Utilizing Business Machines in Traverse and Earthwork Computations

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As an aid in overcoming the critical shortage of engineering manpower, the California Division of Highways has investigated and instituted procedures for calculation of traverse and earthwork data by means of punched card equipment already available in the California Highway Planning Survey tabulating section.

This paper outlines the general procedure used by the engineer in preparing the basic information for computation of traverse and earthwork data.

Samples show, on a standardized computation sheet, the required method of recording the fourteen different problem types currently being processed. The results are listed mechanically on a standardized traverse form.

Eleven samples for earthwork computations are also included, five of which show the acceptable methods of recording the terrain notes, and three the methods of recording the roadbed notes. Also shown are a method of recording data from contour-grading plans, a method of recording additions to the computed quantities for use in compiling data for the mass diagram, and a sample of a suggested form for transmitting the data to the tabulating section.

Included is a sample of the tabulated results of earthwork computations which is returned to the engineer. This tabulation lists the volume of excavation and embankment between each cross section and gives totals for each station. The data furnished will also enable the engineer to prepare a mass diagram.

This paper also outlines some of the changes in procedure necessary on the part of the engineer to make fullest use of this computing service.

While the whole procedure calls for a somewhat different approach to the problem on the part of the engineer, we have found that the savings in both time and money have made this service well worth the effort.

● THE California Division of Highways has been investigating means of reducing the elapsed time and engineering man hours necessary to produce the engineering plans for its expanded highway construction program. The Division has particularly been concerned with the time consumed in computing traverses, plotting and planimetering cross sections, and calculating earthwork quantities. The time required to make and check the traverse computations and to calculate the earthwork quantities manually has been a considerable drain on skilled engineering manpower and has also been a significant portion of the cost of preparing the plans.

For the past 19 years the Division of Highways has utilized conventional tabulating equipment for the solution of many problems. These machines have been employed in the analysis of origin and destination surveys including the assignment of trips to proposed facilities, of construction and maintenance costs, traffic accident reports, personnel statistics, road life studies, road inventories, status of highways, and for many other tasks.

Aware of the rapid development and extended use of electronic computers and automatic calculating processes in scientific, industrial, and business fields, the Division has been seeking methods to short-cut the expensive drudgery of manual calculations.

In January 1955, the writers were assigned the task of finding which, if any, calculations made by engineers in the eleven district offices of the Division of Highways could be adapted to machine computation. There is little doubt that complete automation would be possible for many problems on the complex and expensive electronic computing machines now available. The immediate target, however, was an approach to automation through the use of equipment already available in the tabulating section of the California Highway Planning Survey.

F. M. Reynolds of the California Highway Planning Survey and J. C. Young, Design Engineer, impressed upon the writers that the reason for the investigation was the ultimate release of engineering personnel, now performing the computations, for engineering functions. Comparative costs were to be considered but were not necessarily to control.

In the California Division of Highways, all phases of the preparation of plans except bridge design are the responsibility of the various district offices, and therefore almost all engineering computations are made in these district offices.

Upon investigation it was decided that the greatest immediate over-all benefit would be the application of the equipment to traverse computations such as are involved in location surveys, intersection design, and right-of-way engineering.

The key to the problem of traverse computation was found in a procedure for obtaining the sine and cosine of a bearing accurately to seven decimal places.

As the planning and procedure writing progressed, a traverse computation service was made available on a trial basis to selected units. By July 1955 eight types of traverse problems were considered adequately tested and all districts were informed of the required procedures and the service made available for their use. By November 1, the following fourteen problem types were in use:

1. Traverse computation where all sides and bearings are known. This may be used for original computations in coordinating a traverse or as a check of original computations.

2. Traverse computations where the lengths of two sides are unknown.

3. Traverse computation where the length of one side and the bearing of another side are unknown.

4. The problem described as Type 1 where, in addition, the area within the closed traverse is desired.

5. The problem described as Type 2 where, in addition, the area within the closed traverse is desired.

6. Traverse computation where the length of one side and the bearing of that same side are unknown.

7. The problem described as Type 3 where, in addition, the area within the closed traverse is desired.

8. The problem described as Type 6 where, in addition, the area within the closed traverse is desired.

9. Traverse computation where the bearings of two sides are unknown and the area within the closed traverse is desired.

0. Traverse computation where the bearings of two sides are unknown.

C. Traverse adjustment by compass rule.

D. Traverse adjustment by compass rule where, in addition, the area within the closed traverse is desired.

T. Traverse adjustment by transit rule.

U. Traverse adjustment by transit rule where, in addition, the area within the closed traverse is desired.

Appendix A contains the instructions to the engineer on how to submit the above problem types for machine calculation. It also shows samples of properly submitted traverses and their tabulated results.

To make use of this service, the engineer in the district office, when confronted with a traverse such as the typical example shown in Figure 1, fills out a portion of a traverse sheet with the necessary data, as shown in Figure 2. However, instead of making the usual routine computations, he goes on to more productive work. These traverse sheets are gathered up and mailed into Headquarters daily; air mail is used where it will materially shorten the time in transit.

When the traverse sheets reach the tabulating section the data are first punched on cards, one course to a card. The cards are verified by a second punching operation and are then ready for the calculator.

The bearings are reduced to radians, the sine and cosine computed by the truncated formulas:

$$\text{Sine } x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \ldots + \frac{x^{13}}{13!}$$

$$\text{Cosine } x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \ldots - \frac{x^{14}}{14!}$$

and the results punched on the cards in one pass of the cards through the calculator.

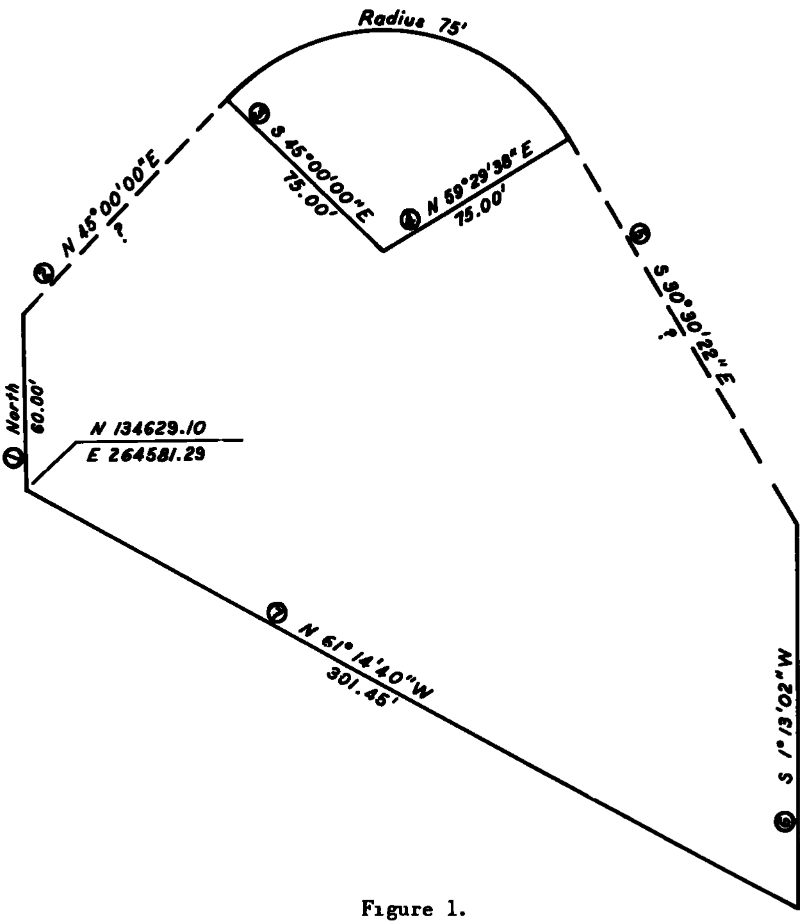

Figure 1.

The process developed depends on a modified IBM Electronic Calculator, Type 604. However, the following six other types of conventional equipment are also required in the process:

Type 024 - Key Punches	Type 082 - Sorters
Type 056 - Verifiers	Type 402 - Tabulators
Type 077 - Collators	Type 513 - Reproducing Punches.

To process all 14 problem types, 96 separate steps are taken using the above equipment, and 19 different wiring panels are utilized in the Type 604 Calculator. Some of these panels accomplish more than one function.

From a tabulating standpoint the volume of cards handled daily in processing these traverse problems is small. However, since calculations are repetitive in nature it is possible to prepare boards which are kept wired permanently for the various steps of each problem type.

This type of equipment is admittedly not the most efficient for these calculations. However, the volume of calculations has not been sufficient to warrant one of the more expensive computing machines at this time.

CHPS TRAVERSE SHEET

PROBLEM TYPE 1 All sides & bearings known; 2. Two sides unknown; 3. 1 side & 1 bearing unknown; 4. Type 1 with area; 5. Type 2 with area; 6. 1 side & its bearing; 7. Type 3 with area; 8. Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
5	13	A	12	8

STATION	CRS NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00				>	13462910	26458129
	1	60000	N000000E				
	2	?	N450000E				
	(3)	75000	S450000E				
	4	75000	N592938E				
	5	?	S303022E				
	6	130625	S 11302W				
	7	301450	N611440W				
	99					13462910	26458129
Add	3	75000	1042938				

Ref. Data — Punch — Verify — Calc Date — Chk Date — Plot Date — Chk Date — Dist Co Rte Sec. — Item — Sheet — Book

Figure 2.

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse
5	13	A	12	8

Course	Distance (Area in Square Feet)	Bearing	Cosine	Sine	Sign	Latitude or Area in Acres	Sign	Departure or Sine of Delta	North Progressive	East Totals	Neg or Unknown
									13462910	26458129	
1	60000	N000000E	10000000			6000					
									13468910	26458129	
2	(101780)	N450000E	7071068	7071068		7197		7197			*
									13476107	26465326	
3	75000 *Calculated Unknowns*	S450000E	7071068	7071068	*	5303		5303			
									13470804	26470629	
4	75000	N592938E	5076303	8615750		3807		6462			
									13474611	26477091	
5	(152540)	S303022E	8615750	5076303	*	13142		7743			*
									13461469	26484834	
6	130625	S011302W	9997743	0212429	*	13060	*	277			
									13448409	26484557	
7	301450	N611440W	4810738	8766801		14502	*	26428			
									13462911	26458129	
99											*
								Error of closure	(1) *		
						(01)	*		1	99999999 *Error of closure to end coordinates*	
	Traverse Area 44907					1031					
3	*Segment Area* 2406					055		(9681743) ← *sine of delta*			
	Net Area 47313		*(Sq Ft)*			1086 *(Acres)*					

Problem Type 1 All sides & bearings known; 2 Two sides unknown; 3 1 side & 1 bearing unknown; 4 Type 1 with area; 5 Type 2 with area; 6 1 side & its bearing; 7 Type 3 with area; 8 Type 6 with area

* South * West

Figure 3.

