SYSTEMS FOR BID ANALYSIS, GUARDRAIL LOCATIONS, CONSTRUCTION SCHEDULING, AND ESTIMATING EARTHWORK QUANTITIES

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BID ANALYSIS

For a number of years, in North Carolina, we have used a series of computer programs to expedite the handling of bid-letting data and associated items. We are now in the process of adding another major program to the series that will greatly expand the current bid facilities and, at the same time, reduce much of the manual work. The new bid series will use the engineer's estimated unit bid prices to assemble the bid items into the proposals, write the item sheets, and list all of the breakdowns for state and federal highway projects. After the letting, all of the listings are repeated and the low bidder's prices are used. The new bid system in conjunction with a system such as a magnetic tape selectric typewriter for the preparation of project special provisions provides our plans and proposal section with a system that is as automated as possible at the present time.

The main purpose in adopting a new bid system was to ease some of the work load caused by the presence of multiple projects within one contract and to facilitate the classification of quantities for each in the proposal. It also allows us to separately prepare sets of items such as roadway, signing, landscaping, culverts, and bridges and to use the computer to combine these sets into one proposal. In the past, the computation of these breakdown estimates has been an extremely time-consuming task for the engineer. For example, one structure proposal had 17 bridges and 2 federal-aid numbers, which required the assembling of 20 different estimates. With the new bid system, this proposal would require only about a minute on the computer. On another occasion, a group of eight bridges and a section of roadway were to be let in two separate contracts. Shortly before letting day, the roadway and structures were combined into one contract, which caused a tremendous amount of work. With the new system, there would have been no difficulty in making the change.

Once the engineer has completed the computation of the quantities and items that make up each project or breakdown, he must prepare input data forms for those projects. We have approximately 500 standard item descriptions that account for about 90 percent of all bid items used except for right-of-way and landscape items. These standard items are stored and may be recalled by a three-digit code. Nonstandard or special items must be completely written out on the input form. The items on the input form are also given a line or ordinal number. These numbers are usually given in increments of 2 so that additional items may be added or deleted without disturbing the remaining numbers. When a computer output is obtained, these lines are renumbered in the standard number sequence, i.e., 1, 2, 3, 4. The maximum number of items allowed in one proposal is 400, and we have had as many as 370. The maximum number of breakdowns that are allowed for any proposal is 30.

In each item description, there is also a code letter to indicate the group type to which an item belongs, e.g., grading, paving, culverts, or bridges. From this a cost analysis of each group can be made.

After the input forms are processed, the breakdown quantities are totaled in the computer for each proposal, and a list with the total quantities is printed for the use of the plans and proposal section in assigning unit prices for the various items in the

proposal. These unit prices are returned to the computer section, and three additional lists are prepared.

The first list contains total quantities for the proposal, from which group costs are obtained. The second list contains each separate breakdown, from which cost per foot for roadways, cost per square foot for bridges, and cost per cubic yard of waterway for culverts are obtained. The third list is for the use of the Federal Highway Administration and is arranged according to its code.

Item sheets may be printed at any time to be photocopied and included in the proposal; they are usually printed on colored paper to simplify assembling the proposal and to facilitate their use.

When alternates are present in a proposal, there are two methods of selecting materials, both of which depend on whether the material choice causes any change in the number of items concerned or the quantities or both.

If the items and quantities are basically the same, the bidder may specify an X, in the space provided, for the material he wishes to use for the next predetermined number of items.

Where the material choice affects the quantities, for example, in brick end walls or concrete end walls, there are several items on each side of an alternate. Contractors may bid on either side of the alternate without specifying which side or may even bid on both sides, in which case the program selects the most economical items and discards the others.

Bidding cards are made up for the exact number of bidders on letting day. These prepunched cards contain the computer proposal number, item number, and lump sum or total in the unit price bid columns where appropriate. Three item bids are entered on each card.

The data processing section normally receives the proposals about Tuesday noon and usually completes the processing about 10:00 a.m., Wednesday. The letting output includes (a) listings of all bidders, three to a page; (b) the engineer's estimate and low bidder printed side by side; and (c) the letting summary showing the three low bidders and the date of availability and date of completion for the project.

After the letting, all engineering breakdowns for the different work orders in the projects are recomputed, and the actual unit bid prices received from the low bidders are used.

For the computation of average unit bid prices, a tape is written of the low bidders' prices, and for each bid item the item description number, quantity, and amount are later punched into the cards along with header information. The header data include the letting date (year and month), the project number, the route number, the location (county, division, and area), and the roadway standard (Interstate, primary, secondary, and rural). The low bid costs are checked out each month and accumulated.

Every 6 months, we print the header details with the total costs, followed by the quantity and average unit bid for each standard item. This is done first for the whole state, then for each of the 14 divisions. For each year, we print and distribute books containing the average unit bids for each standard item.

On demand, we can make a choice of averages by date, project number, route, location, or highway standard. This has been very useful in making Interstate highway estimates.

