A METHOD OF EXTENDING AND LISTING

BAR REINFORCING STEEL

COMPUTER PROGRAM

FORTRAN IV

BY

GLENN H. SIKES

HIGHWAY BRIDGE ENGINEER

A USER'S MANUAL

PRESENTED BY THE

State Highway Department of Georgia

BRIDGE DIVISION

R.L. CHAPMAN, JR.

STATE HIGHWAY BRIDGE ENGINEER

ATLANTA, GEORGIA
AUGUST, 1969

FOREWORD

"A Method of Extending and Listing Bar Reinforcing Steel" presented in this report is a problem-oriented computer program that can be used effectively in the detailing of reinforcing bars, and computation of bar reinforcing quantities. This program is actually the third in a series of bar reinforcing steel programs. The first program was written in 1959 for use on an IBM 650 computer. Since this program proved so successful, the program was rewritten with additional capacities in 1963 for use on an IBM 1620. The computer oriented Symbolic Programming System (SPS) was used to code the IBM 1620 program; whereas, the IBM 650 program was coded in a machine language. Now the program has been rewritten using Fortran IV programming language. This makes the program computer independent with only minor modifications required for operation on any third-generation computer system. In addition, the program has been made more versatile with new features.

This write-up is primarily a user's manual and does not include flow charts or a program listing. However, since a source deck can be obtained by request, a program listing can be obtained by listing or compiling the source deck. In addition, since the program is written in Fortran IV programming language and contains numerous comment cards that describe the program functions, the flow charts are not really essential in order to understand the procedure of the program solution. The reader is assumed to be familiar with the standard terminology of bar reinforcing steel and such terms as bar size, standard hook, etc., are not defined in this report.

This report, then, explains in detail the functions of the program and how the program can be effectively applied in the detailing and extending of bar reinforcing steel used in highway bridges, culverts, retaining walls, etc.

Glenn H. Sikes
Atlanta, Georgia
August 1, 1969

DISCLAIMER

Although this program has been subjected to many rigorous tests - all with excellent results - no warranty, expressed or implied, is made by The State Highway Department of Georgia as to the accuracy and functioning of the program, nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by The State Highway Department of Georgia in any connection therewith.

TABLE OF CONTENTS

I. DESCRIPTION OF THE PROGRAM

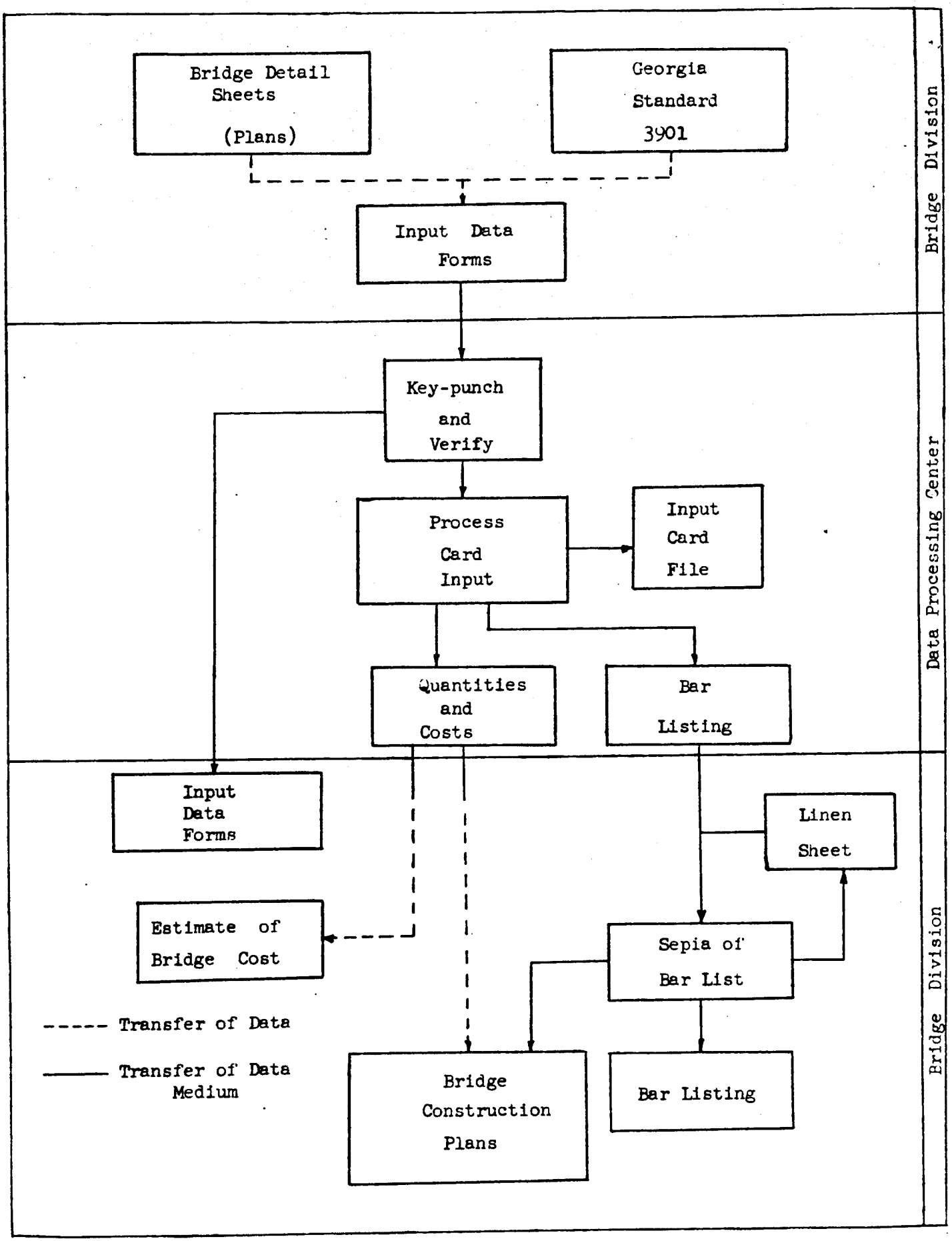
In the past, a considerable amount of the Bridge Engineer's time has been spent in the routine computation of bar reinforcing quantities and the detailing of each reinforcing bar. Because of the large volume of work required by the Interstate and other highway programs, an attempt was made to decrease the amount of time required for these routine tasks. The program presented here is a product of this attempt.

The Bar Reinforcing Steel computer program is designed to assist Bridge Engineers in the tabulation and estimation of bar reinforcing steel quantities. Thus, this program eliminates the detailing of reinforcing bars on bridge plans and the long-hand computations of bar lengths and weights. This results in the saving of a considerable number of man-hours per bridge.