After all the calculations have been completed and the traverses have been listed they are separated by district and mailed. As a general rule, the traverses are processed and mailed out the same day they are received.

In general, no inspection or check of the finished tabulation is made before mailing. The users of this service have found that a detailed check of the computations is not necessary. A check of the traverse sheet before submitting it for computation, together with an inspection of the error of closure, end coordinates, and closure to end coordinates on the completed tabulation will usually show up any significant error.

It is interesting to note that wherever possible each unknown is calculated separately instead of using a forced closure procedure. This provides an additional check of the work.

A sample of the tabulation which is returned to the originator of the traverse is shown in Figure 3.

The whole procedure calls for a somewhat different approach to the problem of traverse calculations on the part of the engineer. One of the greatest obstacles to overcome was the reluctance of the engineers to tolerate a waiting period of approximately one and one-half days between submittal of the problem and the return of the completed computations. At first many of the engineers did not believe this delay was tolerable, as they had been accustomed to using the answer of one calculation as a known quantity to continue on to the next calculation, a procedure which resulted in a string of interdependent traverses. When the engineer made his own calculations there was no object in trying to avoid this situation.

However, to obtain maximum benefits from the new service, the engineer must plan his work to avoid interdependent traverses wherever possible. Controlling networks must be submitted in advance of detailed computations so as not to hold up later work. He should write as many independent traverses as possible for one portion of the work, and then go on to other sections of the job while the computations are being done for him. As an aid in this procedure, certain noncritical distances or bearings may be measured from a scale drawing of the area, leaving, for example, only two unknowns to be solved on a ramp control line.

The change from the usual procedure is difficult for the engineer to get used to, but the saving in time and money makes it well worthwhile. This procedure, of working on more than one section of a job at a time, has been accepted almost universally by the engineering personnel involved in these computations. Short-cuts are being developed within the various design sections, and timing is being revised so that engineering computations are not concentrated at a given time in the design cycle.

In planning for traverse calculations every attempt was made to keep to a minimum the changes in forms and procedures as they affect the engineer. The form used to submit the data for processing can be used by the engineer for manual calculations as well, since it is similar to our previous traverse sheets. Added to our standard traverse sheet are blocks which show problem type, district, group letter, batch number, and traverse number. A column for course number was also added. These are to facilitate processing of the cards and identifying the completed tabulations for return to the originator of the traverse.

Distances may be recorded to an accuracy of $^{1}/_{1000}$ of a foot. However, latitudes and departures and coordinates are rounded to $^{1}/_{100}$ of a foot at the end of each course. When the engineer desires to obtain latitudes and departures and coordinates to $^{1}/_{1000}$ of a foot, he moves the decimal point for distances and coordinates when recording the data on the form. Bearings are recorded to seconds. The calculations of the sine and cosine are accurate to seven decimal places, which is considered sufficient since a distance would have to be greater than 10,000 feet before accuracy of $^{1}/_{1000}$ of a foot is lost.

The procedure used in calculating unknowns by use of the tabulating equipment sometimes gives slightly different answers when compared with manual calculations. For example, an engineer calculating two unknown sides in a traverse normally calculates one unknown side and then forces a closure on the second unknown side. With the tabulating procedure setup, each side is calculated separately. Under the manual approach, in most cases the traverse will show zero error of closure. Under the tabulating machine approach, since the closure is not forced, several hundredths of a foot for the error of closure can appear. The failure to close is bothersome to many engineers as they were accustomed to obtaining a mathematical closure but has the advantage that the error may be distributed by the engineer in a logical manner.

To date we have found the procedure gives remarkably accurate results. The few errors we have found were usually due to human failure. In most cases errors are very apparent as the traverse does not close. Due to the volume being processed it is not possible to note all the nonclosing traverses and have them investigated. In the large majority of cases the reason for the nonclosure was that faulty data was submitted, such as a reverse direction on a bearing, an incorrect distance, or, in the attempt to get 1/1000 of a foot accuracy, forgetting to move the decimal place in both the recorded distances and starting and ending coordinates. These errors are left to the engineer, who submits the problem, to locate and correct.

Although comparative costs were not considered as important as a saving in engineering time in the planning of the program, it turns out that the saving in cost is not negligible. When we were processing a minimum number of problem types it was estimated that if we could process a thousand courses a day the average cost per course would be under five cents. This estimate includes labor and machine rental. This compares with estimated cost of 13 cents per course when done manually, checking not considered. At present we are processing from 1,000 to 3,000 courses daily. This takes from 12 to 24 man-hours of key punch and tabulating machine operator time.

To obtain an estimate of saving in engineering time is rather difficult since there is no such thing as a typical job and the approach to the problem had to be revised for greatest efficiency. However, the users of the service have informed us that savings are definite. Examples are as follows: (a) One squad leader formerly used from three to five men for calculating in the designing process. He now uses from one to two. (b) One man volunteered the information that he designed an interchange in approximately one-half the time it used to take him. (c) A squad leader informed us that one of his

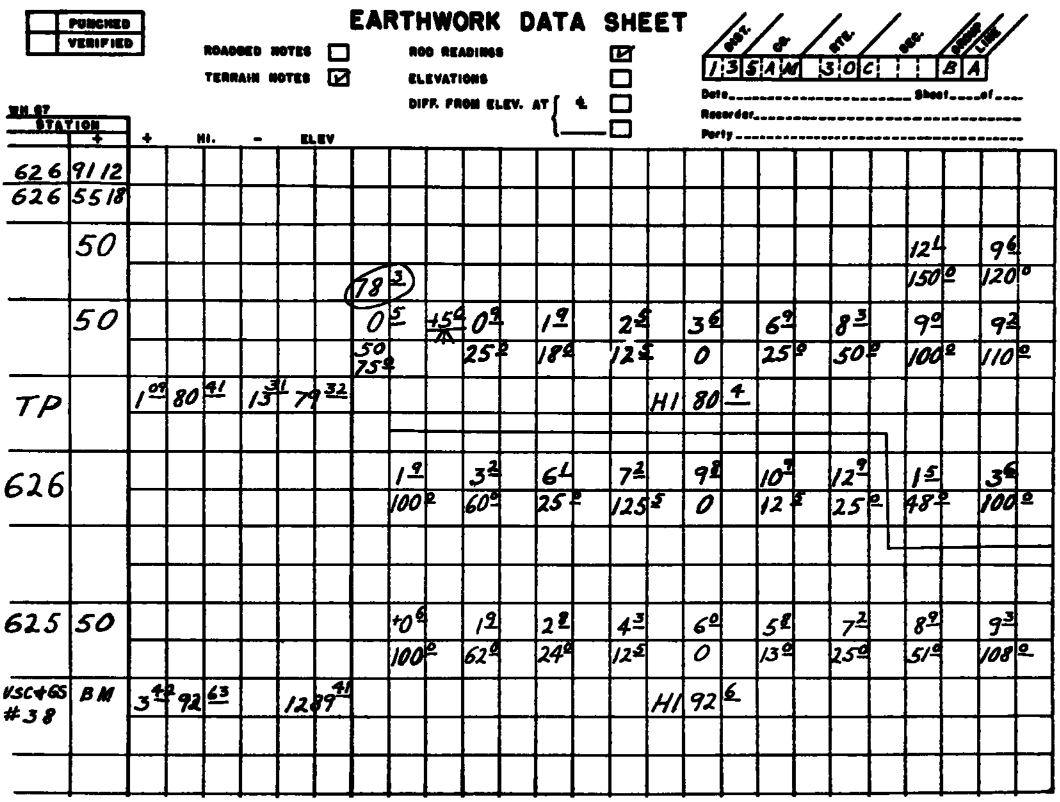

Figure 4.

men completed the geometric design of three freeway interchanges in two weeks.

Before all of the above-listed problem types were programmed and tested, three districts were selected to work with us in planning the procedures for earthwork calculation. We were aware that some work was being done by other states in the machine calculation of earthwork quantities from cut and fill construction notes. However, it was realized that an even larger percentage of time would be saved if it became unnecessary to plot each cross section to scale for planimetering to arrive at the earthwork quantities in the design stage. The procedure that we have set up enables us to take the terrain data from one source and the roadbed data from another, bring them together for the calculation of two catch points in each cross section, and then continue for the calculation of the end areas by the trapezoidal rule and volumes of excavation and embankment by the average end area method. Thus our calculations may be used for preliminary earthwork quantities in the design stage or for final pay quantities in the construction stage.

Again, changes for the engineer from his usual methods of keeping notes were kept to a minimum consistent with machine processing of the data. Appendix B contains instructions to the engineer on how to submit earthwork data for machine computations. It contains samples of properly filled out data sheets.

Terrain notes or original ground cross sections may be submitted as true elevations, as rod readings, or as a difference in elevation from centerline or offset line. Transcribing of field notes prior to punching is not generally necessary. Figure 4 shows a sample of terrain notes based on rod readings. Roadbed template notes may be submitted as true elevations or as a difference in elevation from centerline or offset line. Figure 5 shows a sample of roadbed notes based on difference in elevation from centerline. Roadbed notes may be given to subgrade or to finished grade, in which case correction quantities may be submitted in tabular form. Thousands and hundreds of feet may be omitted from the elevations as long as they are recorded on the same basis for both terrain and roadbed notes for each cross section.

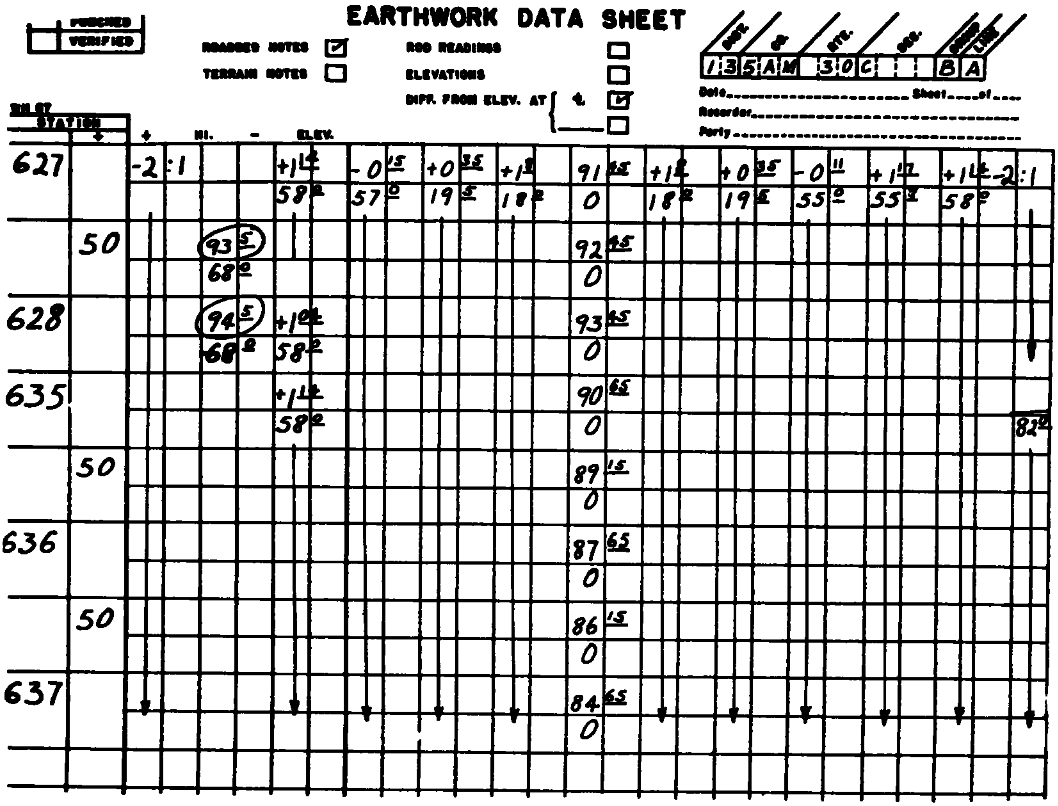

Figure 5.

