TABLES AND NOMOGRAPHIC CHARTS FOR THE PRELIMINARY ANALYSIS OF CONTINUOUS RIGID FRAMES WITH BENT MEMBERS

By

JAMES WILLIAM GILLESPIE

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

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Thesis Approved:

Jan J. Tuma

Thesis Adviser

Roger L. Flanders

Robert MacVicar

Dean of the Graduate School

PREFACE

This study is the first of a series of studies to develop tables and charts for the preliminary analysis of continuous frames with bent members under the direction of Professor Jan J. Tuma.

The author wishes to acknowledge and express his indebtedness to Professor Jan J. Tuma for his invaluable assistance and constructive criticism in the preparation of this thesis and for acting as the writer's major adviser. Acknowledgement is due Dr. John W. Hamblen for making the facilities of the Oklahoma State University Computing Center available to the author; the staff of the School of Civil Engineering and related departments for their most valuable instruction and aid during the writer's graduate study.

The author expresses his gratitude to the Robberson Steel Company for making this year of graduate study possible.

The writer wishes to thank Mrs. Arlene Starwalt for her careful reading and typing of the manuscript.

J. W. G.

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NOMENCLATURE

M_{ij}	Moment at i on member ij
H_{ij}	Horizontal thrust at i on member ij
V_{ij}	Shear at i on member ij
α	Column parameter
β	Gable height parameter
γ	$\sqrt{1 + 4\beta^2}$
θ_i	Angular rotation at i
Δ_{ix}	Horizontal displacement at i
Δ_{ijx}	Relative horizontal displacement $\Delta_{ix} - \Delta_{jx}$
w	Intensity of load
Q_{ij}	Moment coefficient for M_{ij}

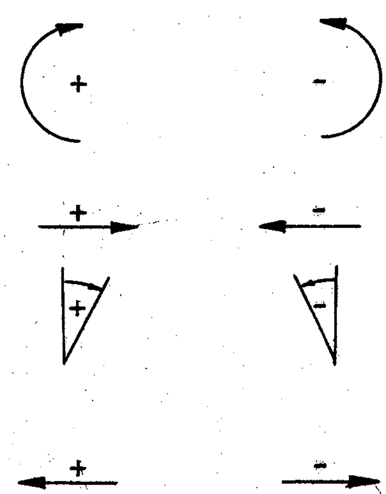
SIGN CONVENTION

Moments

Horizontal thrusts and shears

Angular rotations

Horizontal displacements



PART I

INTRODUCTION

The analysis of continuous rigid frames with bent members by means of energy or deformation methods is a laborious and cumbersome procedure. The main difficulty lies in the preparation and solution of a system of simultaneous equations, which only in special cases can be readily solved by numerical iteration. Analysis by the numerical method of moment distribution and shear equilibrium, while a somewhat simplified method, is also laborious and time-consuming.

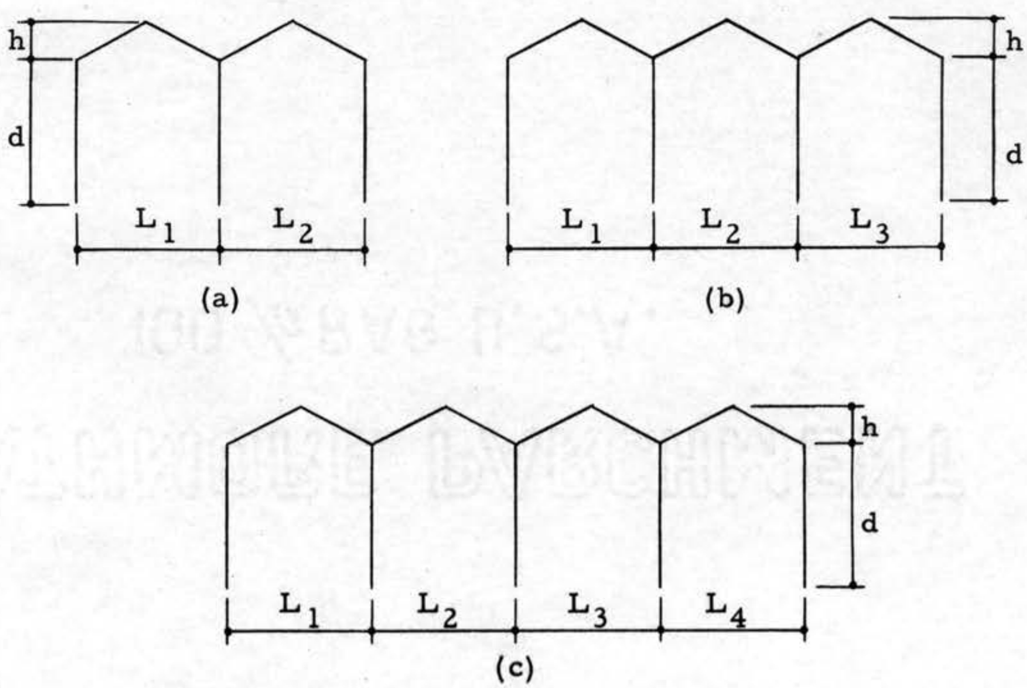


Fig. 1
Typical Continuous Frames with Bent Members

Tables and nomographic charts for the preliminary analysis of symmetrical two, three, and four span rigid gabled frames (Fig. 1a, b, c) with constant cross-section and loaded with a uniform load are developed in this thesis. The parameters α and β are introduced, and the frames are analyzed for all combinations of these parameters that are expected to confront the practicing engineer.

The deformation equations used in the development of these tables and charts were formulated from studies made by Vasquez[3], Hedges[1], and Tuma, Havner, and Hedges[2].

Examples to illustrate the use of the tables and charts are shown in Part IV of this thesis.

The sign convention of the slope-deflection method has been adopted, and the nomenclature used is selected so as to conform to generally accepted standards as closely as possible.