The input data to the program is a list of all reinforcing bars (plus miscellaneous items) for a particular bridge, culvert, etc. This data is listed on an input data form and contains the bar dimensions, number, hook styles, type and bar designation. The input data (bar dimensions, etc.) is entered on the input data form by referring to a standard bar bending details sheet along with the detail sheet (Bridge sheet) from which the reinforcing bar data is being obtained. In Georgia the standard bar bending details is Georgia Standard 3901. After the input data is thoroughly checked for accuracy, it is forwarded to the Data Processing Center for processing. Note that the length of the bar is not required as input since the program has the capacity to compute the bar lengths from the data given. After the bar length is computed, the weight of the bar is computed. The weights of all bars in a particular unit (pier, span, etc.) are summed for presentation in the output of quantities. Also included in the output of quantities is the estimated cost of the reinforcing steel.

It should be clearly noted that the reinforcing bars are not detailed (dimensioned) on the bridge plans. The bridge plans will contain only a bar schedule (made from the output of this program) which includes the bar mark, location, length, number, type, and dimensions of all bars. The reinforcing steel fabricator uses the bar schedule from the bridge plans and Georgia Standard 3901 to fabricate the reinforcing bars.

The output data of the program contains the weight and cost for each unit with subtotals and grand totals for any and all units. The values can be easily transferred to the summary of quantities on the detail sheets and cost estimate form. The tabulation of the bars including the lengths is made on a special form of paper. This list can then be attached to a linen sheet from which a sepia can be made to include in the bridge plans.



BAR REINFORCING STEEL
SYSTEM FLOW CHART

II. PREPARING THE INPUT DATA

The input data to the Bar Reinforcing Steel computer program is entered on a special input form. This form is used to define all bar reinforcing steel in the structure and other miscellaneous items. Any number of input sheets can be used to describe the reinforcing steel. In order to define the reinforcing steel, the Engineer must have Georgia Standard 3901, "Bar Bending Details", in addition to the bridge detail sheets.

The term "Unit" used in this write-up defines a unit of construction. For example; a bent, pier, abutment, span, pour, continuous unit, retaining wall, culvert, etc., could be defined as a "Unit".

In the following discussion refer to the blank input data form on page 12.

A. IDENTIFICATION CARD (* in c.c. 1).

The first line (card) of each problem must be the Identification of that job. This line of the input form must always contain data when beginning a new problem. Whenever more than one sheet is used with a problem, the Identification is given with the first sheet only; that is, all Identification lines are left blank on the subsequent sheets. The asterisk in card column one is used to identify the Identification card. Only one line of this type can be used with each problem. The Identification data is entered on the input form as follows.

1. PROBLEM NUMBER (c.c. 2-5).

The Problem Number should be left blank by the Engineer. A number will be assigned to each problem from the log book of computer problems. The Problem Number will appear in the output of quantities for identification purposes. However, the Problem Number is not listed on the tabulation of the bar reinforcing steel.

2. PRICE (c.c. 6-9). Form: x.xxx $/pound.

Enter in card columns 6-9 the estimated cost of the bar reinforcing steel. If the cost varies from unit to unit, enter the cost of the largest number of units with the same cost. The costs of the remaining units can be given when defining the unit as explained on subsequent pages. The Price may have a value of zero or be left blank. The Price will be shown in the output of quantities, but not on the bar tabulation.

3. PROJECT NUMBER, COUNTY, etc. (c.c. 10-80).

This space of the Identification Card should contain the Project Number, County, Name of person submitting job, Date, and any other pertinent remarks. Card columns 76-80 can also be used although these card columns are not shown.

B. UNIT CARD (U in c.c. 1).

The program has the capacity to process any number of units in a job (problem). Each unit is defined by entering the required information in a Unit Card. The input form is formatted for one unit per sheet. However, more than one unit can be defined on one sheet (by defining additional units on Bar Reinforcing Card lines); or, several sheets of input data may be used to define the reinforcing steel in one unit (in this case the Unit Card on subsequent sheets must be left blank).

For simplicity in entering the input data it is suggested that no more than one unit be defined on an input data sheet.

Following is a list showing the order of the input data for a job.

Identification Card
Unit A Card
Reinforcing Bar Cards for Unit A
Unit B Card
Reinforcing Bar Cards for Unit B
etc.

The letter "U" in card column one defines the Unit Card. If a unit is defined on a Reinforcing Bar Card, the letter "U" must be entered in card column one of that line. Note that the Unit Card format must be used instead of the Reinforcing Bar Card format in this case. The data required to define a unit is entered on the input form as follows.

1. Name of Unit (c.c. 2-17).

The Name of the unit being defined should be entered in these card columns. For example: "Bent 2" or "Span 4". This Name will appear in the output of quantities (for identification purposes) and also appear on the bar listing (tabulation).

2. Number of Units (c.c. 18, 19). Form: xx

Enter in this space the Number of units that are being defined, i.e., exactly alike. For example, if the reinforcing steel of span 2 and 3 is identical it would be unnecessary to define the reinforcing steel of each span separately. In this instance the unit is defined by the Name, "Span 2 or 3", and the Number of units given as two (2). Instead of having to define the reinforcing bars twice, the reinforcing bars would be defined once.

3. PRICE (c.c. 20-23). Form: x.xxx $/pound.

If the cost of the reinforcing steel in the unit being defined is different from the Price given in the Identification Card, enter the price (or cost) of the reinforcing steel in the unit in this data column of the Unit Card. However, if the Price is the same,

this space should be left blank. The Price of the reinforcing steel for each unit will be shown in the output of quantities. The Price is not shown on the bar listing.

4. UNIT REMARKS (c.c. 24-80).

Enter in this space any remarks that you wish to appear on the tabulation of bar reinforcing steel. These Remarks will not appear in the output of quantities and costs. Note that card columns 59-80 can be used although these card columns are not shown.

C. REINFORCING BAR CARDS.

The bar reinforcing steel is defined by detailing each bar type (Mark) on one line of the input form. Any number of bar types may be entered; that is, there is no limit to the number of lines that can be used. Additional pages can be used when required to define all the reinforcing steel in a unit. The Reinforcing Bar Cards can also be used to enter miscellaneous types of data. A discussion of the miscellaneous types of data will be given on subsequent pages.

Following is a discussion of the Reinforcing Bar Card format and the data required to define a reinforcing bar.

1. CODE (c.c. 1). Blank, V, S, R

There are four codes that can be used to define a reinforcing bar. These are as follows:

a. Blank

Leave card column one blank to define a reinforcing bar with a constant length and not appearing in a subsequent unit. This will be the most commonly used code; hence, the blank code. The reinforcing bar length is optional, i.e., not required.

b. V

Enter the letter "V" in card column one to define a reinforcing bar with a varying length. When using this Code, the average length must be computed by the Engineer and given as part of the input data. Also, when using this code the reinforcing bar length should be given as "VARY".

c. S

In order to eliminate the monotonous detailing of a reinforcing bar more than once, the Store Code "S" can be used. This Code (S) instructs the program to store the reinforcing bar for future reference in a subsequent unit. Therefore, the Store Code should be used the first time such a bar is detailed. When the bar is detailed again (in a subsequent unit), it can conveniently be Recalled. This code can be of considerable help when detailing "truss" bars in the bridge superstructure.