EARTHWORK QUANTITY SHEET

DIST	COUNTY	ROUTE	SECTION	GROUP	LINE	STATIONING	+	SHRINKAGE FACTOR	EXCAVATION		EMBANKMENT		MASS DIAGRAM ORDINATE
									END AREA SQ FT	CUBIC YARDS	END AREA SQ FT	CUBIC YARDS	
2	TEH	29	E	A	E	473	00.00	.8500			300.7		
											*	622.4	* 96847
							50.00	.8500			371.5		
											*	748.1	* 96099
											*	1370.5	*
						474	00.00	.8500			436.4		
											*	405.5	* 95693
							25.00	.8500			439.5		
											*	414.1	* 95279
							50.00	.8500			455.0		
											*	755.4	* 94524
											*	1575.0	*
						475	00.00	.8500			360.8		
											*	270.5	* 94253
							20.00	.8500			369.5		
											*	242.6	* 94010
							35.00	.8500			503.7		
											*	231.2	* 93779
							50.00	.8500			328.5		
										7.2	*	423.9	* 93361
										7.2	*	1168.2	*
						476	00.00	.8500	7.8		129.3		
										7.3	*	281.3	* 93086
							50.00	.8500	.1		174.5		
										122.9	*	211.9	* 92979
										130.2	*	493.2	*
						477	00.00	.8500	132.6		54.3		
										805.6	*	50.3	* 93613
							50.00	.8500	737.5				
										1729.4	*		* 95083
										2535.0	*	50.3	*
						478	00.00	.8500	1130.3				
										2069.6	*		* 96842
							50.00	.8500	1104.9				
										1860.5	*		* 98423
										3930.1	*		*
						479	00.00	.8500	904.4				
										1242.8	*		* 99479

Figure 6.

The following tabulations are furnished to the engineer: (1) a tabulation of reduced notes for terrain and roadbed, containing elevations and distances from centerline to a tenth of a foot; (2) a tabulation of catch point elevations and distances from centerline which is used in plotting the limits of the work for right of way acquisition and for use in slope staking; (3) a tabulation showing stations, end areas, quantities, shrinkage factors, and mass diagram ordinates. A sample of this tabulation is shown in Figure 6.

The quantities for each side of a divided highway may be computed separately and subsequently combined with quantities for frontage roads, ditches, and corrections for the structural sections to provide totals and mass diagram ordinates by stations.

Although a basic procedure has been set up for earthwork, each job has a certain amount of work that requires individual attention.

The cost by station of computing earthwork quantities by machine is not uniform. The cost of punching is directly proportional to the number of points used for the roadway and for terrain. The cost of processing the cards is dependent on the number of points involved, the number of cross sections taken, and the type of processing required. These factors vary considerably in different areas of the state and depend upon the type of terrain and the facility proposed for construction. Further savings in design time can be realized, however, by the re-use of the terrain data for several trial lines. Occasional savings can be made in the re-use of roadbed notes when uniform portions of roadbed data from one trial line can be used in subsequent lines.

The procedure as set up arranges for the notes to be transmitted to the key-punch section in installments to reduce the punching load. It has been determined that a key-punch operator will punch and verify over 1,200 points per man-day of terrain or roadbed notes.

On a divided highway project, ten miles in length, through rolling country, the engineer was furnished, within ten working days after the completion of the punching phase, computed elevations and distances from centerline of catch points, end areas and volumes of cut and fill, and ordinates for a mass diagram. Several projects of this sort may be in process simultaneously. Processing of the cards was accomplished by tabulating personnel supervised by professional personnel in a non-engineering classification. This compares with estimates of four engineering man-months to do the equivalent work in the district office.

While our use of business machines for earthwork computations has not been made available to all districts in the Division of Highways at this time, since we still consider it to be in the trial stage, indications are that savings in engineering time and cost realized in this computation procedure may exceed the savings that are being realized by the machine computation of traverses.

It is realized that further savings will occur should the volume of this work increase, requiring the use of a more advanced type of computer such as an IBM Type 650 Drum Calculator. Not only is it expected that the cost will be reduced but the over-all processing time after the key-punch phase will also be reduced materially.

Appendix A

Instructions for Calculation of Traverse Data by Punched Cards

The traverse computation service is furnished by the Tabulating Section of the California Highway Planning Survey. It may be used either for original computations or as a check of the districts' calculations.

This service is limited to the problem types listed below. The necessary information is to be furnished on Form WH-328 in accordance with the following instructions:

Fill in the blocks in the upper right-hand corner for identification purposes during processing as follows:

Problem Type

Record the number of the problem type from the following list:

1. Traverse computation where all sides and bearings are known. This may be used for original computations in coordinating a traverse or as a check of original computations.
2. Traverse computations where the lengths of two sides are unknown.
3. Traverse computation where the length of one side and the bearing of another side is unknown.
4. The problem described as Type 1 where, in addition, the area within the closed traverse is desired.
5. The problem described as Type 2 where, in addition, the area within the closed traverse is desired.
6. Traverse computation where the length of one side and the bearing of that same side are unknown.
7. The problem described as Type 3 where, in addition, the area within the closed traverse is desired.
8. The problem described as Type 6 where, in addition, the area within the closed traverse is desired.
9. Traverse computation where the bearings of two sides are unknown and the area within the closed traverse is desired.

0. Traverse computation where the bearings of two sides are unknown.
C. Adjustment of traverse by compass rule.
D. Adjustment of traverse by compass rule plus area of the adjusted traverse.
T. Adjustment of traverse by the transit rule.
U. Adjustment of traverse by the transit rule plus area of the adjusted traverse.

District

Record the district in arabic numerals.

In Districts IV and VII, for ease in distribution, separate district numbers for use by sections submitting this work are assigned as follows:

District IV. 4 - R/W Engineering; 24 - Design - J. C. Black; 34 - Design - W. P. Smith; 44 - Design - A. E. Simmons; 54 - Design - J. A. Spence; 64 - Surveys; 74 - Administration - H. S. Miles; 84 - Construction.

District VII. 7 - Design A - J. E. Eckhardt; 17 - Design B - E. G. Hanson; 27 - Design C - L. S. Van Voorhis; 37 - R/W Engineering; 47 - Surveys; 57 - Construction.

Headquarters departments will use District 13. The Division of Water Resources will use District 73.

Other sections or districts desiring special district number assignments for this work may request them from the Tabulating Section.

Group Letter

Record the group letter assigned to you.

Group letters A through Z should be assigned within the district to various departments or sections which will be submitting work. The Tabulating Section should be furnished a list by the district showing the person or section to which each group letter is assigned.

If the district desires that work submitted under various group letters be mailed separately to reduce the time loss in distributing the completed calculations, this fact should be indicated on the list. Please inform the Tabulating Section of changes in group letter assignment.

Batch Number

Within each group, give a batch number to each separate transmission of traverses to headquarters. The numbers from 1 to 99 may be used.

Traverse Number

Within each batch, number traverses to a maximum of 99.

The same group, batch, and traverse designation should not be repeated within five working days.

The body of the sheet is to be filled in as shown below. Also, see the special remarks for the particular problem types that appear after these general instructions. To facilitate the card-punch operation, vertical lines have been ruled in the various columns on the sheet. Place only one figure to a square, oriented with the dashed line as the decimal.

Station

This column need not be filled in except for the recording of "add" or "subtract" for segments of circular areas as discussed under Problem Types 4, 5, 7, 8, and 9 below.

It may be used for supplemental notes for district use if desired.

Course Number

Identify as Course 00 the beginning coordinates of the traverse. Then number the courses consecutively from 1 to a maximum of 98.

In all traverses containing unknowns, identify the ending coordinates as Course 99. This must be done for both closed and open ended traverses.

When Problem Types 4, 5, 7, 8, and 9 contain circular segments, certain course numbers are to be circled as discussed under these problem types.

Distance

Record the distances to thousandths, using the dashed line as the decimal and filling all the spaces to the right of the decimal. The maximum distance that can be handled either as given data or the solution of an unknown is 99,999.999.

In traverses containing unknowns, place a question mark in the spaces where the unknowns occur.

Bearing

Record the bearing in degrees, minutes, and seconds. Decimals of seconds cannot be handled. Due north should be recorded as N 00-00-00 E, due west as N 90-00-00 W, etc.

In traverses containing an unknown, place a question mark in the space where it occurs.

In Problem Types 4, 5, 7, 8, and 9 containing circular segments, the delta of the arc is recorded in the bearing column below the regular traverse as discussed under these problem types.

Functions

These columns need not be filled in, as the functions are computed by the punched card equipment. The columns appear so that the forms may be used for district computation as desired.

Coordinates

Fill in the coordinates of the origin of the traverse to two decimals opposite Course 00. The California Coordinate System should be used when the work in on that basis. If these are not available, coordinates should be assumed preferably of such size that negative coordinates do not occur, even at the center of long radius curves.

In all traverses containing unknowns, record the ending coordinates after the last course of the traverse and identify as Course 99. This must be done for both closed and open ended traverses.

The coordinates of Course 00 and Course 99 may only be given as positive or zero. However, if the traverse proceeds into another quadrant, the true negative coordinates will be tabulated. Therefore, to record a traverse occurring in other than the NE quadrant begin on a zero coordinate line and use one or more courses with bearings of 90 degrees or 0 degrees to go to the beginning of the traverse, and, if course 99 is required, return in the same manner.

General Notes

Do not place more than one traverse on a single sheet. All latitudes, departures, and unknown lengths are calculated to thousandths of a foot, and printed to the nearest hundredth.

An asterisk preceding a number on the tabulation sheet indicates a negative number.

On the completed tabulation sheet, the error of closure will appear after the last course in the latitude and departure columns. This figure should be examined for closed traverses to see that it is within allowable limits before further use is made of the traverse. In open ended traverses, the figures in this position give the latitude and departure of the closing course.

