have been allowed for each individual item.

"This estimate." Show the quantity and amount of each item included in this estimate.

"Totals to date." In this column show the sum of the "previous estimates" plus "this estimate."

In making up the estimate sheet, all of the contract items shall be grouped under the general heading of "Contract Work," keeping each division or section separated and all of the extra work shall be grouped under the general heading "Extra Work." Extra work shall be further divided so as to show each individual job and the job name should be shown. It will be noted that there are blanks for the estimate number and the sheet number. Separate estimates should be made for each separate contract. The estimate for each contract will be numbered consecutively, beginning at "one." Should more than one sheet be required in making up any estimate, the sheets should also be numbered.

One copy of the estimate shall be made to which shall be attached one copy of voucher, Form No. 308, and one copy of each of the "statements of force account" (Forms No. 315 and 316) referring to all force account included in that particular estimate. The estimate shall be certified to by the resident engineer, checked and approved by the district engineer, and forwarded to the Iowa State Highway Commission.

#### Vouchers

All payments shall be made from the vouchers prepared on Form 308 and which shall be fully itemized. In preparing vouchers from the engineer's estimates, only the items in the column headed "this estimate" need be copied. Form No. 308 shall be made out by the resident engineer for all estimates, salaries for engineering and supervision, day labor work and miscellaneous bills, except for items of personal expense recorded in daily expense books. Expense books shall be sent to the Highway Commission, where they will be copied on Form No. 308 and returned to the resident engineer for the necessary approval.

Vouchers shall be sworn to by the original claimant signing his or her name in ink, and shall be approved by the resident engineer, the Board of Supervisors (except that vouchers drawn in connection with projects being paid for wholly from the Development fund need not be approved by the Board of Supervisors), the district engineer and then forwarded to the Iowa State Highway Commission for final audit.

Where it is more economical to do certain classes of work by local day labor rather than by contract the resident engineer shall prepare a separate voucher on Form No. 308 for each individual stating specific employment, i. e. (laborer, foreman, man with team, etc.) showing exact dates and hours each day.

#### Preparation of Vouchers, Estimates and Force Account Statements

The resident engineer shall prepare all vouchers, estimates and force account statements, excepting vouchers covering

personal expense account, and shall be responsible for the correctness and mathematical accuracy of same.

### **Approval by District Engineers**

The signed approval of the District Engineer shall signify that the work performed is acceptable, that the quantities are correct, and that the rates for extras and force account work are fair and just, but the district engineer will not be held accountable for the mathematical accuracy of vouchers, estimates, and force account statements.

Each voucher covering a monthly estimate shall be accompanied by said estimate and any force account statements relating to same.

### **Payment**

By the State: Vouchers payable from the Primary Road fund or Primary Road Development fund, when approved by the Iowa State Highway Commission, shall be filed with the Auditor of State, who will issue warrants on the Treasurer of State in payment of same. Said warrants will be forwarded to the Iowa State Highway Commission for record and then distributed to the claimants.

By the County: When approved by the Iowa State Highway Commission vouchers payable from the proceeds of special assessments, bond issues or anticipation certificates, shall be filed by the Iowa State Highway Commission with the County Auditor, who will issue warrants on the County Treasurer in payment of same. Such warrants will be delivered by the County Auditor to the claimants.

## **COPIES OF VOUCHER**

### **Estimate and Force Account Statement**

When the voucher (Form No. 308), the estimate (Form No. 314) and the force account statements (Forms No. 315 and No. 316) have been approved by the Iowa State Highway Commission, copies of same shall be prepared in the office of the Commission and exact copies of the original shall be furnished as follows:

Voucher (Form No. 308)

1. County Auditor
2. Iowa State Highway Commission.
3. District Engineer
4. Resident Engineer
5. Claimant.

Estimate (Form No. 314) and Force Account Statements (Forms No. 315 and 316)

1. County Auditor
2. District Engineer
3. Resident Engineer
4. Contractor



## Funds

The law provides that the cost of improving the Primary Road system shall be paid from the following named funds:

- (a) Primary Road Fund
- (b) Special Assessment Fund
- (c) Bonds or proceeds of same
- (d) Road Certificates issued in anticipation of allotments to the Primary Road fund or proceeds of same
- (e) Primary Road Development fund

Claims for grading, draining, graveling, and for eighty-seven and one-half (87½) percent of the cost of hard surfacing may be paid from the Primary Road fund by the State if the county's allotment of the Primary Road fund is sufficient to cover same. If the county's allotment of the Primary Road fund is not sufficient to pay any claims for the above named classes of improvement, said claims may be paid by the county through the issuance of road certificates in anticipation of the county's allotment from the Primary Road fund for the ensuing year or through the issuance of bonds if the county has voted a bond issue for the purpose.