When using the Store Code, it should be noted that the reinforcing bar should be fully detailed, i.e., type, dimensions, etc. Note also that a bar with a varying length cannot be Stored for subsequent Recall. The reinforcing bar length is not required.

d. R

In order to Recall a reinforcing bar that has previously been defined, enter the letter "R" in card column one. The only data required with this Code is the Mark and Number of Bars. The reinforcing bar length is optional. The Type, hook styles and di-

mensions should be given only when this data is required to appear on the bar tabulation. In order to Recall a reinforcing bar, the bar must previously have been defined with the Store Code "S".

2. MARK (c.c. 2-6).

The bar Mark is made-up of the bar Size and bar Description. In essence the Mark is the bar name or identification. The Size is the standard bar size notation, i.e., #4 (one-half inch diameter round). The program will accept bar sizes 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 18. Any other bar size will result in an "error message". The bar Size is entered in card columns 2 and 3.

The bar Description consists of three characters (letters or numbers) which are used, in addition to the bar size, to identify the bar. This notation is entered in card columns 4-6.

The reinforcing bar Mark is required with all types of reinforcing bar Codes.

3. LENGTH (c.c. 7-11) Form: xxx ft., xx inches.

If the reinforcing bar Code is a blank or the letter "S", the length is optional. That is, the Engineer may compute the Length and enter the value on the input data form; or, the space for the bar length may be left blank, in which case the program will compute the bar length. The above is true only when the bar type (c.c. 22, 23) is detailed on Georgia Standard 3901. Otherwise, the bar length must be given in the input data.

If the Length of the reinforcing bar varies ("V" in c.c. 1), the word "VARY" should be written in card columns 7-10. The average length will be given in card columns 16-21.

The bar Length should be left blank (not required) if the reinforcing bar code is Recall (R in c.c. 1).

If the program computes the bar Length, the Length is computed to the nearest inch for calculating quantities and tabulation.

If the Length of the bar is given on the input data form, the foot dimension is entered in card columns 7-9, and the inch dimension is given in card columns 10, 11.

4. NUMBER OF BARS (c.c. 12-15) Form: xxxx.

Enter in card column 12-15 the Number of bars required in the unit of the type (Mark) being defined. This Number is required for all reinforcing bar codes. If this data field is left blank or given a value of zero (0), an "error message" will result.

5. AVERAGE LENGTH (c.c. 16-21) Form: xxxx.xx feet.

When defining a reinforcing bar that has a varying length, enter the Average Length of the bar in feet in card columns 16-21. Otherwise, this data column is left blank when defining a reinforcing bar.

6. TYPE (c.c. 22, 23)

When the program is to compute the bar length, the bar Type must be given in card columns 22, 23. However, if the bar is being Recalled ("R" in c.c. 1) the type is not required. The Type given in this data field refers to the bar bending type given on Georgia Standard 3901, "Bar Bending Details". If a special bar Type is required (not shown on Georgia Standard 3901), the special type can be entered in the input data field; however, the length must be computed by the Engineer and given in the Length data field.

7. A (c.c. 24) or G (c.c. 25).

The digit codes entered in these two card columns identify the type (style) of standard bar hooks used with the bar type. The bar types shown on Georgia Standard 3901 have two hooks, one hook or no hooks. When a hook is not shown on the bar bending type, the corresponding A or G data column is left blank. Following are the allowable A and G hook codes, and the corresponding hook styles, that are used to define the bar hooks.

A or G hook code (style)	Type of standard bar hook
1	180 degree hook, Grade 50, 60, 75
2	180 degree hook, Grade 40
3	90 degree hook, all Grades
4	90 degree stirrup hook, Grades 40, 50, 60 for bar size 3, 4, 5, and 6 exclusively.
5	135 degree stirrup hook, Grades 40, 50, 60 for bar size 3, 4, 5 and 6 exclusively.
6	Eliminate hook shown on bar type

Note that each hook must be identified by a digit code (1-6). The program will not assume a hook style by default. An "error message" will result if each hook is not defined with a decimal digit (1,2, 3,4,5,6). Note that a hook shown on the bar type can be eliminated by using a digit code of six (6). Note also that a hook shown on the standard can be changed from one type (style) to another.

For example, the 90 degree hooks shown on bar type 25 can be changed to 135 degree hooks by entering the digit five (5) for the A and G hook style.

The A and G hook style is required only when the program is to compute the bar length. However, the style would normally be given for detailing purposes in any event.

8. B, C, D, E, F, H, J, K (c.c. 26-69) Form: xx feet, xx inches, x/x fraction of an inch.

Enter in these data columns the bar dimensions per Georgia Standard 3901. Note that the fraction of an inch dimension is limited to a one digit numerator, and denominator, i.e., 1/2, 3/4, 5/8, etc. This eliminates bars being detailed to the sixteenth of an inch. Fractions of an inch are not allowed with dimension J and K. When a dimension does not exist, the corresponding data column should be left blank. If a dimension varies, the word "VARY" or "VARIES" should be entered in the appropriate data column beginning with the leftmost column of the data field.

9. N (c.c. 70-72) Form: xxx number or degrees.

The data entered in this space of the input form depends on the bar type. The data will either be the number of beams or walls (bar types 42, 43, 44), angle of bar bend (bar types 6,7,8,18) or the number of closed turns of a spiral (bar type 45).

10. θ (c.c. 73-75) Form: xxx ksi or degrees.

Theta (θ) is normally the angle of bar bend in degrees; however, on bar type 45 this data must indicate the Grade of spiral reinforcement, i.e., 40 or 60.

MISCELLANEOUS CARDS

In addition to the bar reinforcing data, other data or commands may be entered in the Reinforcing Bar Cards. Following is a discussion of each type of miscellaneous data, the format (not shown on input form) for this data, and the usage of the data.

D. LUMP WEIGHT CARD (W in c.c. 1).

If the Engineer wishes to add a known weight of reinforcing steel to the total weight of the unit, the Lump Weight miscellaneous card can be used. An example might be concrete handrail reinforcing steel. The Code required to identify such an item is the letter "W" entered in card column 1. The Lump Weight is entered in card columns 16-21 in the form xxxx.xx pounds. The number of Lump Weights is entered in card columns 12-15.

Lump Weight Required Input Data

Item	Card Columns	Form
Code	1	W
Number of Lump Weights	12 - 15	xxxx
Lump Weight	16 - 21	xxxx.xx pounds

E. TOTAL CARD (T in c.c. 1).

The program will automatically give the grand total of all reinforcing steel in the entire problem or job. In addition to this total the Engineer may instruct the program to give totals of related units. For example, the total of all reinforcing steel in the superstructure may be beneficial. This total can be obtained by entering the letter "T" in card column one. The name of the total is entered in card columns 2-17, i.e., substructure sub-total, etc. The Total Code should be entered on the input data form immediately after the last reinforcing bar or lump weight of the last unit in the total. The total will be computed by summing the total weight of all preceding units to the beginning of the job or to a preceding Total Card. If a Total Card has been used previously, the summation is to that card rather than to the beginning of the job. The total name with the total weight and cost will be shown in the output of quantities. Following is an example showing the sequence and usage of the Total Card.