Where unknowns are involved and a Course 99 is given, the difference between the tabulated coordinates of the end point of the traverse and the given coordinates of that point, if any, will appear in the coordinate columns on the line below the listing of Course 99. The last set of numbers in the coordinate columns are meaningless and should be ignored.

Remember that the Headquarters personnel working with your sheets are not engineers. To avoid errors, follow these instructions carefully and write clearly.

Traverse sheets for computation should be mailed to: G. T. McCoy, Attention CHPS Tabulating Section, Room 547, Public Works Building, Box 1499, Sacramento 7, California.

To reduce delay in the mail it is recommended that the traverse sheets be mailed separately by the districts, and not included in the regular bulk mailing. The use of air mail is suggested where this will materially reduce the time in transit.

Traverse sheets will not be returned to the district with the completed tabulations except where errors or incorrect recording methods are found.

The calculations for these problems are based on seven place functions, and latitudes and departures correct to one hundredth. Therefore, closures on problems involving flat angle intersections or extremely unbalanced length of sides in the two unknowns, and which usually involve special calculation procedures in the district, may require adjustments by the engineer when the tabulations are returned.

If it is desired to use thousandths in the coordinate field or to obtain unknown distances to thousandths, it is necessary to record both the distances and coordinates one space to the left of the usual position.

Special Notes for Problem Types 4, 5, 7, 8, and 9

Where the area desired is bounded in part by curves, list the traverse as passing through the center of the curve (BC to R, and R to EC) and circle the course number of the first of the two radius courses. In this case the traverse may not start at the center of a curve. Also, record at the bottom of the traverse the circular segment to be added to, or subtracted from, the traverse area as follows:

1. Indicate in the Station Column "add" if the segment is to be added to the traverse area or "subtract" if it is to be subtracted to obtain the net area.
2. Record the course number of the circled radius.
3. Record the radius in the distance column.
4. Record the delta of the curve in the bearing column.

The area bounded by the long chord of the curve will then be calculated and listed, the areas of the segments and the net area of the traverse will be computed and listed.

The delta of curve segments must be given by the engineer. It cannot be computed from an unknown radial bearing in Problem Types 7, 8, or 9.

The area of segments with a delta greater than 180 degrees cannot be computed by the machine. In cases where this occurs the traverse may be written so as to split the curve into two segments.

On curves of large delta and long radius where the long chord would cut other lines of the traverse, the curve must be broken into smaller segments, as in the manual procedure, to avoid a false area.

Note that we do not handle areas containing circular segments in Problem Types D and U.

Special Notes for Problem Types 3, 7, 9, and 0

Since there are usually two possible solutions to Problem Types 3, 7, 9, and 0 the person submitting these problem types will have to provide for two solutions by indicating in the traverse block two numbers that are consecutive. Both solutions will be returned, one under each of the traverse numbers indicated. The engineer will discard the unwanted solution.

Special Notes for Problem Type 6

Where a series of coordinates are known and the distance and bearing of the courses are desired, they may be listed as Problem Type 6, as shown in the sample traverse numbered 31 to 37. In this case, each course is tabulated as a separate traverse and one traverse number must be allowed for each course.

List the coordinates in order on the sheet. Number the first set as Course 00; the last, 99. Do not number the intermediate courses or coordinates.

Special Notes for Problem Types C, D, T, and U

The data for traverse adjustment may be transmitted to Headquarters in one of two ways. The first, shown in traverse 10, is by returning a tabulation sheet marked as follows:

Cross out the original problem type and write in the letter for the problem type desired. If both compass and transit adjustment are desired, two letters may be used on the one tabulation. The group, batch, and traverse numbers may remain the same, or can be changed, if desired, by crossing out the printed one and writing a new one below.

At the bottom of the traverse, below all other figures, write 99 in the course column, and opposite this in the coordinate columns, write the end coordinates to which the traverse should be adjusted. These may be the same as the 00 coordinates, or may be different. Where the information is submitted on a tabulation sheet, it will be returned to the district with the adjusted tabulation.

If the original traverse has been computed in the district, the work may be submitted as in Traverse 11. Only the data required by the tabulating section is shown on the sample. Bearings and functions may be recorded if desired. Do not include intermediate coordinates. Two problem type letters, C and T or D and U, may be recorded if desired. The coordinates of the origin are recorded and identified as Course 00. Courses are numbered and listed in order, and the distances recorded. Calculated latitudes and departures are recorded in the coordinate field to hundredths. North and east are shown by a plus sign, and south and west by a minus sign. The end coordinates to which the traverse is to be adjusted are listed at the end and identified as Course 99. These may be the same as the 00 coordinate, or may be different.

Since in adjusting a traverse any pairs of radii will not usually remain the same length, and since the delta between them will change in the adjustment, we are not prepared to handle areas containing circular segments in Problem Types D and U. The area furnished will be that bounded by the traverse lines. You are cautioned that, as in the manual procedures, when any course crosses another, a false area will result.

Sample Traverse Sheets

CHPS TRAVERSE SHEET

PROBLEM TYPE 1 All sides & bearings known; 2 Two sides unknown; 3 1 side & 1 bearing unknown; 4 Type 1 with area; 5 Type 2 with area; 6 1 side & its bearing; 7 Type 3 with area; 8 Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
1	13	A	4-8	12

STATION	CSE NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00					20163529	11346212
	1	62340	N621321W				
	2	2113955	S123529E				
	3	29150	S631400W				
	4	1011.620	N 11300E				
	5	645	S845931W				
	6	136244	N302000E				

TRAVERSE COMPUTATIONS

* South or West

Problem Type	District	Group	Batch	Traverse	Course	Distance (Area in Square Feet)	Bearing	Cosine	Sine	Latitude (Area in Acres)	Departure (Error of Closure)	North Progressive	East Totals	Seq Ck
1	13	A	48	12								2016352[illegible]	11346[illegible]12	
					1	62340	N621321W	4660392	8847640	2907	5516	20166434	11340606	
					2	2113955	S123529E	9759495	2179966	* 20631	4608	20145803	11345304	
					3	29160	S631400W	4503502	3928480	* 1313	2604	20144400	1134[illegible]700	
					4	1011620	N011302F	9997743	0212429	101139	2149	202455[illegible]9	1134[illegible]49	
					5	645	S895931W	0001406	10000000		65	20[illegible]45529	11344734	
					6	136244	N302000E	8631019	5050299	11759	6881	20[illegible]57358	11[illegible]51665	
										93859	5453	202573[illegible]8	11[illegible]51665	

Closure

CHPS TRAVERSE SHEET

PROBLEM TYPE
1. All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5. Type 2 with area
6. 1 side & its bearing
7. Type 3 with area
8. Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
2	13	A	48	13

STATION	CSE NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00					13035733	20802897
	1	199510	N755838W				
	2	?	S140122W				
	3	1218330	N323753E				
	4	?	N573207E				
	99					13035733	20802897

Ref Data

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TRAVERSE COMPUTATIONS

* South or West

Problem Type	District	Group	Batch	Traverse	Course	Distance	Bearing	Cosine	Sine	Latitude		Departure	Coordinates North Progressive	Coordinates East Totals	Seq. Ct.
2	13	A	48	13									13035733	20802897	
					1	199510	N755838W	2423076	9701995	4834	*	19356	13040567	20783541	
					2	1217750	S140122W	9701995	2423076	* 118146	*	29507	12922421	20754034	*
					3	1218330	N323753E	8421571	5392322	102603		65696	13025024	20819730	
					4	199510	N573207W	5367802	8437221	10709	*	16833	13035733	20802897	
					99								99999999	99999999	

Handwritten notes: "Unknowns" (pointing to the circled distances for courses 2 and 4); "Zero error of closure to end coordinates" (pointing to 99999999 99999999).

CHPS TRAVERSE SHEET

PROBLEM TYPE
1. All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5. Type 2 with area
6. 1 side & its bearing
7. Type 3 with area
8. Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO.	TRAV NO
3	13	A	48	14 15

STATION	CSE NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00					13064050	20938710
	1	?	N374146E				
	2	759620	S830729E				
	3	652359	?				
	99					13045863	21089541

TRAVERSE COMPUTATIONS

* South or West

Problem Type / District / Group / Batch / Traverse	Course	Distance	Bearing	Cosine	Sine		Latitude / Error of Closure	Departure	North Progressive	East Totals	Seq. Ck.
313A4814									13064050	20938710	
	1	384590	N374146E	7912650	6114733		30431	23517	13094481	209622[illegible]7	*
	2	759620	S830729E	1197085	9928091	*	9093	75416	13085388	21037643	
	3	652359	S524226E	6058881	7955498	*	39526	51898	13045862	21089541	*
	99								* 1	*	*
						*	18188	150831	99999998	99999999	

Unknowns

Error of Closure to end coordinates

Note

The alternate solution is shown as traverse #15. The engineer must decide which to use.

TRAVERSE COMPUTATIONS

* South or West

Problem Type / District / Group / Batch / Traverse	Course	Distance	Bearing	Cosine	Sine		Latitude / Error of Closure	Departure	North Progressive	East Totals	Seq. Ck.
313A4815									13064050	20938710	
	1	393770	N374146E	7912650	6114733		31158	24078	13095208	2096278[illegible]	*
	2	759620	S830729E	1197085	9928091	*	9093	75416	13086115	21038204	
	3	652359	S515404E	6170206	7869470	*	40252	51337	13045863	21089541	*
	99								*	*	*
						*	18187	150831	99999999	99999999	

Unknowns

See note on traverse #14

CHPS TRAVERSE SHEET

PROBLEM TYPE
1. All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5. Type 2 with area
6. 1 side & its bearing
7. Type 3 with area
8. Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
4	13	A	48	16

STATION	CSE NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00					10000000	20000000
	1	103422	N 00 41 40 W				
	(2)	75000	S 45 00 00 E				
	3	75000	N 59 29 38 E				
	4	101162	S 01 13 02 W				
	(5)	100000	S 19 30 00 W				
	6	100000	N 30 10 00 W				
Add	2	75000	1 04 29 38				
Subtract	5	100000	49 40 00				

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TRAVERSE COMPUTATIONS

* South or West

Problem Type	District	Group	Batch	Traverse	Course	Area in Square Feet / Distance	Bearing	Cosine	Sine		Area in Acres / Latitude / Error of Closure		Departure	Handwritten note	Coordinates North Progressive	Coordinates East Totals
4	13	A	48	16											10000000	20000000
					1	103422	N004140W	9999265	0141200		103414	*	1253		10103414	19998747
					2	75000	S450000E	7071068	7071068	*	5303		5303		10098111	20004050
					3	75000	N592938E	5076303	8615750		3807		6462		10101918	20010512
					4	101162	S011302W	9997743	0212429	*	101139	*	2149		10000779	20008363
					5	100000	S193000W	9426415	3338069	*	9426	*	3338		9991353	20005025
					6	100000	N301000W	8645673	5025170		8646	*	5025		9999999	20000000
										*	(01)	*		← Error of closure	9999999	20000000
						102947		Sq. ft. ← Area of traverse →			2363 acres					
					2	2406		← Area of circular segment →			055		9681743	← Sine of delta		
					5	523				(*)	012		7622920			
						104830		sq. ft. ← Net area →			2406 acres					