PART II

EQUATIONS OF DEFORMATION

1. Slope-Deflection Equations

The slope-deflection equations for a symmetrical gabled frame with constant cross-section loaded with a uniform load in the vertical plane are (Fig. 2):

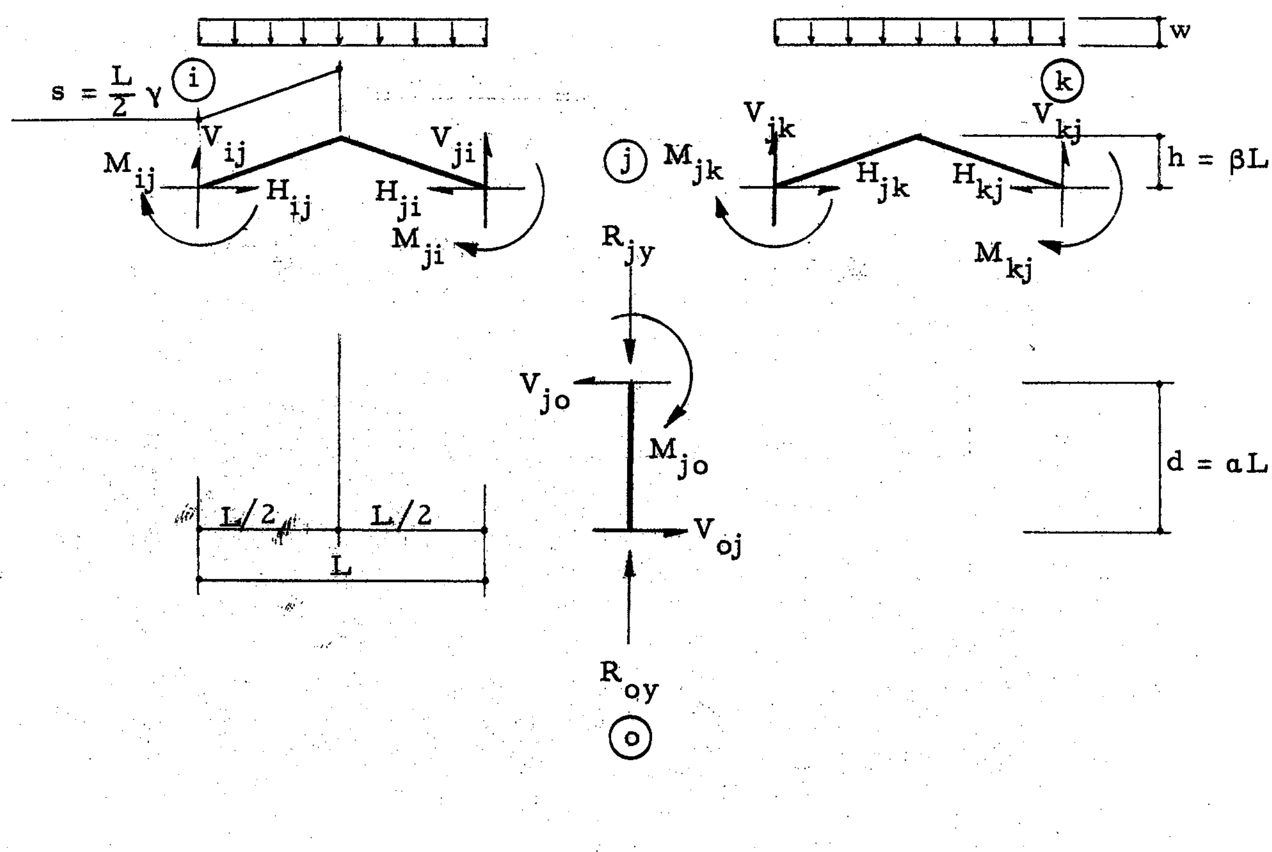


Fig. 2
A Typical Joint

Moment equations:

$$M_{ji} = \frac{7}{2}\frac{EI}{s}\theta_j - \frac{1}{2}\frac{EI}{s}\theta_i + \frac{3EI}{sh}\Delta_{ijx} + \frac{wL^2}{48}$$

$$M_{jk} = \frac{7}{2}\frac{EI}{s}\theta_j - \frac{1}{2}\frac{EI}{s}\theta_k - \frac{3EI}{sh}\Delta_{jkx} - \frac{wL^2}{48} \qquad (1a)$$

$$M_{jo} = \frac{3EI}{d}\theta_j + \frac{3EI}{d^2}\Delta_{jx}$$

Thrust and shear equations:

$$H_{ji} = \frac{3EI}{sh}\theta_i - \frac{3EI}{sh}\theta_j - \frac{6EI}{sh^2}\Delta_{ijx} + \frac{wL^2}{8h}$$

$$H_{jk} = \frac{3EI}{sh}\theta_j - \frac{3EI}{sh}\theta_k - \frac{6EI}{sh^2}\Delta_{jkx} + \frac{wL^2}{8h} \qquad (2a)$$

$$V_{jo} = V_{oj} = \frac{3EI}{d^2}\theta_j + \frac{3EI}{d^3}\Delta_{jx}$$

These equations in terms of α , β , and γ ($\gamma = \sqrt{1 + 4\beta^2}$) are:

Moment equations:

$$M_{ji} = \frac{7EI}{L\gamma}\theta_j - \frac{1EI}{L\gamma}\theta_i + \frac{6EI}{L^2\beta\gamma}\Delta_{ijx} + \frac{wL^2}{48}$$

$$M_{jk} = \frac{7EI}{L\gamma}\theta_j - \frac{1EI}{L\gamma}\theta_k - \frac{6EI}{L^2\beta\gamma}\Delta_{jkx} - \frac{wL^2}{48} \qquad (1b)$$

$$M_{jo} = \frac{3EI}{L\alpha}\theta_j + \frac{3EI}{L^2\alpha^2}\Delta_{jx}$$

Thrust and shear equations:

$$H_{ji} = \frac{6EI}{L^2\beta\gamma}\theta_i - \frac{6EI}{L^2\beta\gamma}\theta_j - \frac{12EI}{L^3\beta^2\alpha}\Delta_{ijx} + \frac{wL}{8\beta}$$

$$H_{jk} = \frac{6EI}{L^2\beta\gamma}\theta_j - \frac{6EI}{L^2\beta\gamma}\theta_k - \frac{12EI}{L^3\beta^2\gamma}\Delta_{jkx} + \frac{wL}{8\beta} \qquad (2b)$$

$$V_{jo} = V_{oj} = \frac{3EI}{L^2\alpha^2}\theta_j + \frac{3EI}{L^3\alpha^3}\Delta_{jx}$$

2. Joint Equations

Three equations of static equilibrium can be written for each joint of a continuous frame. The equilibrium of moments:

$$\Sigma M = 0 \qquad (3a)$$

The equilibrium of horizontal forces:

$$\Sigma F_x = 0 \qquad (4a)$$

The equilibrium of vertical forces

$$\Sigma F_y = 0 \qquad (5a)$$

With the assumption that there is no vertical displacement, Equation (5a) can be eliminated in the solution.

Applying conditions (3a) and (4a) to a typical joint (Fig. 2), the equations of equilibrium are:

$$\Sigma M_j = 0 \qquad M_{ji} + M_{jo} + M_{jk} = 0 \qquad (3b)$$

$$\Sigma F_{jx} = 0 \qquad - H_{ji} - V_{jo} + H_{jk} = 0 \qquad (4b)$$

3. Matrix Tables

Symmetrical two, three, and four span frames are considered. Substituting Equations (1b) and (2b) into Equations (3b) and (4b), the Matrix Tables 1, 2, and 3 are formulated in terms of the deformation equivalents.