Identification Card (begin job)
Unit A Card
Reinforcing Bar Cards for Unit A
Unit B Card
Reinforcing Bar Cards for Unit B
Total Card (gives total of Unit A plus B)

Unit C Card
Reinforcing Bar Cards for Unit C
Unit D Card
Reinforcing Bar Cards for Unit D
Total Card (gives total of unit C plus D)

F. COMMENTS CARD (C in c.c. 1).

The Engineer may use the Reinforcing Bar Cards to enter comments that will be printed on the tabulation or bar list. The letter "C" entered in card column 1 identifies such a card. The Comments are entered in card columns 2-80. The Comments card can be used effectively to add notes to the bar reinforcing listing which give special instructions, etc. Comments Cards may be used at any place in the input data.

G. SKIP CARD (K in c.c. 1).

The Skip Card can be used if the user wishes the bar tabulation to contain blank lines or skips. The Skip Card is defined by entering the letter "K" in card column 1, and the number of lines to be skipped is entered in card columns 2, 3. Any number of lines may be skipped. At least one line is always skipped when this code is used. The Skip Code may be used at any place in the input data.

H. END JOB CARD (Z in c.c. 1).

The last input data of the problem must be the End of Job Card. In addition, this indicates to the program that a Grand Total of all quantities in the job is desired. This Card is coded by entering the letter "Z" in card column one.

GEORGIA DEPARTMENT OF TRANSPORTATION
BRIDGE DESIGN OFFICE

QUANTITIES AND LISTING

BAR REINFORCING STEEL

360

SHEET___OF___.

IDENTIFICATION CARD

	PROG.	PROB. NO	PRICE	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*	B,0,6			

UNIT CARD

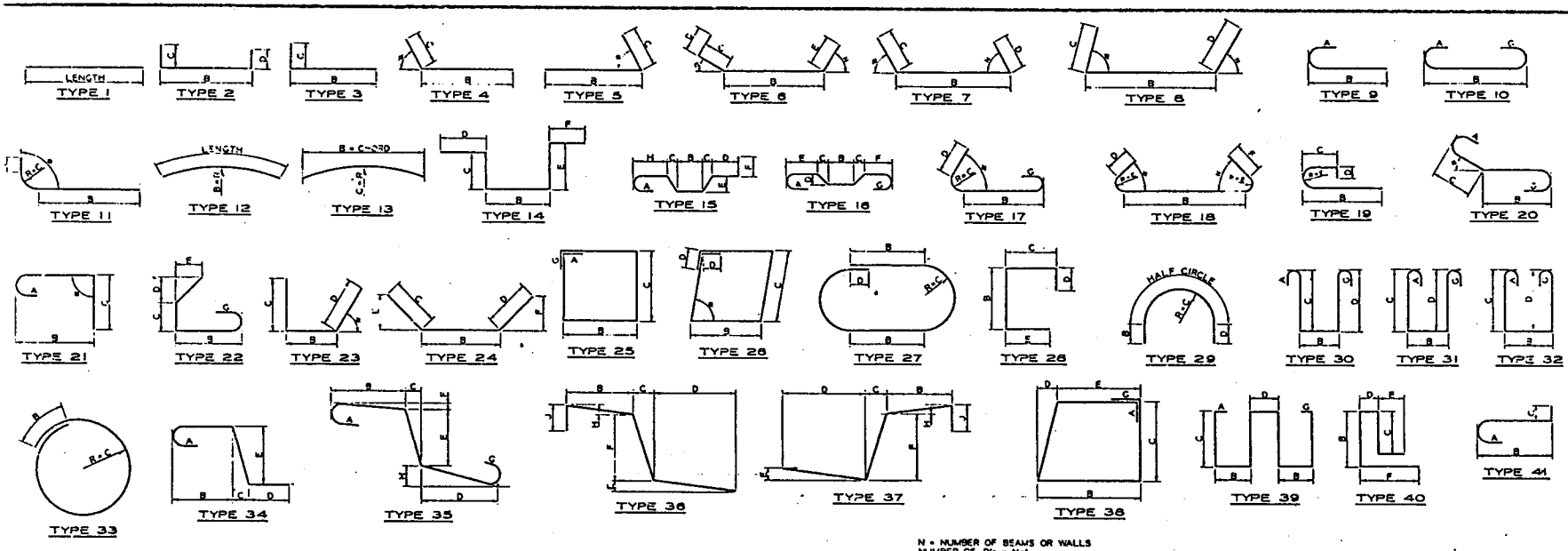
	NAME OF UNIT	NO.	PRICE	UNIT REMARKS
U				

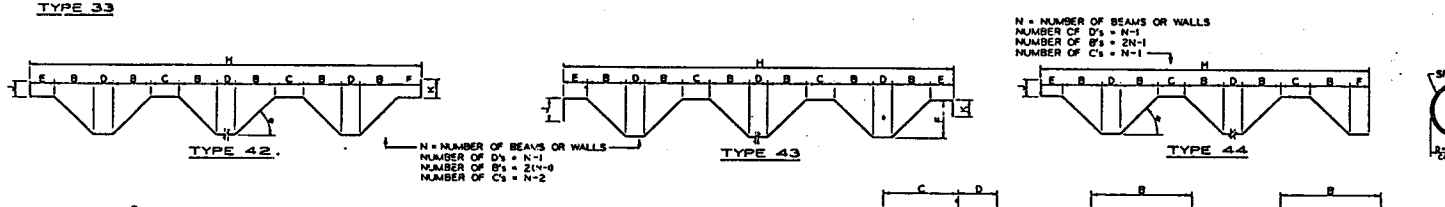
CODES:
S – STORE BAR
R – RECALL BAR
K – SKIP LINE
U – UNIT
Z – END PROBLEM (GRAND TOTAL)
BLANK – BAR
C – COMMENTS
V – VARIABLE BAR
W – LUMP WEIGHT
T – TOTAL (SUB)

REINFORCING BAR CARDS

CODE

MARK SIZE	MARK DES.	LENGTH FT.	LENGTH IN.	NO. BARS	LUMP WT. AVG. LENGTH	TYPE	A	G	B FT.	B IN.	B FR.	C FT.	C IN.	C FR.	D FT.	D IN.	D FR.	E FT.	E IN.	E FR.	F FT.	F IN.	F FR.	H FT.	H IN.	H FR.	J FT.	J IN.	K FT.	K IN.	N	Θ
1 2	6	7	11	12 15	16 21	22 23	24	25	26		31	32		37	38		43	44		49	50		55	56		61	62	65	66	69	70 72	73 75
											/			/			/			/			/			/						





N = NUMBER OF BEAMS OR WALLS
NUMBER OF D's = N-1
NUMBER OF B's = 2N-1
NUMBER OF C's = N-1

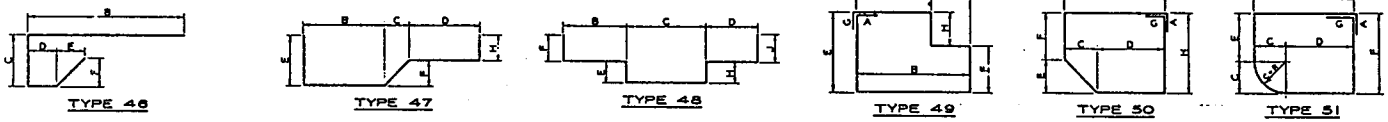
SPIRAL
D = OUTSIDE CORE DIA.