(*) Indicates this segment was subtracted

CHPS TRAVERSE SHEET

PROBLEM TYPE 1 All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5 Type 2 with area
6. 1 side & its bearing
7 Type 3 with area
8 Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
5	13	A	48	17

STATION	CSE NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00					13062072	20941226
	1	R	N374146E				
	2	787260	N815547W				
	3	R	S514924E				
	99					13062072	20941226

TRAVERSE COMPUTATIONS

* South or West

Problem Type, District, Group, Batch, Traverse	Course	Area in Square Feet: Distance	Bearing	Cosine	Sine	Area in Acres: Latitude	Error of Closure: Departure	Coordinates: North Progressive	East Totals	Seq Ch.
513A4817								13062072	20941226	
	1	394900	N374146E	7912650	6114733	31247	24147	13093319	20965373	*
	2	787260	N815547W	1403876	9900966	11052	* 77946	13104371	20887427	
	3	684360	S514924E	6180883	7861087	* 42299	53798	13062072	20941225	*
	99							*	* (1)	*
						*	* 01	99999999	99999998	
		135125				3102				
		135125	*S.F. ← area →*			3102 *acres*				

Unknowns (394900, 684360)

Error of closure (01)

Error of closure to end coordinate (1)

CHPS TRAVERSE SHEET

PROBLEM TYPE 1 All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5 Type 2 with area
6. 1 side & its bearing
7 Type 3 with area
8 Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
6	13	A	48	18

STATION	CSE NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00					13042679	26342196
	1	R	R				
	99					13165819	26153648

TRAVERSE COMPUTATIONS

* South or West

Problem Type, District, Group, Batch, Traverse	Course	Area in Square Feet: Distance	Bearing	Cosine	Sine	Area in Acres: Latitude	Error of Closure: Departure	Coordinates: North Progressive	East Totals	Seq Ch.
613A4818								13042679	26342196	
	1	225197	N565106W	5468084	8372578	123140	* 188548	13165819	26153648	*
	99							*	*	*
						123140	* 188548	99999999	99999999	

Unknowns (225197, N565106W)

CHPS TRAVERSE SHEET

PROBLEM TYPE 1 All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5 Type 2 with area
6. 1 side & its bearing
7 Type 3 with area
8 Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
6	13	A	48	31 to 37

STATION	CSE NO.	DISTANCE	BEARING (N/S, DEG, MIN, SEC, E/W)	COS	SIN	N	E
	00					19178072	28163510
		?	?				
						19162534	28161015
		?	?				
						19153120	28150379
		?	?				
						19173804	28101679
		?	?				
						19201657	28116389
		?	?				
						19316592	28263945
		?	?				
						19384562	28373440
		?	?				
	99					19374629	28363440

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CHPS TRAVERSE SHEET

PROBLEM TYPE 1 All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4 Type 1 with area
5 Type 2 with area
6. 1 side & its bearing
7 Type 3 with area
8 Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
7	13	A	48	19 20

STATION	CSE NO.	DISTANCE	BEARING (N/S, DEG, MIN, SEC, E/W)	COS	SIN	N	E
	00					13724591	24361015
	1	?	N 04140 W				
	(2)	75000	S 450000 E				
	3	75000	N 592938 E				
	4	1011620	?				
	(5)	100000	S 193000 W				
	6	100000	N 301000 W				
	99					13724591	24361015
Add	2	75000	1042938				
Subtract	5	100000	494000				

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TRAVERSE COMPUTATIONS

* South or West

Problem Type / District / Group / Batch / Traverse	Course	Distance (Area in Square Feet)	Bearing	Cosine	Sine	Latitude (Area in Acres)	Departure (Error of Closure)	Coordinates North Progressive	Coordinates East Totals
713A4819								13724591	24361015
	1	987890	N004140W	9999265	0121200	98782	* 1197	13823373	24359818
	2	75000	S450000E	7071068	7071068	* 5303	5303	13818070	24365121
	3	75000	N592938E	5076303	8615750	3807	6462	13821877	24371583
	4	1011620	S011832W	9997391	0228424	* 101136	* 2311	13720741	24369272
	5	100000	S193000W	9426415	3338069	* 9426	* 3338	13711315	24365934
	6	100000	N301000W	8645673	5025170	8646	* 5025	13719961	24360909
	99							* 4630	* 106
						* 4630	* 106	99995369	99999893
			102125			2344			
	2		2406			055	9681743		
	5		523			* 012	7622920		
			104008			2387			

Unknown (points to the circled 987890 and S011832W)

This traverse fails to close, which is an indication that the second solution (Trav. #20) is the acceptable one.

TRAVERSE COMPUTATIONS

* South or West

Problem Type / District / Group / Batch / Traverse	Course	Distance (Area in Square Feet)	Bearing	Cosine	Sine	Latitude (Area in Acres)	Departure (Error of Closure)	Coordinates North Progressive	Coordinates East Totals
713A4820								13724591	24361015
	1	1034230	N004140W	9999265	0121200	103415	* 1253	13828006	24359762
	2	75000	S450000E	7071068	7071068	* 5303	5303	13822703	24365065
	3	75000	N592938E	5076303	8615750	3807	6462	13826510	24371527
	4	1011620	S011302W	9997743	0212429	* 101139	* 2149	13725371	24369378
	5	100000	S193000W	9426415	3338069	* 9426	* 3338	13715945	24366040
	6	100000	N301000W	8645673	5025170	8646	* 5025	13724591	24361015
	99							*	*
						*	*	99999999	99999999
			102947	Sq Ft	Area of traverse	2363	acres		
	2		2406		Area of circular segments	055	9681743	Sum of Delta	See note on traverse #19
	5		523		" " "	* 012	7622920		
			104830	Sq Ft.	Net area	2406	acres		

* — Indicates the area was subtracted

CHPS TRAVERSE SHEET

PROBLEM TYPE
1. All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5. Type 2 with area
6. 1 side & its bearing
7. Type 3 with area
8. Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
8	13	A	48	21

STATION	CSE NO.	DISTANCE	BEARING N/S	DEG	MIN	SEC	E/W	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00									10000000	20000000
	1	683379	N	37	41	46	E				
	2	?			?						
	3	562899	S	70	49	58	E				
	99									10000000	20000000

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TRAVERSE COMPUTATIONS

* South or West

Problem Type	District	Group	Batch	Traverse	Course	Area in Square Feet / Distance	Bearing	Cosine	Sine	Area in Acres / Latitude / Error of Closure	Departure	Coordinates North / Progressive	Coordinates East / Totals	Seq Ck.
8	13	A	48	21								10000000	20000000	
					1	683379	N374146E	7912650	6114733	54073	41787	10054073	20041787	
					2	1014070	S692709W	3509938	9363815	* 35592	* 94956	10018481	19946831	*
					3	552899	S704958E	328[illegible]263	9445643	* 18481	53169	10000000	20000000	
					99							*	*	*
											*	99999999	99999999	
							182364			4187				
							182364 Sq. Ft		Area	4187 Acres				

Unknowns

CHPS TRAVERSE SHEET

PROBLEM TYPE
1 All sides & bearings known
2 Two sides unknown
3 1 side & 1 bearing unknown
4 Type 1 with area
5 Type 2 with area
6 1 side & its bearing
7 Type 3 with area
8 Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
9	13	A	48	3 4

STATION	CSE NO.	DISTANCE	BEARING	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00					13035733	20802897
	1	199510	N755838W				
	2	1217750	?				
	3	1218330	?				
	4	199510	N573207W				
	99					13035733	20802897

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse	Course	Area in Square Feet or Distance	Bearing	Cosine	Sine	Latitude Or Area in Acres / Error of Closure	Departure Or Sine of Delta / Error of Closure	Coordinates North Progressive	Coordinates East Totals	[illegible]
9	13	A	4J	3								13035733	20802897	
					1	199510	N755838W	2423076	9701995	4834	* 19356	13040567	20783541	
					2	1217750	N322751E	8437273	5367720	102745	65365	13143312	20848906	*
					3	1218330	S135120W	9709025	2394750	* 118288	* 29176	13025024	20819730	*
					4	199510	N573207W	5367802	8437221	10709	* 16833	13035733	20802897	
					99									*
												*	*	
										*	*	99999999	99999999	
							230414			529				
							230414			529				

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse	Course	Area in Square Feet or Distance	Bearing	Cosine	Sine	Latitude Or Area in Acres / Error of Closure	Departure Or Sine of Delta / Error of Closure	Coordinates North Progressive	Coordinates East Totals	[illegible]
9	13	A	48	4								13035733	20802897	
					1	199510	N755838W	2423076	9701995	4834	* 19356	13040567	20783541	
					2	1217750	S140119W	9702030	2422935	* 118146	* 29505	12922421	20754036	*
					3	1218330	N323750E	8421650	5392200	102603	65695	13025024	20819731	*
					4	199510	N573207W	5367802	8437221	10709	* 16833	13035733	20802898	
					99									*
												*	1	
										*	01	99999999	1	
							243011			5579				
							243011			5579				

CHPS TRAVERSE SHEET

PROBLEM TYPE
1 All sides & bearings known
2 Two sides unknown
3 1 side & 1 bearing unknown
4 Type 1 with area
5 Type 2 with area
6 1 side & its bearing
7 Type 3 with area
8 Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
0	13	A	48	1/2

STATION	CSE. NO.	DISTANCE	BEARING N/S	DEG	MIN	SEC	E/W	FUNCTIONS COS	FUNCTIONS SIN	COORDINATES N	COORDINATES E
	00									19178072	23469172
	1	199510	N	75	58	38	W				
	2	1217750			?						
	3	1218330	N	32	37	53	E				
	4	199510			?						
	99									19178072	23469172

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse	Course	Area in Square Feet or Distance	Bearing	Cosine	Sine	Latitude Or Area in Acres	Departure Or Sine of Delta	Coordinates North Progressive	Coordinates East Totals	Seq Ck or Unknown
0	13	A	4 [illegible]	1										
												19178072	23469172	
					1	199510	N755838W	2423076	9701995	4834	* 19356			
												19182906	23449816	
					2	1217750	S140122W	9701995	2423076	118146	29507			*
												19064760	23420309	
					3	1218330	N323753E	8421571	5392322	102603	65696			
												19167363	23486005	
					4	199510	N573212W	5367597	8437351	10709	16833			*
												19178072	23469172	
					99									*
												*	*	
										*	*	99999999	99999999	

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse	Course	Area in Square Feet or Distance	Bearing	Cosine	Sine	Latitude Or Area in Acres	Departure Or Sine of Delta	Coordinates North Progressive	Coordinates East Totals	Seq Ck or Unknown
0	13	A	48	2										
												19178072	23469172	
					1	199510	N755838W	2423076	9701995	4834	* 19356			
												19182906	23449816	
					2	1217750	S323826W	8420709	5393670	102543	* 65681			*
												19080363	23384135	
					3	1218330	N323753E	8421571	5392322	102603	65696			
												19182966	23449831	
					4	199510	S754800E	2453074	9694453	4894	19341			*
												19178072	23469172	
					99									*
												*	*	
										*	*	99999999	99999999	