In the formation of these matrices, the reoccurrence of certain constants was noted. This phenomena is due to the nature of the slope-deflection equations.

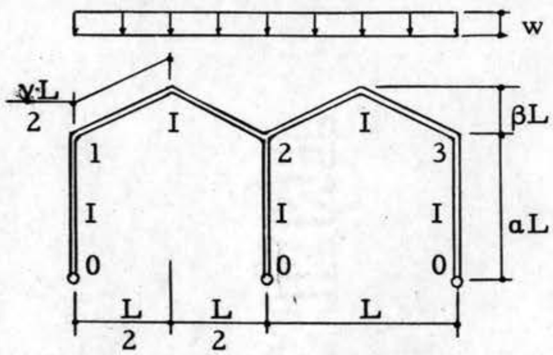
4. Solution

The matrix constants were evaluated by the use of a desk calculator, punched into standard eight-ten word machine data cards,

TABLE 1	TABLE 2
TWO SPAN FRAME — BENT GIRDERS	THREE SPAN FRAME — BENT GIRDERS

TABLE 1

TWO SPAN FRAME — BENT GIRDERS



$\Delta_1 = -\Delta_3 \qquad \Delta_2 = 0$

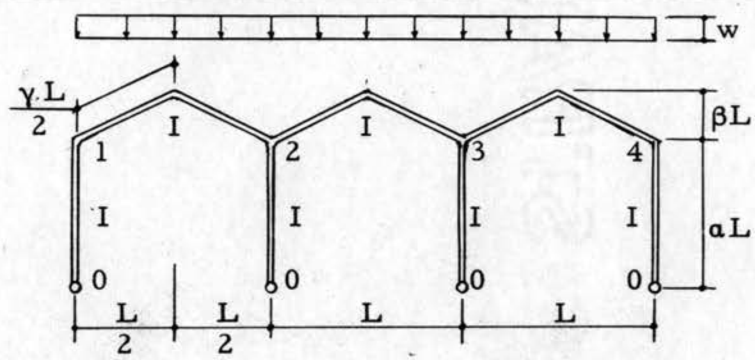
$\theta_1 = -\theta_3 \qquad \theta_2 = 0$

MATRIX CONSTANTS

	$\frac{3EI}{L\gamma}\theta_1$	$\frac{3EI}{L^2\gamma}\Delta_1$	wL^2
$\Sigma M_1 = 0$	$\frac{\gamma}{\alpha} + \frac{7}{3}$	$\frac{\gamma}{\alpha^2} - \frac{2}{\beta}$	$\frac{1}{48}$
$\Sigma F_{1x} = 0$	$\frac{\gamma}{\alpha^2} - \frac{2}{\beta}$	$\frac{\gamma}{\alpha^3} + \frac{4}{\beta^2}$	$\frac{1}{8\beta}$

TABLE 2

THREE SPAN FRAME — BENT GIRDERS



$\Delta_1 = -\Delta_4 \qquad \Delta_2 = -\Delta_3$

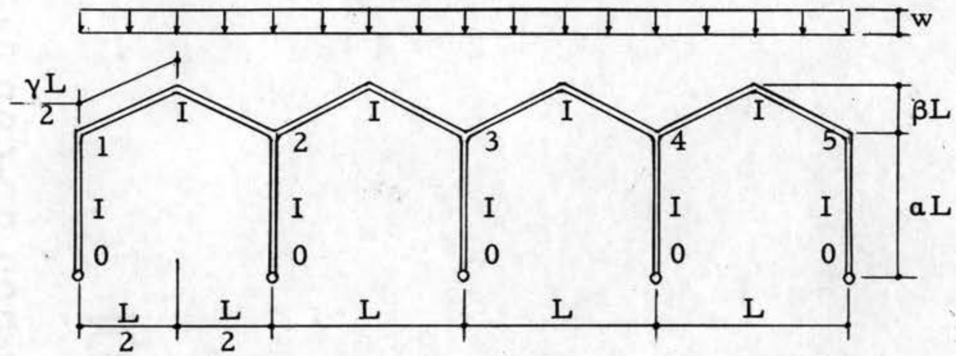
$\theta_1 = -\theta_4 \qquad \theta_2 = -\theta_3$

MATRIX CONSTANTS

	$\frac{3EI}{L\gamma}\theta_1$	$\frac{3EI}{L\gamma}\theta_2$	$\frac{3EI}{L^2\gamma}\Delta_1$	$\frac{3EI}{L^2\gamma}\Delta_2$	wL^2
$\Sigma M_1 = 0$	$\frac{\gamma}{\alpha} + \frac{7}{3}$	$-\frac{1}{3}$	$\frac{\gamma}{\alpha^2} - \frac{2}{\beta}$	$\frac{2}{\beta}$	$\frac{1}{48}$
$\Sigma M_2 = 0$	$-\frac{1}{3}$	$\frac{\gamma}{\alpha} + 5$	$\frac{2}{\beta}$	$\frac{\gamma}{\alpha^2} - \frac{6}{\beta}$	0
$\Sigma F_{1x} = 0$	$\frac{\gamma}{\alpha^2} - \frac{2}{\beta}$	$\frac{2}{\beta}$	$\frac{\gamma}{\alpha^3} + \frac{4}{\beta^2}$	$-\frac{4}{\beta^2}$	$\frac{1}{8\beta}$
$\Sigma F_{2x} = 0$	$\frac{2}{\beta}$	$\frac{\gamma}{\alpha^2} - \frac{6}{\beta}$	$-\frac{4}{\beta^2}$	$\frac{\gamma}{\alpha^3} + \frac{12}{\beta^2}$	0

TABLE 3

FOUR SPAN FRAME — BENT GIRDERS



$\Delta_1 = -\Delta_5$ $\quad$ $\Delta_2 = -\Delta_4$ $\quad$ $\Delta_3 = 0$

$\theta_1 = -\theta_5$ $\quad$ $\theta_2 = -\theta_4$ $\quad$ $\theta_3 = 0$

MATRIX CONSTANTS

	$\frac{3EI}{L\gamma}\theta_1$	$\frac{3EI}{L\gamma}\theta_2$	$\frac{3EI}{L^2\gamma}\Delta_1$	$\frac{3EI}{L^2\gamma}\Delta_2$	wL^2
$\Sigma M_1 = 0$	$\frac{\gamma}{\alpha} + \frac{7}{3}$	$-\frac{1}{3}$	$\frac{\gamma}{\alpha^2} - \frac{2}{\beta}$	$\frac{2}{\beta}$	$\frac{1}{48}$
$\Sigma M_2 = 0$	$-\frac{1}{3}$	$\frac{\gamma}{\alpha} + \frac{14}{3}$	$-\frac{2}{\beta}$	$\frac{\gamma}{\alpha^2} - \frac{4}{\beta}$	0
$\Sigma F_{1x} = 0$	$\frac{\gamma}{\alpha^2} - \frac{2}{\beta}$	$\frac{2}{\beta}$	$\frac{\gamma}{\alpha^3} + \frac{4}{\beta^2}$	$-\frac{4}{\beta^2}$	$\frac{1}{8B}$
$\Sigma F_{2x} = 0$	$\frac{2}{\beta}$	$\frac{\gamma}{\alpha^2} - \frac{4}{\beta}$	$-\frac{4}{\beta^2}$	$\frac{\gamma}{\alpha^3} + \frac{8}{\beta^2}$	0

and read into the IBM 650 digital computer with a program for solving systems of simultaneous linear equations. This program is on file in the Oklahoma State University Computing Center Library and the IBM program library under the title "Equ Solv". This program is a regenerative program utilizing Cholesky's scheme in the evaluation of the unknowns.