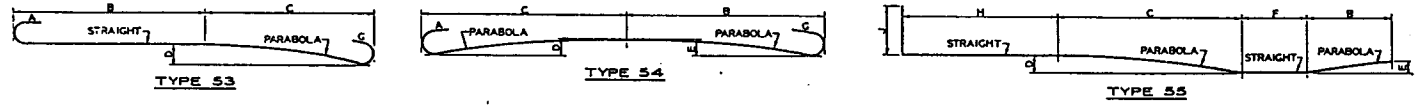
C = PITCH
B = OVERALL HEIGHT

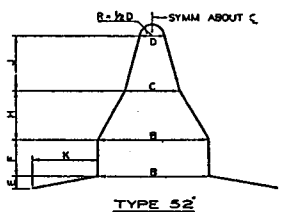
Φ = 40 - SPIRAL IS MADE OF GRADE 40 BILLET STEEL DEFORMED BARS - A.S.T.M. DESIGNATION A-615.

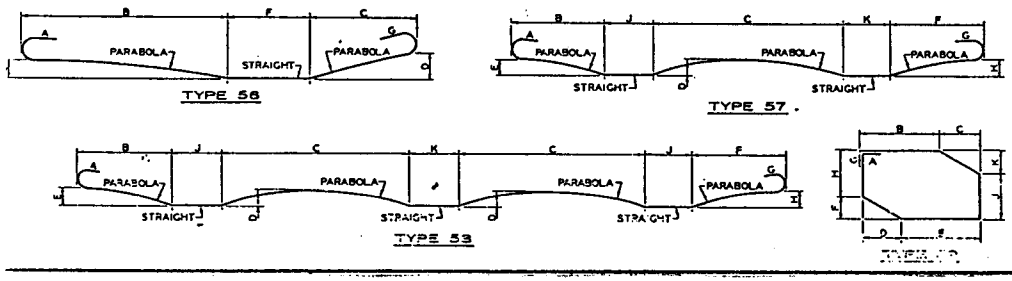
Φ = 60 - SPIRAL IS MADE OF COLD DRAWN STEEL WIRE - A.S.T.M. DESIGNATION A-82.

SPLICES MAY BE ACCOMPLISHED BY LAPPING AND WELDING 1½ TURNS. PROVIDE 'N' = TOTAL NUMBER OF CLOSED TURNS AT TOP AND BOTTOM OF COLUMNS. COST OF CHANNEL SPACERS AND SPLICES SHALL BE INCLUDED IN PRICE BID FOR REINFORCEMENT STEEL.









NOTES

ALL DIMENSIONS ARE OUT TO OUT UNLESS NOTED.

ALL RADII ARE OUTSIDE.

SEE HOOK DETAILS FOR HOOK DESCRIPTIONS AND NOTES.

A DIMENSION SHOWN AS ZERO ON BAR SCHEDULE DELETES THAT PART OF BAR TYPE.

FED. ROAD DIV. NO.	STATE	FED. AID PROJ. NO.	STATE JOB NO.	SHEET NO.	TOTAL SHEETS
3	GA				

HOOK DETAILS

RECOMMENDED 180° HOOKS

GRADE 40 ksi
D = 5d for #3 through #11
D = 10d for #14 and #18

GRADES 50-60-75 ksi
D = 6d for #3 through #8
D = 8d for #9, #10, and #11
D = 10d for #14 and #18

RECOMMENDED 180° END HOOK DIMENSIONS

BAR SIZE	GRADES 50-60-75 ksi		GRADE 40 ksi	
	A or G	J	A or G	J
#3	6	2	6	2½
#4	8	3	8	3½
#5	10	4	10	4½
#6	8	5	8	5½
#7	10	7	10	6½
#8	11	8	10	7
#9	1-3	1-1½	1-0	8
#10	1-5	1-10½	1-1	9
#11	1-7	1-2-4	1-2	10
#14	2-0	1-9½	2-2	1-0½
#18	2-11	2-3	2-7	1-3
STYLE	1		2	

RECOMMENDED 90° END HOOK DIMENSIONS
ALL GRADES
D = 6d for #3 through #8
D = 8d for #9, #10, and #11
D = 10d for #14 and #18

BAR SIZE	HOOK A or G
#3	6
#4	8
#5	10
#6	1-0
#7	1-2
#8	1-4
#9	1-6
#10	1-8
#11	2-0
#14	2-7
#18	3-5
HOOK STYLE 3	

STIRRUP AND TIE HOOK

STIRRUPS (TIES SIMILAR)

STIRRUP AND TIE HOOK DIMENSIONS GRADES 40-50-60 ksi

BAR SIZE	D (in.)	90° HOOK A or G	135° HOOK A or G	135° HOOK H (approx.)
#3	2½	4	4	2½
#4	3	4½	4½	3
#5	3¾	6	5½	3¾
#6	5	6½	6½	4½
STYLE		4	5	

STYLE 6 = NO HOOK

HOOK STYLES DETAILED ON THIS SHEET ARE FOR ILLUSTRATION ONLY. ACTUAL HOOK STYLE FOR ANY PARTICULAR BAR WILL BE SHOWN UNDER A or G HEADING ON BAR SCHEDULE.

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

STANDARD
BAR BENDING DETAILS

NO SCALE — AUGUST 1969

DESIGNED — DETAILED — CHECKED — SUBMITTED — APPROVED

NUMBER 3901

III. THE OUTPUT DATA

The Bar Reinforcing Steel computer program produces two types of output data: quantities and a listing of all reinforcing bars. The quantities are given on the standard type of output paper, and the bars are listed on a special form with headings and carbon backing for reproduction purposes. Following is a discussion of each type of output and its usage. Refer to the example problem output on pages 23-26.

QUANTITIES

The information given in the Identification Card will head the output of quantities. The following information will be given for each unit defined in the input data.

A. NAME OF UNIT.

The Name of each unit is listed with the quantities of that unit for identification purposes. Note that the Name will appear exactly as given in the Unit Card.

B. WEIGHT/UNIT.

The total weight of all reinforcing bars plus lump weights in one unit is given in this column of the output data. The weight is given to the nearest pound.

C. NO. UNITS.

The Number of units given in the Unit Card is repeated in the output data. It is suggested that these numbers be compared to check the validity of the input data.

D. TOTAL WEIGHT.

The Total Weight is the product of the weight per unit and the number of units in pounds.