TRAVERSE COMPUTATIONS

* South or West

Problem Type	District	Group	Batch	Traverse	Course	Distance	Bearing	Cosine	Sine	Latitude / Area in Acres	Error of Closure	Departure	North Progressive	East Totals
C	13	A	50	10									19178072	26432961
					1	2200000	N450000E	7071068	7071068	155563		155563	19333635	26588524
					2	3000000	N720118W	3086573	9511733	92597	*	285352	19426232	26303172
					3	2800000	S273617E	8861654	4633691	* 248126		129743	19178106	26432915
										34	*	46	19178106	26432915
					99								19178072	26432961

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse	Course	Distance	Bearing	Cosine	Sine	Latitude Or Area in Acres	Departure Or Sine of Delta	North Progressive	East Totals	Seq. or Delta
C	13	A	50	10								19178072	26432961	
					1	2200020	N450014E			155554	155576	19333326	26588537	
					2	2999800	N720123W			92584	* 285335	19426210	26303202	
					3	2800180	S273623E			* 248138	129759	19178072	26432961	
					99									*
												*	*	
										*	*	9999999	9999999	

CHPS TRAVERSE SHEET

PROBLEM TYPE
1. All sides & bearings known
2. Two sides unknown
3. 1 side & 1 bearing unknown
4. Type 1 with area
5. Type 2 with area
6. 1 side & its bearing
7. Type 3 with area
8. Type 6 with area

PROB TYPE	DIST	GROUP LETTER	BATCH NO	TRAV NO
CT	13	A	50	11

STATION	CSE NO.	DISTANCE	BEARING	COS	SIN	N	E
	00					20163529	11346212
	1	62340				+ 2905	− 5516
	2	211395				− 20631	+ 4608
	3	29160				− 1313	+ 2604
	4	1011620				+ 101139	+ 2149
	5	645				000	− 65
	6	136244				+ 11759	+ 6881
	99					20257353	11351702

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse	Course	Distance	Bearing	Cosine	Sine	Latitude Or Area in Acres	Departure Or Sine of Delta	North Progressive	East Totals	Seq. or Delta
C	13	A	50	11								20163529	11346212	
					1	62320	N621412W			2903	* 5514	20166432	11340698	
					2	211450	S123604E			* 20636	4613	20145796	11345311	
					3	29160	S631300W			* 1314	* 2603	20144482	11342708	
					4	1011380	N011356E			101115	2175	20245597	11344883	
					5	650	N900000W				* 65	20245597	11344818	
					6	136230	N302110E			11756	6884	20257353	11351702	
					99									*
												*	*	
										93824	5490	99999999	99999999	

TRAVERSE COMPUTATIONS

Problem Type	District	Group	Batch	Traverse	Course	Area in Square Feet or Distance	Bearing	Cosine	Sine	Latitude Or Area in Acres (Error of Closure)	Departure Or Size of Delta (Error of Closure)	Coordinates North (Progressive)	Coordinates East (Totals)	[illegible]
T	13	A	50	11										
												20163529	11346212	
					1	62260	N621150W			2904	* 5507			
												20166433	11340705	
					2	211460	S123631E			* 20636	4616			
												20145797	11345321	
					3	29130	S631232W			* 1313	* 2600			
												20144484	11342721	
					4	1011360	N011311E			101113	2153			
												20245597	11344874	
					5	650	N900000W				* 65			
												20245597	11344809	
					6	136280	N302303E			11756	6893			
												20257353	11351702	
					99									
														*
												*	*	
										93824	5490	99999999	99999999	

Appendix B

Instructions for Calculation of Earthwork Data by Punched Cards

The tabulating section of the California Highway Planning Survey is now prepared to compute elevations, earthwork quantities, and mass diagram ordinates from data supplied by the districts. This service is being furnished with the intention of relieving engineering personnel from monotonous routine plotting of cross sections and calculating of earthwork data, giving them more time for actual engineering work. In preparing this service every attempt was made to make as few changes as possible in the normal approach to the problem by the engineer. The changes that do occur have been found necessary to mechanically process the data.

It is not intended to eliminate all plotting of cross sections. However, it is believed that only representative and critical sections need be plotted, and these to a much smaller scale than previously since they are not needed for quantities.

It is believed that considerable engineering time will be saved if full use is made of this service. It will be possible, for example, to use terrain data submitted for one "P" line for subsequent "P" lines and the final line. It will also be possible to process at one time several alternate lines if roadbed data is furnished. It should be unnecessary to resubmit roadbed data for subsequent lines if it would require the engineer to recopy information already available in notes previously submitted, since instructions can be given to the tabulating section to re-use portions of the roadbed data.

The necessary information, where computation of end areas is involved, is to be furnished on the Earthwork Data Sheet, Form WH-67, which may be obtained on requisition in pads of 50 sheets. Samples of this form properly filled out, are attached.

Fill in the identification blocks in the upper right hand corner of each sheet as follows:

District, County, Route, Section

Record the district in arabic numerals.

In District IV and VII, for ease in distribution, separate district numbers for use by sections submitting this work are assigned as follows:

District IV. 24 - Design - J. C. Black; 34 - Design - W. P. Smith; 44 - Design - A. E. Simmons; 54 - Design - J. A. Spence; 64 - Surveys; 74 - Administration - H. S. Miles; 84 - Construction.

District VII. 7 - Design A - J. E. Eckhardt; 17 - Design B - E. G. Hanson; 27 - Design C - L. S. Van Voorhis; 37 - R/W Engineering; 47 - Surveys; 57 - Construction.

Headquarters departments will use District 13. Division of Water Resources will use District 73.

Other sections or districts desiring special district number assignments for this work may request them from the tabulation section.

Only one county, route, and section or city may be indicated on any one sheet. Place the section or start the city in the left square of the coding blocks assigned.

Group, Line

Group and line are district designations to aid in identification and segregation of the work. Each shall consist of one letter only.

When stationing is repeated within a project, a new line letter should be assigned.

Date, Sheet, Recorder, Party

These lines are for district use as desired.

TERRAIN NOTES

Terrain notes, or original ground cross sections, may be submitted as true elevations, as rod readings, or as a difference in elevation from center or offset line. Check the appropriate box on each sheet to show the method used therein.

Sections may read either up or down the page. If there is insufficient room for all points on one line, they may be continued on the next line. Do not crowd the work. Additional lines must also be labeled as to station and all points must appear on the proper side of centerline.

A space has been provided immediately to the right of the station column for carrying the HI and elevations. If the space is used for this purpose, no cross section points should be recorded therein on that page, if not, the space may be used for additional points.

Rod readings and/or elevations may be expressed to tenths or hundredths of a foot. Horizontal distances shall be expressed to the nearest one-tenth foot and must always be from centerline. Where distances are to the even foot, the zero tenths should be shown. Use a line under the decimal figures in lieu of a decimal point.

No two horizontal distances are to be identical. In case of vertical faces, the second point shown should be one-tenth foot farther from centerline.

The thousands or hundreds of feet may be omitted from the notes if desired. However, at any one section the terrain and roadbed notes must be on the same basis.

Whenever possible a section should be shown at an equation.

Terrain notes should be submitted in sufficient widths to cover any line changes which appear probable. However, we are not prepared to handle sections extending beyond 999.9 feet either side of the centerline. It will not be necessary to resubmit terrain notes when sending in subsequent line or grade changes provided reference is made in the transmittal to the previously submitted terrain notes. Supplemental terrain notes may be submitted in the event additional cross sections are taken or it becomes necessary to cover a wider area. These notes are to be submitted in the same form as the original notes. Be sure to fully identify group, line, station, and right or left of centerline.

It is recommended that the original field notes be taken on this new form, WH-67, in the form prescribed herein so as to avoid the necessity for recopying the notes. Two sets of notes may be made by using carbon, one set to be retained in the district and one to be submitted for computations.

Elevations

Sample 1. When this box is checked, the elevation and distance of each point must be given, with no reductions necessary in Headquarters.

If additional figures are included, the top figure at any one point will be taken as the elevation and the bottom figure as the horizontal distance.

Rod Readings

Sample 2. The HI will be shown near the centerline. The notes will clearly indicate the points to which each HI applies. The HI must be repeated on each sheet.

Rod readings will be considered as negative unless marked "plus."

Where the elevations of any points on this sheet are determined by another method, notes for those points will be reduced in the district, the elevations circled, and the correct horizontal distance from centerline inserted below, as shown in the sample.

Difference from Elevation at Centerline

Sample 3. The HI for the centerline elevation will be shown below the centerline. The notes will clearly indicate the stations to which each HI applies. The HI must be repeated on each sheet.

The elevation of points other than the centerline will be shown as plus or minus from centerline elevation. Where the elevations of any points on this sheet are determined by another method, notes for these points will be reduced in the district, the elevations circled, and correct horizontal distance from centerline inserted below.

Difference from Elevation at Centerline and Δ

Sample 4. Where the notes contain setup points in addition to centerline, check the box labeled "Diff. from Elev. at ℄" and draw a Δ around ℄ as shown in Sample 4 attached. Elevations will be shown as plus or minus from centerline until a new setup is reached. Place a Δ below this point to which subsequent differences apply. All horizontal distances are to be reduced to distance from centerline in the district, and recorded as shown on the sample.

Difference from Elevation at Offset Line

Sample 5. If an offset line is used as the base, its distance right or left of centerline should be shown in the blank in front of the checked box. For example, an offset line 90 feet right of the centerline would be recorded as "90R." This offset distance will apply to all sections on the page.

The notes for points on this offset line must be reduced to true elevation. The notes for points other than the offset line will be shown as plus or minus from the elevation at the offset line. Where the elevations of any points on this sheet are determined by another method, notes for these points will be reduced in the district, the elevations circled, and the correct distances from centerline inserted below.

ROADBED NOTES

Roadbed or template notes may be submitted as true elevations or as a difference in elevation from centerline or offset line. Check the appropriate box on each sheet to show the method used therein.

Sections may read either up or down the page. If there is insufficient room for all points on one line, they may be continued on the next line or on an additional sheet. Each line must be labeled as to station and all points must appear on the proper side of centerline.

Elevations or differences in elevations may be expressed to tenths or hundredths of a foot. Horizontal distances shall be expressed to the nearest one-tenth foot and must be measured from the same centerline as the corresponding terrain notes. Where distances are to the even foot, the zero tenths should be shown. Use a line under the decimal figures in lieu of a decimal point.