The deformation equivalents obtained from the IBM 650 output were used to evaluate the moment coefficients by substitution into the slope-deflection Equations (1b) and (2b).

PART III

TABLES AND CHARTS

1. General Notes

The end moment coefficient tables and charts presented in this part are divided into the following groups:

Group A-2. Two Span Frame

Group A-3. Three Span Frame

Group A-4. Four Span Frame

Each table's symbol is composed of two terms: first the capital letter A indicating gabled; second, an Arabic number indicating the number of spans. The charts have one additional Arabic number which identifies the sequence of end moments from left to right.

Each table or chart is composed of the following major parts:

1. Illustration of Frame: Figure containing symbols for all structural elements such as symbols for joints, lengths, moments of inertia, and intensity of load.

2. Column Parameter - α :

3. Gable Height Parameter - β :

4. Moment Coefficient - Q :

5. End Moments: Formulas for evaluating end moments, $M_{ij} = \pm Q_{ij} wL^2$.

The number of horizontal rows is equivalent to the number of α values for which the frame was analyzed, and the number of vertical columns corresponds to the number of β values for which the frame was analyzed. Each curve plotted on a chart corresponds to a value of β .

2. Steps of Procedure

1. Select the table or charts for the case to be investigated and adjust the symbols to those shown.

2. Determine the values of α and β as indicated.

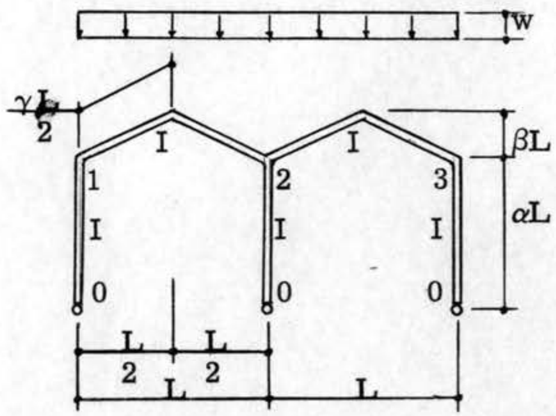
3. Determine the moment coefficient Q by the use of α and β previously evaluated.

4. Determine end moments by the use of the formulas given.

3. Interpolation

The tables can be utilized very efficiently if α and β have values that are tabulated, but the charts lend themselves more readily to interpolation. Quite accurate results can be obtained by linear interpolation from either the tables or charts as will be shown in the examples.

TWO SPAN FRAME　　BENT GIRDERS　　TABLE A-2



$$M_{12} = -Q_{12} \times wL^2$$

$$M_{21} = +Q_{21} \times wL^2$$

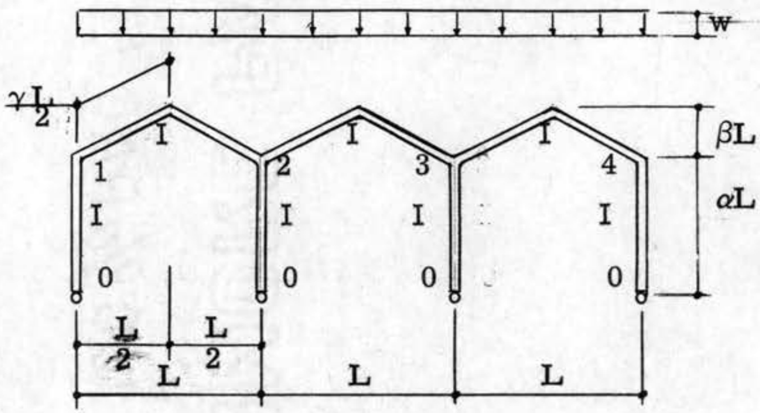
Q_{12}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.06554	.05887	.05155	.04511	.03977
0.4	.05757	.05838	.05752	.05556	.05299
0.5	.05327	.05523	.05598	.05568	.05456
0.6	.04918	.05190	.05361	.05445	.05448
0.7	.04601	.04870	.05096	.05258	.05347
0.8	.04300	.04575	.04831	.05043	.05194
1.0	.03798	.04063	.04340	.04603	.04829

Q_{21}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.06766	.05141	.04123	.03477	.03055
0.4	.08542	.07391	.06389	.05555	.04882
0.5	.09037	.08081	.07182	.06375	.05680
0.6	.09411	.08608	.07809	.07055	.06371
0.7	.09706	.09021	.08314	.07618	.06962
0.8	.09947	.09355	.08726	.08088	.07468
1.0	.10316	.09859	.09353	.08817	.08275

THREE SPAN FRAME BENT GIRDERS TABLE A-3



$$M_{12} = -Q_{12} \times wL^2$$
$$M_{21} = +Q_{21} \times wL^2$$
$$M_{23} = -Q_{23} \times wL^2$$
$$M_{20} = +Q_{20} \times wL^2$$

Q_{12}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.07076	.06329	.05451	.04699	.04095
0.4	.06153	.06337	.06250	.06002	.05674
0.5	.05689	.05990	.06101	.06058	.05904
0.6	.05283	.05627	.05849	.05946	.05932
0.7	.04929	.05284	.05564	.05752	.05844
0.8	.04621	.04969	.05280	.05525	.05690
1.0	.04108	.04430	.04755	.05055	.05307