E. COST/LB.

The Cost or Price per pound is a repeat of the input data Price. This should be checked for accuracy of input.

F. TOTAL COST.

The Total Cost is the product of the Total Weight and the Cost per pound. The output of Total Cost is given in dollars to the nearest cent.

The output data will contain a Total (actually a sub-total) for each Total Code given in the input data. The data given for each sub-total will consist of the Name of the sub-total, the Total Weight of all units in that sub-total, and the Total Cost of all units in that sub-total.

The Grand Total given in the output data consists of the Total Weight of all reinforcing steel in the problem or job, and the Total Cost of all the reinforcing steel in the job.

The unit weights given in the output data can be entered (by hand) in the table of estimated quantities on the bridge plans, and the Total costs values can be used to assist in estimating the bridge cost. The output of quantities are usually incorporated into the design notes for permanent record.

BAR LISTING

The list of all reinforcing bars and units is printed on a special two-part form with carbon back, and contains all the required headings to define the reinforcing bars. The form is separated and the front part (bar list) is then attached (commonly by using transparent tape) to a linen sheet containing a title block, etc. This sheet is then processed through a Diazo white print machine (or equivalent) to produce a sepia. The sepia is then incorporated into the bridge plans after completing the title block, etc. The linen sheet is saved for future use, and the bar list and input form are put on permanent file or discarded. It is suggested that the bar list be compared to the input form to check the accuracy of the bar list.

ERROR MESSAGES

The program checks the validity of procedure used to enter the input data. In addition, certain types of data can be checked for accuracy of allowable range. For example a number twelve (12) bar is treated as an error. When an error is detected, a message is printed which gives the cause and location of the error.

IV. EXAMPLE PROBLEM

An example problem is given on the following pages. This example is an actual four-span bridge and the data given here is exactly as processed by the program, except that the Identification card has been changed. The input data is given on the following six pages. The output of quantities is shown on page 23 and the bar listing (one-half size) is shown on pages 24 to 26. Shown on page 27 is a reduced print of the sepia incorporated into the bridge plans which was made from the bar listing. However, the bridge plans from which the bars were taken are not shown.

It should be noted that this example shows all features of the program.

QUANTITIES AND LISTING

BAR REINFORCING STEEL

SHEET 1 OF 6

360

IDENTIFICATION CARD

	PROB NO.	PRICE	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*	EX..1	120	EXAMPLE PROBLEM, BAR REINFORCING STEEL, BY G.H.S., 7-28-69

UNIT CARD

	NAME OF UNIT	NO.	PRICE	UNIT REMARKS
U	END BENTS 1 & 5	2		BENT 1 SAME AS BENT 5

CODES:
S - STORE BAR
R - RECALL BAR
K - SKIP LINE
U - UNIT
Z - END PROBLEM (GRAND TOTAL)
BLANK - BAR
C - COMMENTS
V - VARIABLE BAR
W - LUMP WEIGHT
T - TOTAL (SUB)

—— CODE

REINFORCING BAR CARDS

	MARK SIZE	MARK DES.	LENGTH FT.	LENGTH IN.	NO BARS	LUMP WT AVG. LENGTH	TYPE	A	G	B FT.	B IN.	B FR.	C FT.	C IN.	C FR.	D FT.	D IN.	D FR.	E FT.	E IN.	E FR.	F FT.	F IN.	F FR.	H FT.	H IN.	H FR.	J FT.	J IN.	K FT.	K IN.	N	O
K	1											/			/			/			/			/			/						
S	4	51			89		25	44		1	8	/	2	2	/			/			/			/			/						
V	4	52	VARY		20	6.25	32	55		2	2	/	VARIES			VARIES					/			/			/						
	4	53			6		25	44		1	8	/	1	8	/			/			/			/			/						
	4	54	1	8	8		1					/			/			/			/			/			/						
	4	55			8		2			1	8	/	1	3	/	1	3	/			/			/			/						
K	1											/			/			/			/			/			/						
	5	51	5	5	52		1					/			/			/			/			/			/						
	5	52	12	2	24		1					/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
	6	51			3		24			3	10	/	1	0	/	1	6	/	1	0	/	1	1	1/8			/						
	6	52			3		24			7	6	/	1	6	/	1	0	/	0	6	1/8	0	5	1/2			/						
K	1											/			/			/			/			/			/						
	10	51			4		4			24	4	/	2	0	/			/			/			/			/						48
	10	52	29	2	4		1					/			/			/			/			/			/						
	10	53			4		3			29	2	/	1	6	/			/			/			/			/						
	10	54			4		3			4	6	/	1	6	/			/			/			/			/						
	10	55			4		6			23	4	/		8	7/8	2	0	/	0	0	/			/			/						
S	10	56	1	3	10		1					/			/			/			/			/			/					0	41
K	2											/			/			/			/			/			/						

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

QUANTITIES AND LISTING

BAR REINFORCING STEEL

SHEET 2 OF 6

IDENTIFICATION CARD

	PROB NO.	PRICE	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*			

UNIT CARD

	NAME OF UNIT	NO.	PRICE	UNIT REMARKS
U	INT., BENTS 2 & 4	2		BENT 2 SAME AS BENT 4

CODES:
S – STORE BAR
R – RECALL BAR
K – SKIP LINE
U – UNIT
Z – END PROBLEM (GRAND TOTAL)
BLANK – BAR
C – COMMENTS
V – VARIABLE BAR
W – LUMP WEIGHT
T – TOTAL (SUB)

CODE

REINFORCING BAR CARDS

	MARK SIZE	MARK DES.	LENGTH FT.	LENGTH IN.	NO. BARS	LUMP WT. AVG. LENGTH	TYPE	A	G	B FT.	B IN.	B FR.	C FT.	C IN.	C FR.	D FT.	D IN.	D FR.	E FT.	E IN.	E FR.	F FT.	F IN.	F FR.	H FT.	H IN.	H FR.	J FT.	J IN.	K FT.	K IN.	N	O
K	1																																
R	4	5.1			8.6																												
V	4	5.2	VARY		1.6	6.2.5																											
S	4	6.1			1.8		2			2	1.0	3/4	1	6		1	6															
K	1																																
S	5	6.1			8		2			1	8		1	6		1	6															
S	5	6.2			8		2.5	4	4	2	2		1	8																		
S	5	6.3			1.2		3.2	5	5	2	2		1	8		1	8															
K	1																																
S	6	6.1	8	9	4		1																										
K	1																																
R	1.0	5.6			1.0																												
S	1.0	6.1			2		3			4.9	1		1	6																		
S	1.0	6.2	4.9	1	2		1																										
S	1.0	6.3			6		3			5	0		1	6																		
S	1.0	6.4			2		3			4.6	1.0	3/4	1	6																		
S	1.0	6.5	4.6	1.1	2		1																										
K	2																																