No two horizontal distances are to be identical. In case of vertical faces, the second point shown should be one-tenth foot farther from centerline. In the case of a vertical match line, the same effect may be obtained by offsetting the top and bottom of the line by at least one-tenth. It is recommended that the roadbed hinge point be set in one-tenth of a foot from the desired match line and the catch point on existing ground be set one-tenth outside the match line. This should give the same quantity as a vertical match line and has the advantage that you do not have to determine and specify cut or fill for the match line. The elevation at the point where the match line touches original ground need not be given. As an example, the roadbed notes which include a match line 100 feet right of the centerline might be written as follows:

$$\frac{88^5}{0} \quad \frac{88^8}{19^0} \quad \frac{89^6}{55^0} \quad \frac{90^0}{99^9} \quad \frac{\quad}{100^1}$$

Roadbed notes may be given to subgrade or finished grade. In the latter case, a tabulation of yards per station correction may be submitted as discussed below.

If requested in the transmittal sheet, computed catch points will be checked against any specified minimum distance from centerline and revised where necessary before computing areas.

In recording elevations the thousands and hundreds of feet may either be shown or omitted but must correspond with the terrain notes for each cross section. In general, no inspection or adjustment of datum between the two sets of notes will be made in Headquarters.

Elevations

Sample 6. Where preliminary quantities are to be computed, notes will be shown as in Sample 6. Elevation of the catch point need not be shown. In cases where the horizontal position of the catch point is set and the slope is variable, this distance will appear with the elevation blank at the last point in the section, as shown at the right side of this sample. In cases where both horizontal position and elevation are unknown, the slope will be shown beyond the hinge point and will be indicated as plus for cut or minus for fill. This situation is shown at the left side of this sample. Where the elevation and distance from centerline of the catch point is given it should be identified by an X below the distance from centerline as in Sample 7.

Sample 7. Where final quantities are to be computed after slope stakes have been set, the notes will be shown as in Sample 7. Catch points will be identified by an X below their distance from centerline. Notes for points beyond the X will be disregarded in the computations. In case additional figures are shown at any point, the top figure will be taken as the elevation and the bottom figure as the distance from centerline.

Difference from Elevation at Centerline or Offset Line

Sample 8. As an alternate to either of the preceding methods of showing roadbed notes, they may be indicated as plus or minus from the elevation at centerline or an offset line. In many cases this method will save computation or writing time. If an offset line is used as the base, its distance from centerline and right or left should be shown in the blank in front of the checked box. This offset distance will apply to all sections on the page. Where the template is sufficiently uniform, points may be shown to apply to all sections on the sheet by arrows, as shown in Sample 8. If notes read up the page, the difference from elevation at centerline and distance from ℄ should appear at each end of the ditto arrows. Points must be repeated on succeeding sheets. Additional non-uniform points may also be shown. If expressed in elevation rather than difference from centerline, the elevation must be circled as shown.

Stations need not be consecutive. If desired, notes may be segregated by types of typical section to facilitate writing.

CONTOUR AREA NOTES

Where planimetered areas have been obtained in the district from a contour-grading plan and quantities and mass-diagram ordinates are desired, the information may be submitted on the regular Quantity Sheet, Form WH-29, as shown in Sample 9, or on a similar district form. Indicate district, county, route, section, group, and line in the same manner as on terrain and roadbed notes. Stationing at the beginning and ending of each area shall be shown in the "Sum Reading" columns. Elevations of the contour areas will be shown in the "Station" column, and planimetered areas in the "Planimeter Reading" columns. Be sure that the elevation of the zero area point is shown at the beginning and end of each group of areas.

Additional quantities to be added should be identified by the beginning station of the area to which it applies.

Between station limits, more than one volume of excavation or embankment may be included provided each volume starts and ends with zero in the area column and occurs on the same sheet. Otherwise, attention should be drawn to this item in the transmittal.

TRANSMITTAL SHEET

A transmittal sheet similar to the one shown in Sample 11 should be used. The identification information in the upper right is to be filled in in the same manner as for individual sheets. Where a job contains more than one county, route, or section, each section should have a separate transmittal sheet. A separate transmittal sheet should also be used for each group or line.

If mass-diagram ordinates are to be continuous through separate transmittals, this fact should be indicated on the subsequent transmittal sheets on the line "start with mass diagram ordinate."

If contour area notes are transmitted, check the applicable box and circle the scale.

If terrain or roadbed notes, or both, are attached, check whether each is complete, a part of the job, or the final transmittal where portions have previously been sent in.

When roadbed notes are transmitted, indicate whether they are to be used with enclosed terrain notes or with terrain notes previously submitted. If the latter, be sure to fully identify the desired combination.

The mass-diagram ordinate to be used at the beginning of the line should be shown in the space provided. The capacity of listing for mass-diagram ordinate is from +9,999,999 to -9,999,999. If a mass diagram is not desired, indicate by checking the box provided.

Shrinkage factors to be applied are to be indicated by station limits.

Amounts to be added or subtracted from computed quantities for subgrade, slope rounding, ditches, etc., should be tabulated by station. Indicate whether these quantities are to be added to or subtracted from the cut or fill quantities. The mass diagram sheet, Form WH-30, is suggested as a convenient form for this tabulation. A sample of such a tabulation is shown in Sample Sheet 10. These quantities will be added following their listed station. For example, quantities given to be added at station 31 will be shown between stations 31 and 32.

Quantities which have been computed separately for divided highways, frontage roads, or other parallel construction may, when requested, be combined to give a final quantity and mass diagram tabulation. Stationing on the parallel lines must be identical or an equation given. Such combination of additional lines and miscellaneous quantities should be fully explained on the transmittal sheet.

Equations affecting the length of any lines should be listed on the transmittal sheet, as well as appearing in the notes.

Time will be saved on large projects by sending in the terrain notes or a portion of them as soon as possible. The roadbed notes may also be forwarded in portions. Instructions to calculate and combine should be sent with the final lot of roadbed notes.

In general we will be able to make horizontal and vertical shifts in roadbed notes previously submitted where the template remains the same without the necessity of new roadbed notes being submitted. Certain portions of the roadbed notes, defined either longitudinally or laterally also may be replaced with other notes without the necessity of rewriting the whole job or all of the cross section template. If you are unsure how to handle special problems of this sort, it is suggested that you request additional information on your particular job from the tabulating section of the Planning Survey.

Zero area for both cut and fill may be specified at any station.

TABULATIONS

The following tabulations will be furnished:

1. A tabulation of reduced notes for terrain and roadbed containing elevations and distances from centerline to tenths of a foot.
2. A tabulation of catch point elevations and distances from centerline.
3. A tabulation showing stations, end areas, quantities, shrinkage factors, and mass-diagram ordinates.

Sample Earthwork Data Sheets

EARTHWORK DATA SHEET

	PUNCHED
	VERIFIED

(SAMPLE #1)

ROADBED NOTES ☐ TERRAIN NOTES ☑ ROD READINGS ☐ ELEVATIONS ☑ DIFF FROM ELEV AT { ℄ ☐ / ____ ☐

DIST 13 CO SAM RTE 30C SEC GROUP B LINE A

Date________ Sheet___of___
Recorder________
Party________

WH 67

STATION	+	+	HI	−	ELEV										
625			109^{5} / 120^{0}										79^{6} / 120^{0}	79^{3} / 100^{0}	
625			107^{4} / 79^{0}	106^{4} / 62^{0}	99^{5} / 53^{0}		96^{3} / 32^{0}	96^{0} / 20^{0}	99^{3} / 0	95^{0} / 20^{0}	95^{3} / 34^{0}	97^{8} / 42^{0}	89^{3} / 51^{0}	78^{3} / 60^{0}	77^{5} / 86^{0}
	50													80^{3} / 120^{0}	
	50		108^{4} / 120^{0}	106^{1} / 81^{0}	105^{3} / 61^{0}		99^{1} / 51^{0}	95^{5} / 24^{0}	98^{6} / 0	94^{5} / 21^{0}	95^{6} / 30^{0}	98^{1} / 45^{0}	81^{5} / 50^{0}	82^{1} / 73^{0}	82^{3} / 89^{0}
624			107^{5} / 120^{0}										94^{1} / 120^{0}	94^{0} / 100^{0}	
624			105^{2} / 98^{0}	103^{1} / 85^{0}	98^{1} / 63^{0}		96^{3} / 45^{0}	96^{1} / 24^{0}	97^{5} / 0	97^{2} / 20^{0}	97^{1} / 31^{0}	95^{0} / 45^{0}	95^{2} / 50^{0}	96^{0} / 79^{0}	95^{2} / 89^{0}

EARTHWORK DATA SHEET

	PUNCHED
	VERIFIED

(SAMPLE #2)

ROADBED NOTES ☐ TERRAIN NOTES ☑ ROD READINGS ☑ ELEVATIONS ☐ DIFF FROM ELEV AT { ℄ ☐ / ____ ☐

DIST 13 CO SAM RTE 30C SEC GROUP B LINE A

Date________ Sheet___of___
Recorder________
Party________

WH 67

STATION	+	+	HI	−	ELEV										
626 / 626	9/12 / 55 18														
	50													12^{1} / 150^{0}	9^{6} / 120^{0}
	50					(78^{3}) 0^{5} / 50 / 75^{0}	$+5^{2}$	0^{9} / 25^{0}	1^{9} / 18^{0}	2^{5} / 12^{5}	3^{6} / 0	6^{9} / 25^{0}	8^{2} / 50^{0}	9^{2} / 100^{0}	9^{2} / 110^{0}
TP		1^{09}	80^{41}	13^{31}	79^{32}					HI	80^{4}				
626							1^{9} / 100^{0}	3^{2} / 60^{0}	6^{1} / 25^{0}	7^{2} / 12^{5}	9^{8} / 0	10^{3} / 12^{5}	12^{3} / 25^{0}	1^{5} / 48^{0}	3^{8} / 100^{0}
625	50						$+0^{6}$ / 100^{0}	1^{8} / 62^{0}	2^{8} / 24^{0}	4^{3} / 12^{5}	6^{0} / 0	5^{8} / 13^{0}	7^{2} / 25^{0}	8^{9} / 51^{0}	9^{3} / 108^{0}
USC+GS #38	BM	3^{48}	92^{63}		1289^{21}					HI	92^{6}				