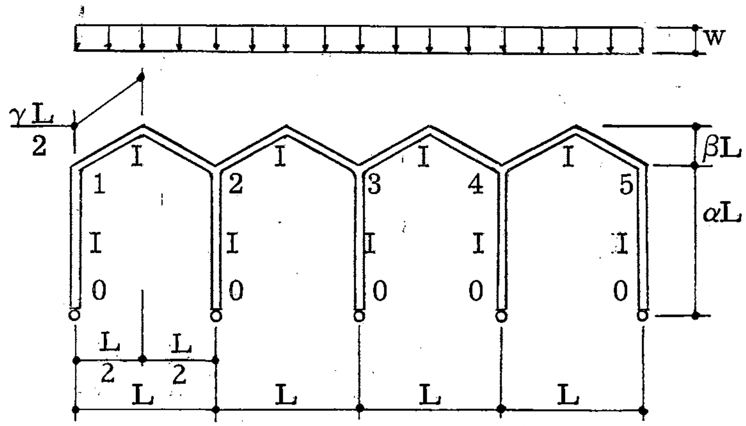
Q_{21}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.05978	.04235	.03342	.02866	.02594
0.4	.07924	.06592	.05489	.04637	.04005
0.5	.08396	.07314	.06318	.05458	.04756
0.6	.08719	.07838	.06967	.06156	.05443
0.7	.08951	.08225	.07472	.06732	.06043
0.8	.09123	.08517	.07867	.07203	.06556
1.0	.09359	.08921	.08431	.07902	.07356

TABLE A-3 (CONTINUED)

Q_{23}						Q_{20}					
$\alpha \backslash \beta$	0.1	0.2	0.3	0.4	0.5	$\alpha \backslash \beta$	0.1	0.2	0.3	0.4	0.5
0.2	.06623	.05014	.03972	.03329	.02923	0.2	+.00645	+.00779	+.00630	+.00463	+.00329
0.4	.07809	.06912	.06032	.05260	.04625	0.4	-.00115	+.00320	+.00543	+.00623	+.00620
0.5	.08068	.07383	.06658	.05961	.05335	0.5	-.00328	+.00069	+.00340	+.00503	+.00579
0.6	.08251	.07711	.07112	.06501	.05919	0.6	-.00468	-.00127	+.00145	+.00345	+.00476
0.7	.08392	.07952	.07450	.06920	.06391	0.7	-.00559	-.00273	-.00022	+.00188	+.00348
0.8	0.8505	.08137	.07711	.07249	.06772	0.8	-.00618	-.00380	-.00156	+.00046	+.00216
1.0	.08681	.08408	.08086	.07726	.07343	1.0	-.00678	-.00513	-.00345	-.00176	-.00013

FOUR SPAN FRAME | BENT GIRDERS | TABLE A-4



$$M_{12} = -Q_{12} \times wL^2$$
$$M_{21} = +Q_{21} \times wL^2$$
$$M_{23} = -Q_{23} \times wL^2$$
$$M_{20} = +Q_{20} \times wL^2$$
$$M_{32} = +Q_{32} \times wL^2$$

Q_{12}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.07502	.06615	.05603	.04778	.04138
0.4	.06438	.06722	.06612	.06295	.05896
0.5	.05906	.06334	.06476	.06405	.06198
0.6	.05448	.05920	.06204	.06310	.06270
0.7	.05056	.05529	.05886	.06108	.06198
0.8	.04715	.05174	.05564	.05859	.06044
1.0	.04159	.04569	.04971	.05332	.05626

Q_{21}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.05367	.03662	.02946	.02609	.02429
0.4	.07628	.06069	.04891	.04065	.03506
0.5	.08206	.06905	.05776	.04871	.04186
0.6	.08608	.07531	.06509	.05609	.04863
0.7	.08904	.08005	.07101	.06249	.05494
0.8	.09126	.08369	.07577	.06792	.06057
1.0	.09441	.08886	.08274	.07627	.06977

TABLE A-4 (CONTINUED)

Q_{23}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.06846	.05078	.03966	.03304	.02898
0.4	.08068	.07121	.06156	.05315	.04635
0.5	.08336	.07626	.06835	.06069	.05388
0.6	.08534	.07977	.07327	.06656	.06017
0.7	.08693	.08238	.07696	.07113	.06531
0.8	.08824	.08442	.07982	.07474	.06949
1.0	.09035	.08749	.08399	.08002	.07576

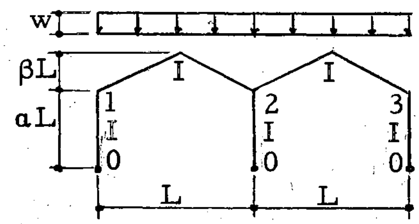
Q_{20}

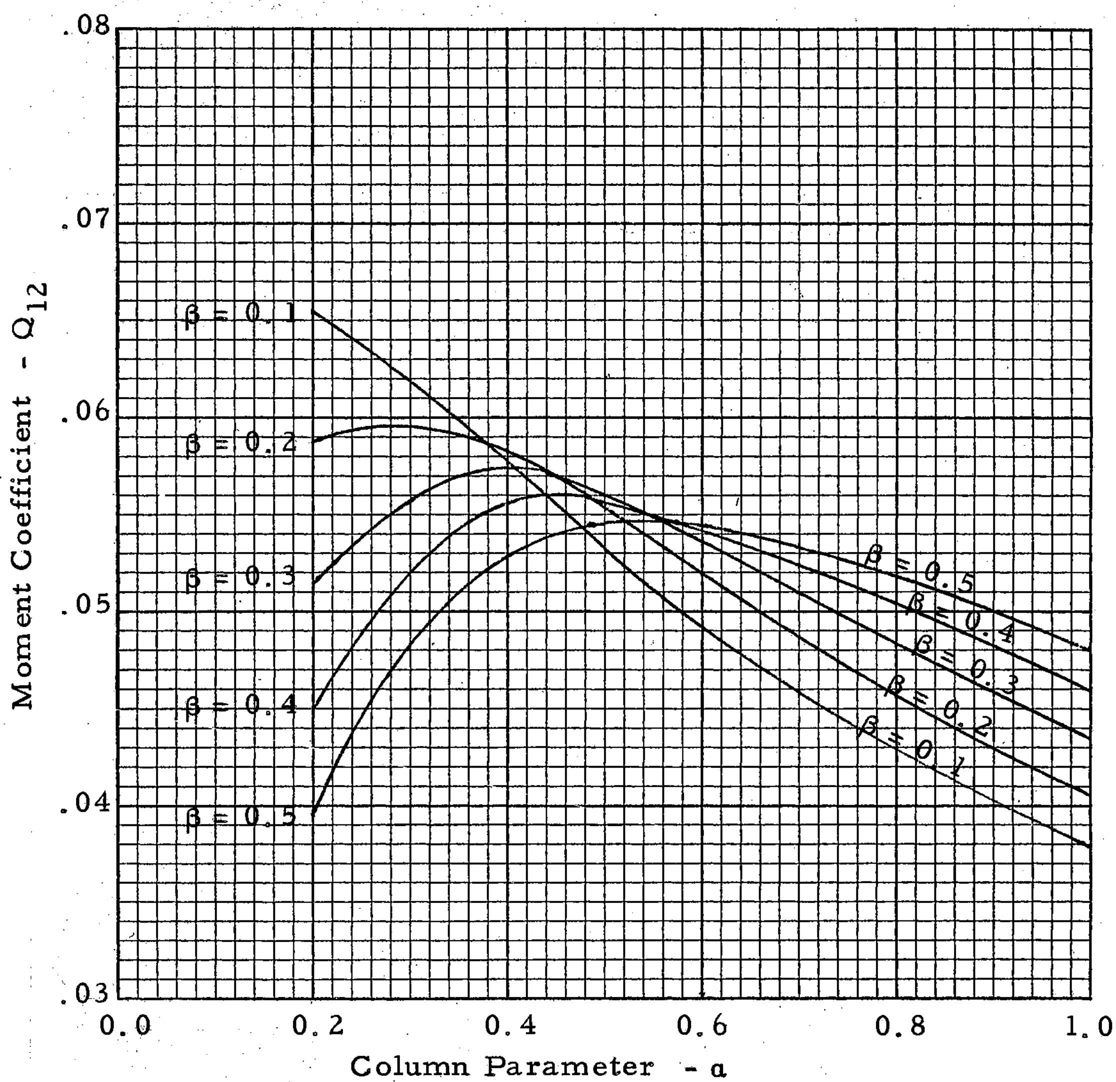
α \ β	0.1	0.2	0.3	0.4	0.5
0.2	+.01479	+.01416	+.01020	+.00695	+.00469
0.4	+.00440	+.01052	+.01265	+.01250	+.01129
0.5	+.00130	+.00721	+.01059	+.01198	+.01202
0.6	-.00074	+.00446	+.00818	+.01047	+.01154
0.7	-.00211	+.00233	+.00595	+.00864	+.01037
0.8	-.00302	+.00073	+.00405	+.00682	+.00892
1.0	-.00406	-.00137	+.00125	+.00375	+.00599