GUARDRAIL LOCATIONS

We have used the computer to determine guardrail locations in preliminary design for several years. Our program bases guardrail warrants entirely on embankment geometry as outlined in the National Cooperative Highway Research Program Report 54.

Our guardrail program is a subsystem of the earthwork system. The guardrail locations, along with the slope required to eliminate the guardrail, are returned each time the earthwork system is run and the guardrail is requested. This enables the design engineer to determine whether it is more economical to flatten fill slopes to eliminate the need for guardrail or to place the guardrail.

This study can be conducted in a variety of ways; the following approach can be used both by installations that have a plotter and by those that do not.

Figure 1. Construction limit plot with clearing-seeding-guardrail.

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SCALE 1 INCH = 50 FEET
I INDICATES THE RIGHT OF WAY LINE
. INDICATES THE SLOPE STAKE LIMIT
   (NOT PRINTED WHEN ON THE R/W LINE)
* BESIDE THE CENTERLINE INDICATES
   THAT GUARD RAIL IS REQUIRED
SLOPE NO-GR IS THE SLOPE REQUIRED TO
   ELIMINATE GUARD RAIL
CLEARING AND SEEDING AREAS ARE IN
   SQUARE FEET UNLESS OTHERWISE NOTED
STEEP SEEDING (SLOPE STEEPER THAN 1.5 TO 1)
CLEAR TO THE CONSTRUCTION LIMITS
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SLOPE LEFT	SLOPE NO-GR	CLEARING LEFT	SEEDING LEFT	R/W LT	C L	STATION LINE BK	C. L	R/W RT	SEEDING RIGHT	CLEARING RIGHT	SLOPE NO-GR	SLOPE RIGHT
3.00C				80	I	11+00	I	70				2.00C
3.00C			4059.0		I	12+00	I		3072.5			2.00C
3.00C		2945	5909.0		I	13+00	I		2804.5	3450		2.00C
3.00C		6790	6320.5		I	14+00	I		2603.5	3275		2.00C
3.00C		6175	5672.5		I	15+00	I		2592.0	3270		2.00C
3.00C		4965	4391.5		I	16+00	I		2648.0	3320		2.00C
3.00C		4410	3806.0		I	17+00	I		2883.0	3525		2.00C
3.00C		5390	4833.5		I	18+00	I		3743.5	4285		2.00C
3.00C		5340	4770.5		I	19+00	I		4850.5	5270		2.00C
3.00C		4060	3426.5		I	20+00	I		5644.5	5990		2.00C
3.00C		2745	3078.5		I	21+00	I		5532.5	4492		2.00C
3.00C			3474.0		I	22+00	I		3989.5			2.00C
3.00F			3338.5		I	23+00	I		2565.0			4.00F
3.00F			3332.0		I	24+00	I		3294.5			1.50C
4.00C			3721.0		I	25+00	I		5085.0			1.50C
4.00C			3803.5		I	26+00	I		6067.5			1.50C
4.00C			3030.0		I	27+00	I		5725.0			1.50C
2.00F	2.44F		3759.0		*I	28+00	I		3763.5			2.00F
2.00F	2.46F		5223.5		*I	29+00	I*		3010.0		2.06F	2.00F
2.00F	2.39F		5145.0		*I	30+00	I*		3893.5		2.18F	2.00F
2.00F	2.25F		4815.0		*I	31+00	I*		4195.0		2.20F	2.00F
2.00F	2.10F		4234.0		*I	32+00	I		4105.5			2.00F
2.00F	2.58F		4776.5		*I	33+00	I		3602.5			2.00F
2.00F	2.58F		5693.0		*I	34+00	I		3188.5			2.00F
2.00F	2.71F		6084.5		*I	35+00	I*		4127.5		2.42F	2.00F
2.00F	2.69F		6420.0		*I	36+00	I*		5245.5		2.51F	2.00F
2.00F	2.73F		6475.5		*I	37+00	I		5368.5			2.00F
2.00F	2.19F		5424.5		*I	38+00	I		3636.0			2.00F
2.00F	2.14F		4150.0		*I	39+00	I		2354.0			2.00F
2.00F	2.21F		4851.0	100I	*I	40+00	I		2846.5			1.50C
1.50C		5235	5113.0		I	41+00	I		5157.5	5390		1.50C
1.50C		6480	6462.0		I	42+00	I		8141.5	7875		1.50C
1.50C		8360	8722.5		I	43+00	I		7988.5	7745		1.50C
1.50C		8285	8632.0		I	44+00	I		6582.0	6755		1.50C
1.50C		7300	7444.5		I	45+00	I		5238.5	5465		1.50C
1.50C			6924.5		I	46+00	I		4842.0			1.50C
1.50C			6861.5		I	47+00	I		4643.5			2.41F	1.50C
2.00F	2.12F		5332.5		*I	48+00	I*		5172.5		2.66F	2.00F
2.00F	2.12F		204.2		*I	48+05	I		317.1		2.66F	2.00F
						BEG BR						
						END BR						
2.00F	2.44F				*I	50+25	I*				2.52F	2.00F
2.00F	2.44F		3976.5		*I	51+00	I*		3884.3		2.27F	2.00F
2.00F	2.41F		5067.0		*I	52+00	I*		4474.5		2.14F	2.00F
2.00F	2.31F		4474.5		*I	53+00	I*		4038.5		2.07F	2.00F
2.00F	2.11F		3815.0		*I	54+00	I*		3759.0		2.05F	2.00F
2.00F			3736.5		I	55+00	I		3535.5			2.00F
2.00F			3580.0		I	56+00	I		3233.5			2.00F
2.00F			3144.0		I	57+00	I		3077.0			2.00F
2.00F			3010.0		I	58+00	I		3122.0			2.00F
1.50C			3054.0		I	59+00	I		3133.0			2.00F
1.50C			4779.0		I	60+00	I		2872.5			2.00F
1.50C			5852.0		I	61+00	I		1727.5			4.00F
1.50C			7087.0		I	62+00	I		3691.5			3.00C
1.50C			9800.5		I	63+00	I		5942.5			3.00C
1.50C			10377.5		I	64+00	I		5672.0			3.00C
1.50C			8718.5		I	65+00	I		5482.5			3.00C
1.50C			9052.0		I	66+00	I		4779.0			3.00C
1.50C			9232.5		I	67+00	I		3980.0			3.00C