PUNCHED	
VERIFIED	

EARTHWORK DATA SHEET

ROADBED NOTES ☐ TERRAIN NOTES ☑ ROD READINGS ☐ ELEVATIONS ☐ DIFF. FROM ELEV AT { ℄ ☑ / ____ ☐ }

DIST / CO / RTE / SEC / GROUP / LINE: 1 | 3 | 5 | A | M | 3 | 0 | C | | | B | A

Date________ Sheet____of____

Recorder________

Party________

SAMPLE 3

WH 87

STATION	+	+	HI	−	ELEV	Readings
628						-2^{1}/78^{0}, -3^{2}/100
628						-1^{8}/63^{0}, -0^{9}/50^{0}, $+0^{3}$/25^{0}, $+1^{6}$/15^{0}, 5^{1}/0, $+1^{8}$/15^{0}, $+3^{9}$/25^{0}, $+6^{3}$/50^{0}, $+7^{4}$/100^{0}
TP		6^{22}	76^{32}	10^{31}	70^{10}	HI 76^{3}
	50					-3^{8}/100^{0}, -2^{6}/70^{0}, $+0^{2}$/25^{0}, $+1^{2}$/15^{5}, 9^{1}/0, $+3^{5}$/12^{5}, $+6^{3}$/25^{0}, $+8^{3}$/70^{0}, $+1^{3}$/100^{0}
627						-1^{5}/71^{0}, -1^{9}/89^{0}, -2^{6}/100^{0}, -3^{1}/110^{0}, -2^{3}/100^{0}, -1^{9}/80^{0}
627						-0^{6}/50^{0}, $+0^{9}$/37^{0}, $+1^{8}$/24^{0}, $+2^{1}$/10^{0}, 8^{4}/0, $+3^{8}$/12^{5}, $+2^{1}$/24^{0}, -4^{6}/50^{0}, -1^{3}/60^{0}
						HI 80^{4}

PUNCHED	
VERIFIED	

EARTHWORK DATA SHEET

ROADBED NOTES ☐ TERRAIN NOTES ☑ ROD READINGS ☐ ELEVATIONS ☐ DIFF. FROM ELEV. AT { △ ☑ / ____ ☐ }

DIST / CO / RTE / SEC / GROUP / LINE: 1 | 3 | 5 | A | M | 3 | 0 | C | | | B | A

Date________ Sheet____of____

Recorder________

Party________

(SAMPLE #4)

WH 87

STATION	+	+	HI	−	ELEV	Readings
630						$+3^{2}$/50^{0}/100^{0} △, -1^{6}/20^{0}/120^{0}, -2^{3}/50^{0}/150^{0}, $+1^{3}$/10^{0}/135^{0}, -1^{6}/75^{0}/125^{0} △
630						$+3^{2}$/25^{0}/75^{0}, $+1^{3}$/15^{0}/65^{0}, -2^{1}/50^{0} △, -1^{8}/25^{0}, 9^{2}/0, $+3^{6}$/25^{0}, $+2^{2}$/50^{0} △, $+1^{6}$/24^{0}/74^{0}, $+1^{8}$/50^{0}/100^{0}
	50					-2^{2}/50^{0}/100^{0}, -2^{1}/25^{0}/75^{0}
629	50					-2^{4}/50^{0}/100^{0}, -1^{2}/25^{0}/75^{0}, $+3^{6}$/50^{0} △, $+2^{1}$/12^{0}, 8^{5}/0, $+2^{5}$/13^{0}, $+2^{4}$/24^{0}, $+3^{7}$/50^{0} △, -1^{2}/10^{0}/60^{0}
		2^{39}	72^{60}		70^{31}	HI 72^{6}

	PUNCHED
	VERIFIED

EARTHWORK DATA SHEET

SAMPLE 5

ROADBED NOTES ☐ · TERRAIN NOTES ☑ · ROD READINGS ☐ · ELEVATIONS ☐ · DIFF. FROM ELEV AT ℄ ☑ / 90R ☐

DIST	CO.	RTE	SEC	GROUP	LINE
13	5AM	30C		B	A

Date____ Sheet____ of____
Recorder____
Party____

WN 67

STATION	+	+	HI	-	ELEV									
TBM#2				6^{01}	70^{31}									
629						-10^{2} 135 45^{0}	-3^{8} 60^{0}	-5^{2} 110^{0}						
													68^{1}	
629						-10^{2} 130 40^{0}	-6^{9} 110 20^{0}	-5^{3} 90 0^{0}	-2^{9} 87 3^{0}	-1^{8} 50 40^{0}	-1^{6} 37 53^{0}	-0^{3} 15 75^{0}	8^{2} 90^{0}	$+0^{2}$ 10 100^{0}
													70^{2}	
628	50					-12^{6} 200 110^{0}	-10^{4} 150 60^{0}	-3^{8} 115 25^{0}	-4^{9} 90 0^{0}	-2^{8} 86 4^{0}	-1^{7} 37 53^{0}	-0^{3} 14 76^{0}	6^{1} 90^{0}	$+0^{2}$ 10 100^{0}
												HI	76^{3}	

	PUNCHED
	VERIFIED

EARTHWORK DATA SHEET

SAMPLE 6

ROADBED NOTES ☑ · TERRAIN NOTES ☐ · ROD READINGS ☐ · ELEVATIONS ☑ · DIFF. FROM ELEV AT ℄ ☐ / ____ ☐

DIST	CO.	RTE	SEC	GROUP	LINE
13	5AM	30C		B	A

Date____ Sheet____ of____
Recorder____
Party____

WN 67

STATION	+	+	HI	-	ELEV											
	50													82^{0}	89^{55} 61^{0}	
	50		-2:1		89^{59} 58^{0}	88^{3} 57^{0}	88^{8} 19^{5}	90^{25} 18^{0}	88^{45} 0	90^{25} 18^{0}	88^{8} 19^{5}	88^{34} 55^{0}	89^{62} 55^{7}	89^{59} 58^{2}		
625			-2:1		88^{57} 58^{0}	87^{3} 57^{0}	87^{8} 19^{5}	89^{25} 18^{0}	87^{45} 0	89^{25} 18^{0}	87^{8} 19^{5}	87^{34} 55^{0}	88^{62} 55^{7}	88^{57} 58^{0}		82^{0}

EARTHWORK DATA SHEET

	PUNCHED
	VERIFIED

(SAMPLE #7)

ROADBED NOTES ☑ TERRAIN NOTES ☐ ROD READINGS ☐ ELEVATIONS ☑ DIFF. FROM ELEV. AT ℄ ☐ ____ ☐

DIST. 13 CO. SAM RTE. 30 SEC. C GROUP B LINE A

Date ____ Sheet ____ of ____
Recorder ____
Party ____

WH 67

STATION	+												
626 / 626	91.12 / 55.18												
	50	73.4 / 110.3 X											
	50	90.5 / 61.0	90.6 / 58.0	90.3 / 57.0	90.8 / 19.5	92.25 / 18.0	90.45 / 0	92.25 / 18.0	90.8 / 19.5	90.3 / 55.0	91.6 / 55.3	90.6 / 58.0	88.6 / 82.0 X
626		76.0 / 112.5 X	90.6 / 58.0	89.3 / 57.0	89.8 / 19.5	91.25 / 18.0	89.45 / 0	91.25 / 18.0	89.8 / 19.5	89.3 / 55.0	90.6 / 55.3	89.6 / 58.0	87.3 / 82.0 X

EARTHWORK DATA SHEET

	PUNCHED
	VERIFIED

(SAMPLE #8)

ROADBED NOTES ☑ TERRAIN NOTES ☐ ROD READINGS ☐ ELEVATIONS ☐ DIFF. FROM ELEV. AT ℄ ☑ ____ ☐

DIST. 13 CO. SAM RTE. 30 SEC. G GROUP B LINE A

Date ____ Sheet ____ of ____
Recorder ____
Party ____

WH 67

STATION	+													
627		-2.1		+1.4 / 58.0	-0.5 / 57.0	+0.35 / 19.5	+1.8 / 18.0	91.45 / 0	+1.8 / 18.0	+0.35 / 19.5	-0.4 / 55.0	+1.2 / 55.3	+1.4 / 58.0	-2.1
	50		(93.5) / 68.0					92.45 / 0						
628			(94.5) / 68.0	+1.04 / 58.0				93.45 / 0						
635				+1.4 / 58.0				90.65 / 0						82.0
	50							89.15 / 0						
636								87.65 / 0						
	50							86.15 / 0						
637								84.65 / 0						

FORM WH 29A

QUANTITY SHEET

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS—DIVISION OF HIGHWAYS

Dist 13 County SAM Route 30 Section C Group B Line A Sheet No

Calculated by ... Date ...

Checked by ... Date ...

(Sample #9)

STATION	EXCAVATION: Planimeter Reading	Sum Reading	Length Feet	Quantity Cubic Yards	Station Cubic Yards	EMBANKMENT: Planimeter Reading	Sum Reading	Length Feet	Quantity Cubic Yards	Station Cubic Yards
42	0	88			20	0	88			
44	1.04				22	12.95				
46	3.50				24	13.09				
48	5.10				26	13.84				
50	5.14				28	14.50				
52	5.05				30	14.86				
54	4.96				32	15.21				
56	4.81				34	15.13				
58	4.76				36	14.94				
60	4.53				38	14.86				
62	4.20				40	13.52				
64	3.87				42	9.20				
66	2.80				44	3.25				
68	1.91				46	0.05				
70	0.79				46 3/	0				
72	0.02									
72 5	0									
		92					92			
45 5/	0									
46	0.50									
48	1.15									
50	1.25									
52	1.36									
54	1.52									
56	1.48									
58	1.32									
60	0.75				none					
62	0									
45 8/	0									
46	0.04									
48	0.95									
50	1.21									
52	1.37									
54	1.50									
56	1.61									
58	1.38									
60	1.10									
62	0.78									
64	0.25									
66	0									
		96					96			
		TOTAL CU YDS					TOTAL CU YDS			

SAMPLE 10

MASS DIAGRAM SHEET

CALCULATED BY *Additions for Quantities* ____ 19__

CHECKED BY ____ 19

DIST	13
	SAM
ROUTE	30
SEC.	C

Sta	Exc C.Y	Swell or Shrinkage %	Applied Exc C.Y		Emb C.Y		Algebraic Sum		Group Ordinate Line	B A
	← Cut		→		← Fill		→			
	Subgrade	Ditch	Slope	Round	Subgrade		Front Rd			
650	+32		+5							
651	↓		↓							
652										
653										
654										
655										
656										
657							+36			
658	↓		↓				+34			
659	+16									
660		+16			−30					
661		+78			−34					
662		+35			↓					
663					↓					

	Punched
	Verified

(SAMPLE #11)

Dist.	Co.	Rte.	Sec.	Group	Line
13	SAM	30	C	B	A

FROM: District 13

TO: CHPS Tabulating Section

Enclosed are the following data for yardage calculations

Contour Area Sheets ☐ Map Scale 1" = 50' - 100'

Terrain Notes - Complete ☐ Partial ☐ Final ☑

Roadbed Notes - Complete ☑ Partial ☐ Final ☐

To be combined with enclosed terrain notes ☐

To be combined with terrain notes for *Group B, Line A - part enclosed and part* previously submitted.

Start with Mass Diagram ordinate *100,000*

Do not calculate Mass Diagram ☐

Shrinkage factors to be used are:

0.85	from Station	*625*	to Station	*651*
0.90	" "	*651*	" "	*690*
	" "		" "	
	" "		" "	
	" "		" "	
	" "		" "	
	" "		" "	
	" "		" "	
	" "		" "	
	" "		" "	

Remarks: *Equation 626+55.18 BK = 626+91.12 Ah*
Run quantities for Group B Line A, then run final tabulation combining this with Group B, Line B