Q_{32}

α \ β	0.1	0.2	0.3	0.4	0.5
0.2	.05709	.03938	.03066	.02637	.02412
0.4	.07176	.06024	.04990	.04184	.03597
0.5	.07426	.06571	.05692	.04904	.04255
0.6	.07561	.06920	.06203	.05493	.04851
0.7	.07636	.07146	.06569	.05955	.05358
0.8	.07674	.07395	.06830	.06310	.05774
1.0	.07701	.07461	.07154	.06787	.06377

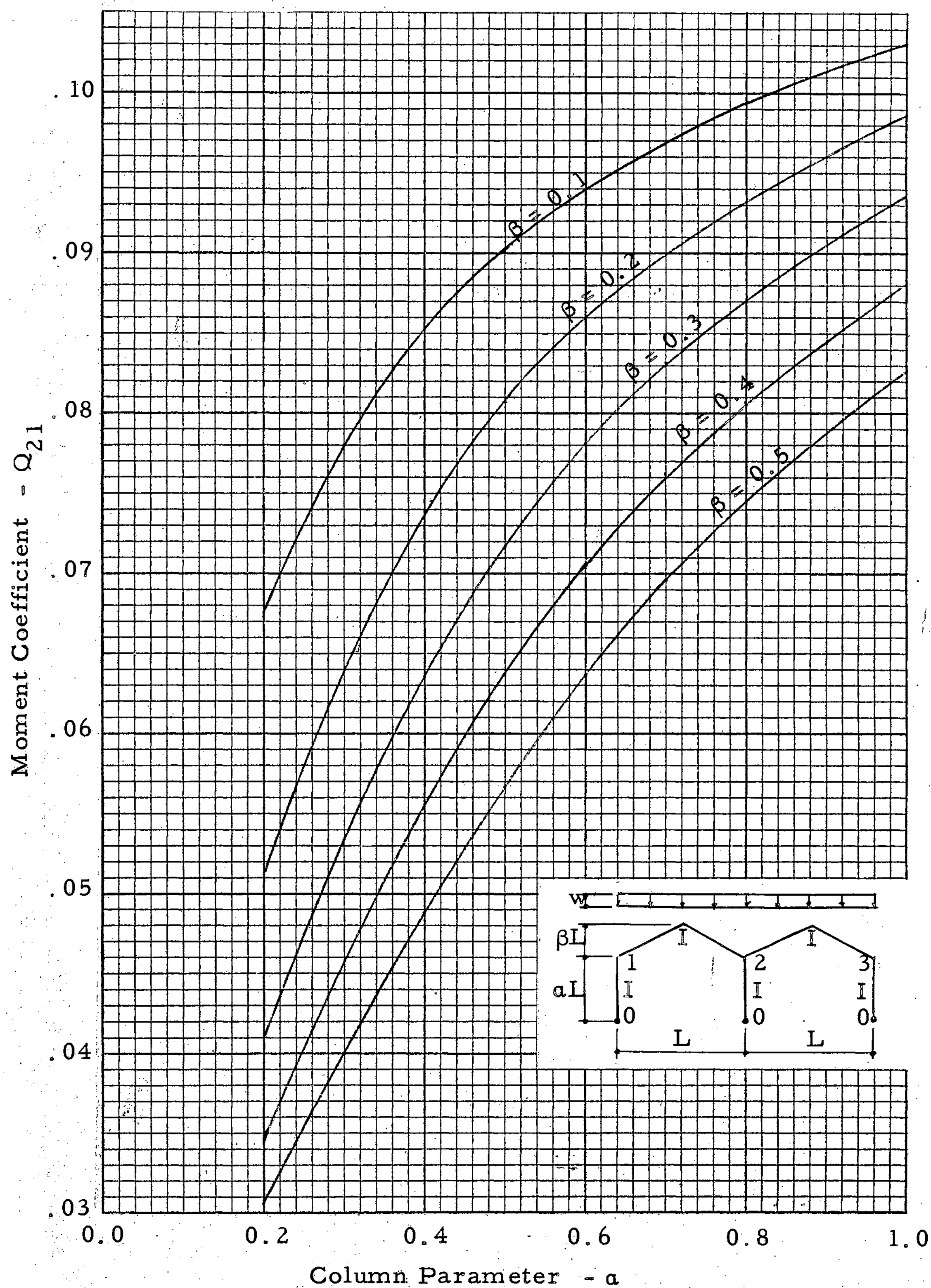
$$M_{12} = -Q_{12} w L^2$$


w
βL
αL
I
I
1
I
0
2
I
0
3
I
0
L
L


.08
.07
.06
.05
.04
.03
0.0
0.2
0.4
0.6
0.8
1.0
Moment Coefficient - Q12
Column Parameter - α
β = 0.1
β = 0.2
β = 0.3
β = 0.4
β = 0.5
β = 0.5
β = 0.4
β = 0.3
β = 0.2
β = 0.1