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        LEFT                    LEFT                            RIGHT               RIGHT
      CLEARING                SEEDING                          SEEDING             CLEARING
         TOTAL  78480  288471.2 TOTAL                    TOTAL 226925.4    70107 TOTAL
    OUTSIDE R/W      0   32052.4 TOTAL SQ YDS        TOTAL SQ YDS 25213.9   1638 OUTSIDE R/W
   ACRES IN R/W  1.802       0.0 SQ YDS STEEP CUT  SQ YDS STEEP CUT    0.0 1.572 ACRES IN R/W
  ACRES OUT R/W  0.000       0.0 SQ YDS STEEP FILL SQ YDS STEEP FILL   0.0 0.376 ACRES OUT R/W
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A guardrail and construction limit plot are prepared for the roadway section (Fig. 1). The slopes used are printed on the left and right sides of the sheet. In areas where guardrail is warranted, the slope required to eliminate the need for guardrail is printed next to the slope used. The clearing and seeding areas are the next items printed and then the distance from the centerline of lane to the right-of-way. The right-of-way line is indicated by a row of I's and the slope stake line by a series of dots. This gives the design engineer an idea of how much he may flatten slopes without exceeding the right-of-way. At guardrail locations, a series of asterisks representing the lane centerline is printed next to the row of I's. The station value at which the cross sections are taken is the final item on the listing.

This list was generated on a printer; if a plotter were used, a better representation of the right-of-way line and slope stake limits could be obtained. The total areas of clearing inside and outside the right-of-way are printed at the bottom of the list along with the areas for erosion control.

CONSTRUCTION SCHEDULING

The use of the critical path method for the scheduling of highway construction work has been tried several times in North Carolina. The results have not been satisfactory. The major difficulty in preparing a critical path before a contract is let is that the exact resources of the successful bidder are not known; the critical path is, of course, somewhat dependent on these resources. However, the method does help the engineer in planning work over which he has control. The method requires that the engineers familiar with construction requirements, bridge design, and roadway design get together and build the highway on paper. This eliminates some of the problems that occur during the actual construction of the project.

The difficulties in preparing a critical path may possibly be avoided by preparing a tentative critical path based on past experience with similar projects. Once the contract has been let, this tentative critical path could be changed to conform to the capabilities of the contractor. Once these changes are made, a final critical path could be prepared for use in the construction of the project.

ESTIMATING EARTHWORK QUANTITIES

The use of computers to compute final earthwork quantities has simplified the work of resident engineers.

We are set up to handle cross sections, which may be taken in several ways. The fastest method is the use of photogrammetric processes. In this system, the project area is flown and photographed in stretches of approximately 2 miles as it is cleared and grubbed. Vertical and horizontal controls are, of course, established at the time of photographing, and the cross sections prepared on a stereo compiler are closely edited for conformance to these controls. When grading is completed, the project area is photographed again; these photographs provide information for the final, or as-graded, cross sections. After these sections are edited to ensure conformity with the vertical and horizontal controls, they are merged with the original sections and the volumes are computed. When a section is paved before being photographed, the resident engineer must supply template sections that cover the area from ditch point to ditch point; the remainder of the section is supplied by the photogrammetric section.

On small jobs where the cost of flying is not justified by the savings in time, cross sections may be taken by field methods. These field sections also serve as input to the final estimate volume program. The program is flexible enough to handle a mixture of the two types of sections if necessary.

The output of the program consists of excavation quantities, and embankment quantities and borrow pit calculations are available if desired. On sections that are taken by photogrammetric processes, or sections that are taken to actual elevations, the centerline subgrade elevation is given. The left and right tie point distances from the centerline are also given along with the depth of cut or height of fill at the tie point.