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

QUANTITIES AND LISTING

BAR REINFORCING STEEL

SHEET 3 OF 6

360

IDENTIFICATION CARD

	PROB NO.	PRICE	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*			

UNIT CARD

	NAME OF UNIT	NO.	PRICE	UNIT REMARKS
U	INT. BENT 3	1		

CODES:
S – STORE BAR
R – RECALL BAR
K – SKIP LINE
U – UNIT
Z – END PROBLEM (GRAND TOTAL)
BLANK – BAR
C – COMMENTS
V – VARIABLE BAR
W – LUMP WEIGHT
T – TOTAL (SUB)

CODE

REINFORCING BAR CARDS

	MARK SIZE	MARK DES.	LENGTH FT.	LENGTH IN.	NO. BARS	LUMP WT. AVG. LENGTH	TYPE	A	G	B FT.	B IN.	B FR.	C FT.	C IN.	C FR.	D FT.	D IN.	D FR.	E FT.	E IN.	E FR.	F FT.	F IN.	F FR.	H FT.	H IN.	H FR.	J FT.	J IN.	K FT.	K IN.	N	Θ
K	1											/			/			/			/			/			/						
R	4	5,1			8,6							/			/			/			/			/			/						
V	4	5,2	VARY		1,6	6.25						/			/			/			/			/			/						
R	4	6,1			1,8							/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
R	5	6,1			8							/			/			/			/			/			/						
R	5	6,2			8							/			/			/			/			/			/						
R	5	6,3			1,2							/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
R	6	6,1			4							/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
R	10	6,1			2							/			/			/			/			/			/						
R	10	6,2			2							/			/			/			/			/			/						
R	10	6,3			6							/			/			/			/			/			/						
R	10	6,4			2							/			/			/			/			/			/						
R	10	6,5			2							/			/			/			/			/			/						
T	SUB	STRUCTURE										/			/			/			/			/			/						

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

QUANTITIES AND LISTING

BAR REINFORCING STEEL

SHEET 4 OF 6

IDENTIFICATION CARD

	PROB NO.	PRICE	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*			

UNIT CARD

	NAME OF UNIT	NO.	PRICE	UNIT REMARKS
U	END SPANS 1 & 4	2	135	SPAN 1 SAME AS SPAN 4

CODES:
S - STORE BAR
R - RECALL BAR
K - SKIP LINE
U - UNIT
Z - END PROBLEM (GRAND TOTAL)
BLANK - BAR
C - COMMENTS
V - VARIABLE BAR
W - LUMP WEIGHT
T - TOTAL (SUB)

REINFORCING BAR CARDS

CODE

	MARK SIZE	MARK DES.	LENGTH FT.	LENGTH IN.	NO. BARS	LUMP WT. AVG. LENGTH	TYPE	A	G	B FT.	B IN.	B FR.	C FT.	C IN.	C FR.	D FT.	D IN.	D FR.	E FT.	E IN.	E FR.	F FT.	F IN.	F FR.	H FT.	H IN.	H FR.	J FT.	J IN.	K FT.	K IN.	N	Θ
K	1											/			/			/			/			/			/						
S	4	01	36	8	182		1					/			/			/			/			/			/						
S	4	02			58		25	4	4	1	1	/	2	5	7/8			/			/			/			/						
S	4	03			60		2			2	5	7/8	1	1	/	1	1	/			/			/			/						
S	4	04			272		2			1	1	3/8	0	6	/	0	6	/			/			/			/						
	4	05			68		21	2		1	0	/	1	8	/			/			/			/			/						
S	4	06	16	5	16		1					/			/			/			/			/			/						
S	4	07			308		14			1	1	/	2	6	1/8	1	0	/	2	5	5/8	1	0	/			/						
S	4	08	36	7	20		1					/			/			/			/			/			/						
S	4	09	12	7	16		1					/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
	5	01	43	4	2		1					/			/			/			/			/			/						
S	5	02			204		14			0	8	1/2	36	11	/	1	0	/	0	0	/	0	0	/			/						
S	5	03			204		3			36	11	/	1	0	/			/			/			/			/						
S	5	04			90		37			4	11	/	0	1	3/4	1	0	/	0	0	1/4	0	10	1/2	0	1	1/4	0	0				
K	1											/			/			/			/			/			/						
	6	01	49	10	4		1					/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
S	7	01	17	0	4		1					/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
S	8	01			3		14			1	0	/	49	3	1/2		8	1/2			/			/			/						
S	8	02			3		3			45	4	3/4	1	0	/			/			/			/			/						
S	8	03	14	10	4		1					/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
S	11	01			40		10	1	1	36	6	1/2			/			/			/			/			/						
S	11	02	31	0	4		1					/			/			/			/			/			/						
S	11	03	25	9	4		1					/			/			/			/			/			/						
S	11	04	17	10	4		1					/			/			/			/			/			/						
S	11	05	30	6	12		1					/			/			/			/			/			/						
S	11	06	24	10	12		1					/			/			/			/			/			/						
S	11	07	27	4	4		1					/			/			/			/			/			/						
W					2	8500						/			/			/			/			/			/						

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

QUANTITIES AND LISTING

BAR REINFORCING STEEL

SHEET 5 OF 6

IDENTIFICATION CARD

	PROB NO.	PRICE	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*			

UNIT CARD

	NAME OF UNIT	NO.	PRICE	UNIT REMARKS
U				

CODES:
S – STORE BAR
R – RECALL BAR
K – SKIP LINE
U – UNIT
Z – END PROBLEM (GRAND TOTAL)
BLANK – BAR
C – COMMENTS
V – VARIABLE BAR
W – LUMP WEIGHT
T – TOTAL (SUB)

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

CODE

REINFORCING BAR CARDS

	MARK SIZE	MARK DES.	LENGTH FT.	LENGTH IN.	NO. BARS	LUMP WT. AVG. LENGTH	TYPE	A	G	B FT.	B IN.	B FR.	C FT.	C IN.	C FR.	D FT.	D IN.	D FR.	E FT.	E IN.	E FR.	F FT.	F IN.	F FR.	H FT.	H IN.	H FR.	J FT.	J IN.	K FT.	K IN.	N	O
W					1 4	4 2 4 0						/			/			/			/			/			/						
W					5 5	9 7 6						/			/			/			/			/			/						
K	2											/			/			/			/			/			/						
U	I N T . .		S P A N S		2 & 3	2 . 1	3 5		S	P A N	2	/	S A M E		/ A S		S P A N	/	3		/			/			/						
K	1											/			/			/			/			/			/						
R	4 0 1				1 8 2							/			/			/			/			/			/						
R	4 0 2				5 8							/			/			/			/			/			/						
R	4 0 3				6 0							/			/			/			/			/			/						
R	4 0 4				5 4 4							/			/			/			/			/			/						
R	4 0 6				1 6							/			/			/			/			/			/						
R	4 0 7				3 0 8							/			/			/			/			/			/						
R	4 0 8				2 0							/			/			/			/			/			/						
R	4 0 9				1 6							/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
R	5 0 2				2 0 4							/			/			/			/			/			/						
R	5 0 3				2 0 4							/			/			/			/			/			/						
R	5 0 4				9 0							/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
R	7 0 1				4							/			/			/			/			/			/						
K												/			/			/			/			/			/						
R	8 0 1				6							/			/			/			/			/			/						
R	8 0 2				6							/			/			/			/			/			/						
R	8 0 3				4							/			/			/			/			/			/						
K	1											/			/			/			/			/			/						
R	1 1 0 1				4 0							/			/			/			/			/			/						
R	1 1 0 2				4							/			/			/			/			/			/						
R	1 1 0 3				4							/			/			/			/			/			/						
R	1 1 0 4				4							/			/			/			/			/			/						
R	1 1 0 5				1 2							/			/			/			/			/			/						
R	1 1 0 6				1 2							/			/			/			/			/			/						
R	1 1 0 7				4							/			/			/			/			/			/						
W					1 4	4 2 4 0						/			/			/			/			/			/						