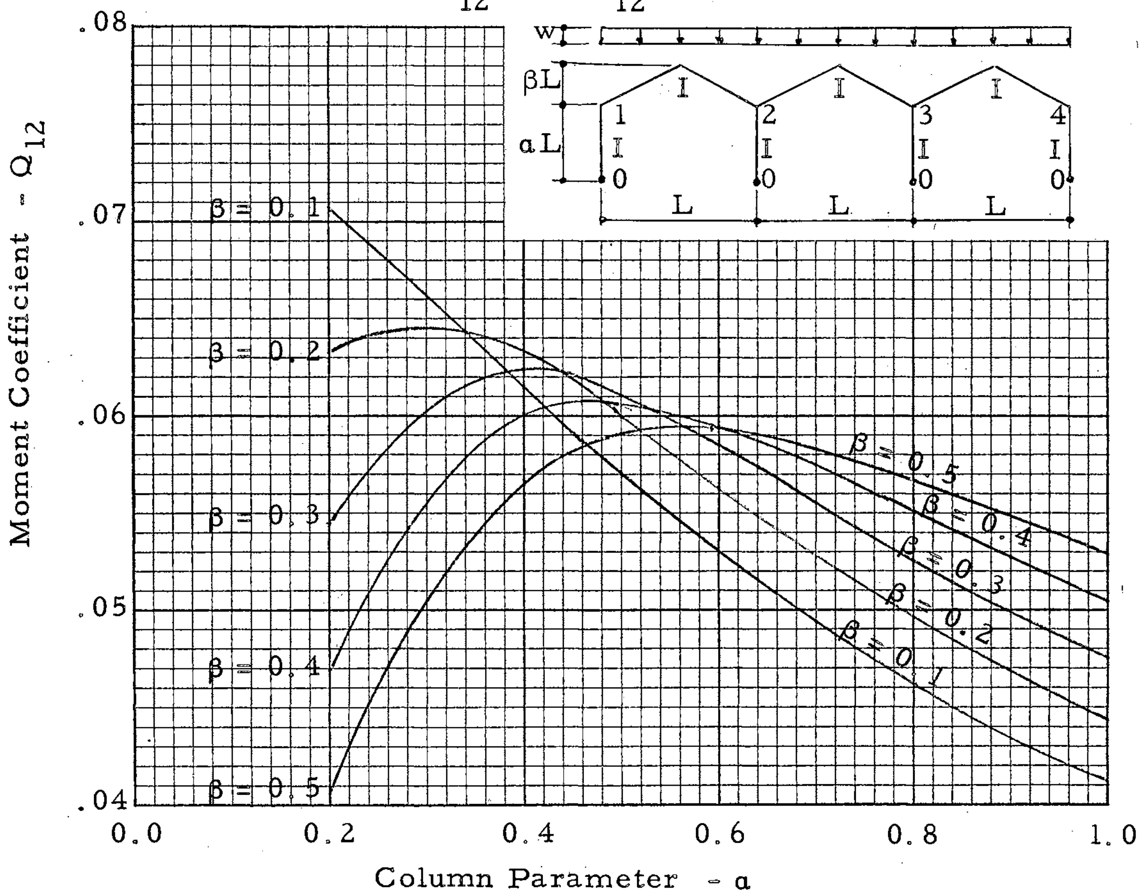
TWO SPAN FRAME BENT GIRDERS CHART A-21

$$M_{21} = + Q_{21} w L^2$$



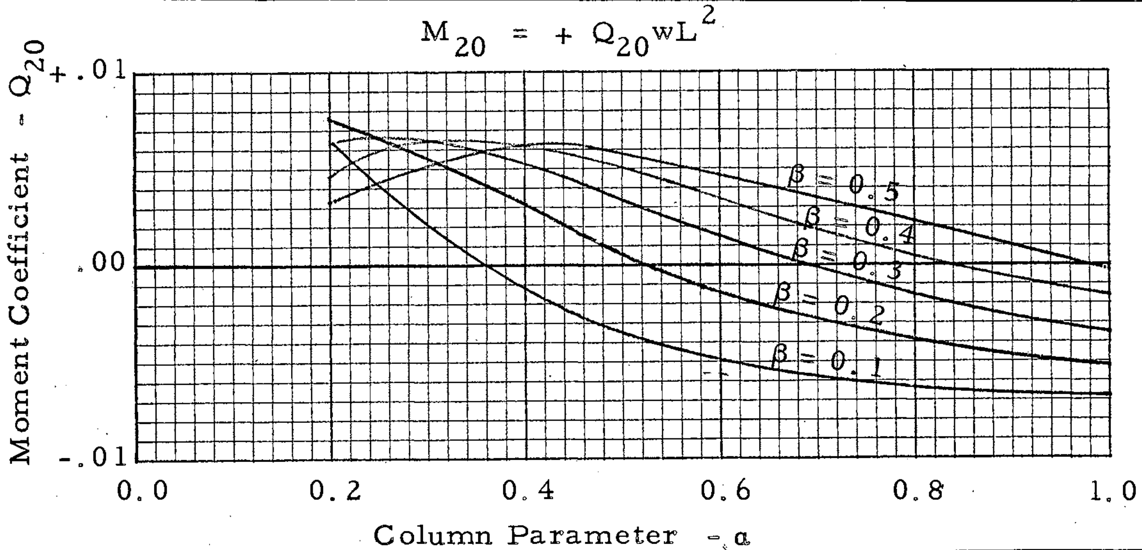
THREE SPAN FRAME BENT GIRDERS CHART A-30