Claims for twelve and one-half (12½) percent of the cost of hard surfacing shall be paid by the county from special assessments or through the issuance of special assessment certificates in anticipation of the collection of such assessments.

The Primary Road Development fund will be expended in paying the costs of construction of certain projects as may be determined by the Highway Commission.

### Cost of Engineering

The cost of all engineering supervision, including salaries, mileage, meals, supplies, and all miscellaneous items of expense incident to the engineering supervision on Federal Aid and Primary projects shall be billed on Form No. 308 and shall be approved and paid in the same manner as other claims.

### Personal Expense Accounts

All the instructions set forth in Part Three of Fiscal Regulations shall apply to personal expense accounts incurred in connection with construction work except that the manner of audit and payment of vouchers shall be as set forth under Part Four of Fiscal Regulations.

## PRIMARY BRIDGE CONSTRUCTION

### General

The same rules will apply to payments of bridge construction as set forth under payments on Primary Road Construction with the following changes:

The Bridge Project Number shall be considered the unit in preparing vouchers, estimates, etc.

## Forms Used

The following named forms shall be used:

- No. 308-B, Voucher or bill.
- No. 314-B, Estimate sheet.
- No. 315-B, Force account statement, material, etc.
- No. 316-B, Force account statement, payroll.
- No. 317, Daily material report, force account work.
- No. 318, Daily time report, force account work.

### Preparation of Estimate Form 314-B

The monthly estimates are to be prepared on Form No. 314-B. All data required by this form shall be added thereto. The data required by the various columns is as follows:

"Item No." The numbers entered in this column should be the same as those shown in the proposal form, for the culvert or bridge listed.

"Description." Show the exact size and kind of culvert or bridge, i. e., (2x2x35 Concrete Box Culvert).

Extra work shall be shown directly under the respective culvert or bridge on which such work was done or material furnished.

"Rates." List the agreed unit price.

"Sum of previous estimates." Show "Material and Construction" or "Completed" and amounts which have been allowed for each individual item.

"This estimate." Show "Material and Construction" or "Completed" and amount of each item included in this estimate.

"Totals to Date." In this column show the sum of the "previous estimates" plus "this estimate."

### Claims for Material or Labor

Anyone who performs labor or furnishes material, service or transportation in the construction of a bridge or road improvement, may file with the county auditor an itemized sworn statement of his claim (Section 10305, Code 1924). Such claim may be filed any time previous to the expiration of 30 days following the completion of the work.

### Certificate of Completion

It is the duty of the resident engineer to prepare and present to the board for signature certificates of completion on Form 435 immediately following the completion and acceptance of the work. This certificate determines the date from which the 30-day period for filing of claims begins to run. It is very essential that the exact and true date of completion be determined and certified to by Board and Commission.

### Final Estimate

The statute provides that payments shall be made on the basis of monthly estimates of labor performed and material

delivered; payment to be made for not more than 90 percent of said estimates and at least ten percent of the contract price shall remain unpaid at the date of the completion of the contract. The retained percentage shall be held for a period of 30 days after completion of the improvement and if no claims are filed within the 30-day period, the final estimate is due and payable. In case claims are filed the retained percentage or a portion thereof, in a sum not less than double the total amount of claims, will be held until the claims are disposed of or will be paid out in accord with order of court.

The sub-final estimate must show total quantities and total amounts due the contractor. The final estimate will repeat and show final quantities, but will call for the payment of the retained percentage only.

The filing of claims does not operate to withhold contractor's funds other than retained percentage.

Resident engineers shall prepare sub-final and final estimates promptly following the determination of the date of completion and acceptance of the work and these estimates should be promptly approved by the board and district engineer and sent in to the main office of the Highway Commission regardless of whether claims have been filed or not.

Final estimate will not be approved for payment by the Commission until the expiration of the 30-day period nor until it has been determined that same is due and payable under the provisions of the Code.

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