QUANTITIES AND LISTING

SHEET 6 OF 6

BAR REINFORCING STEEL

IDENTIFICATION CARD

	PROB. NO.	PRICE	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*			

UNIT CARD

	NAME OF UNIT	NO.	PRICE	UNIT REMARKS
U				

CODES:
S - STORE BAR
R - RECALL BAR
K - SKIP LINE
U - UNIT
Z - END PROBLEM (GRAND TOTAL)
BLANK - BAR
C - COMMENTS
V - VARIABLE BAR
W - LUMP WEIGHT
T - TOTAL (SUB)

REINFORCING BAR CARDS

CODE

CODE	MARK SIZE	MARK DES.	LENGTH FT.	LENGTH IN.	NO. BARS	LUMP WT. AVG. LENGTH	TYPE	A	G	B FT.	B IN.	B FR.	C FT.	C IN.	C FR.	D FT.	D IN.	D FR.	E FT.	E IN.	E FR.	F FT.	F IN.	F FR.	H FT.	H IN.	H FR.	J FT.	J IN.	K FT.	K IN.	N	θ
W					62	97.6																											
C	SEE GA. STD. 3633 FOR DETAILS OF BARS IN CONCRETE HANDRAILING.																																
T	SUPERSTRUCTURE																																
Z																																	

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

REINFORCING STEEL QUANTITIES PROBLEM EX.1 EXAMPLE PROBLEM BAR REINFORCING STEEL BY G.H.S. 7-28-6

NAME OF UNIT	WEIGHT/UNIT		NO. UNITS		TOTAL WEIGHT	COST/LB.	TOTAL COST
END BENTS 1&5	3406 LBS.	X	2	=	6812 LBS. AT	0.120 =	$ 817.44
INT. BENTS 2&4	2765 LBS.	X	2	=	5530 LBS. AT	0.120 =	$ 663.60
INT. BENT 3	2712 LBS.	X	1	=	2712 LBS. AT	0.120 =	$ 325.44
	SUBSTRUCTURE		SUBTOTAL	=	15054 LBS.		$ 1806.48
END SPANS 1&4	41781 LBS.	X	2	=	83562 LBS. AT	0.135 =	$ 11280.87
INT. SPANS 2&3	42305 LBS.	X	2	=	84610 LBS. AT	0.135 =	$ 11422.35
	SUPERSTRUCTURE		SUBTOTAL	=	168172 LBS.		$ 22703.21
			GRAND TOTAL	=	183226 LBS.		$ 24509.69

Sheets 24, 25, 26, and 27 have been removed

V. OPERATING PROCEDURE

The Bar Reinforcing Steel Computer Program is written in F level, Fortran IV and has been compiled and run under IBM's Disk Operating System employing the IBM 360, mod. 50 with 256K core storage. The input to the program is punched cards and the entire output is by printer. A disk is used by the program as an intermediate storage device. The program requires approximately 43,550 bytes of core storage, excluding any supervisor program, and the processing time is proportional to the amount of input data. Approximately 45 seconds is required to process 100 cards. This time does not include any paper changing time. The program should be compatible with other computer systems.

KEY-PUNCH INSTRUCTIONS

The input data will consist of one or more input data sheets per problem with each line of the input data sheets representing a card. The numbers of the card columns are given in the headings of the various types of input lines for reference during and after punching. Note that the position of the decimal that is shown on the input form does not occupy a card column and should not be punched. However, on occasions a decimal may be entered in a card column and, in this instance, the decimal should be punched.

All blank data fields or card columns must be left blank (skipped), i.e., these columns should not be punched as zeros. These data fields are read as alphabetic characters and, therefore, a blank or zero would have a significant meaning. Only the lines that contain data entered by hand (data that is not a part of the green ink of the input data form) should be punched. The input data should be punched in the same sequence as given on the input data forms. That is, the key-punch operator should punch the input data in the same sequence that it is received. Any exception to this will be clearly noted on the input forms by the Engineer. In general the input data should be punched exactly as shown on the input data form.

COMPUTER OPERATOR INSTRUCTIONS

No instructions on the manual operation of the computer will be given in this write-up. The computer operator is assumed to be fully versed on computer operations. Primarily, this discussion will present the characteristics of the program which the computer operator is required to know in order to process the program.

The input data (punched cards) should be received from the key-punch section in the correct sequence, i.e., there should be no reason to rearrange the sequence of the input data. All input data to the program is from punched cards, and all output from the program is listed by the printer. The only other I/O device used is the disk, i.e., for temporary storage of the input data. The program has the ability to process one or

several problems requiring only one EXECute Control Card, i.e., the program automatically continues from one problem to another. The output form is automatically advanced by the program before printing the output data of each problem. The output data is printed on two types of paper: the standard form of printer paper and a special two-part paper with carbon backing. The output of quantities for all problems is listed first on the standard paper. The computer will "Pause" after completing the quantities in order for the computer operator to change to the special form of paper. When the computer pauses, the message, "PLACE BAR REINFORCING STEEL LISTING PAPER ON PRINTER", is typed by the console typewriter. After the special form is placed on the printer, the computer is restarted. However, if the message, "BAR LISTING NOT REQUIRED, ALL PROBLEMS HAVE ERRORS", is typed, the special form need not be placed on the printer. The job will terminate after this message.

The special form should be positioned for printing on the first line when setting the carriage tape (standard). Then the form should be backspaced one line. In the lateral direction the first print position should be immediately to the right of the paper perforation. The lateral position can best be learned by "trial and error".

The processing time required per problem will vary depending on the amount and type of input data. The average problem will probably require approximately one minute. Following is an example of the job set-up using IBM's DOS.

```
1. // JOB REINFOR  (Job Control Card)
2. // EXEC REBARS  (Execute Control Card)
3.    Input data for all problems
4. /*              (End of Data Control Card)
5. /&              (End of Job Control Card)
```

Of course the control cards are dependent on the operating system being used.

After completing the processing of all problems, the output data along with the input forms are returned to the Bridge Division. The card input data is filed for future reference. Any "Error Messages" are listed in the output of quantities and should be of no concern to the computer operator.