$$M_{12} = -Q_{12}wL^2$$



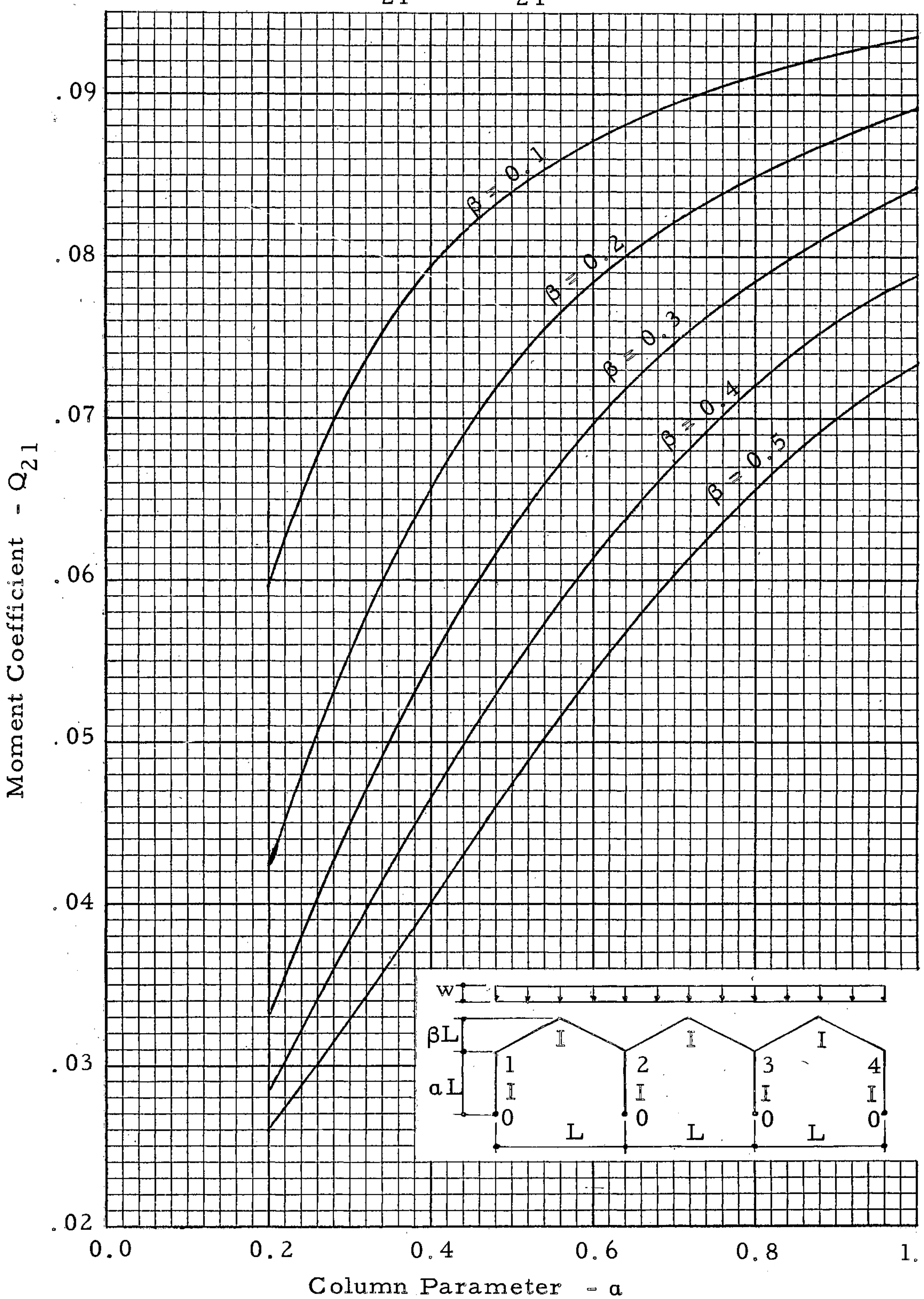
THREE SPAN FRAME BENT GIRDERS CHART A-32

$$M_{20} = +Q_{20}wL^2$$



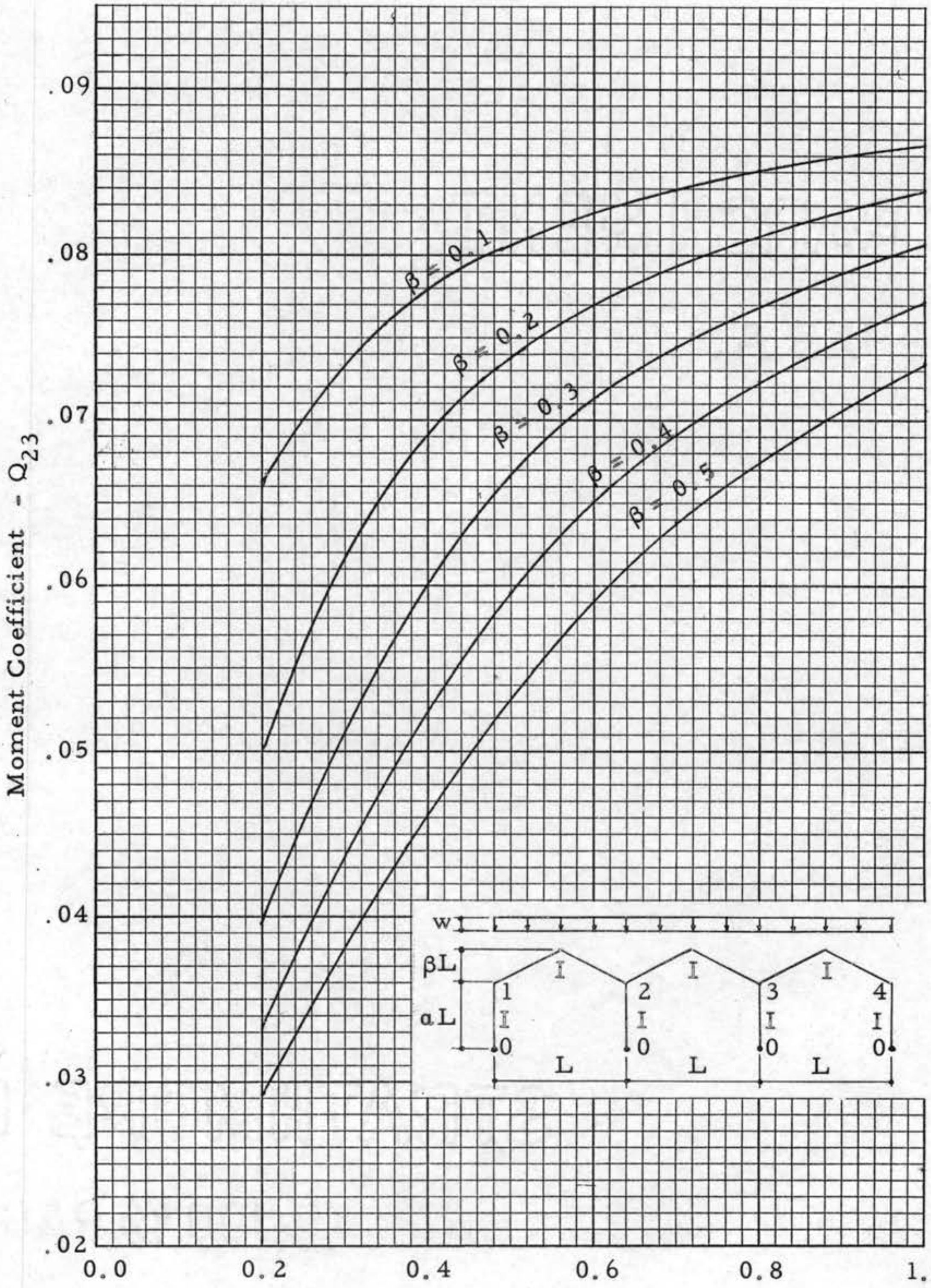
THREE SPAN FRAME BENT GIRDERS CHART A-31

$$M_{21} = + Q_{21} w L^2$$



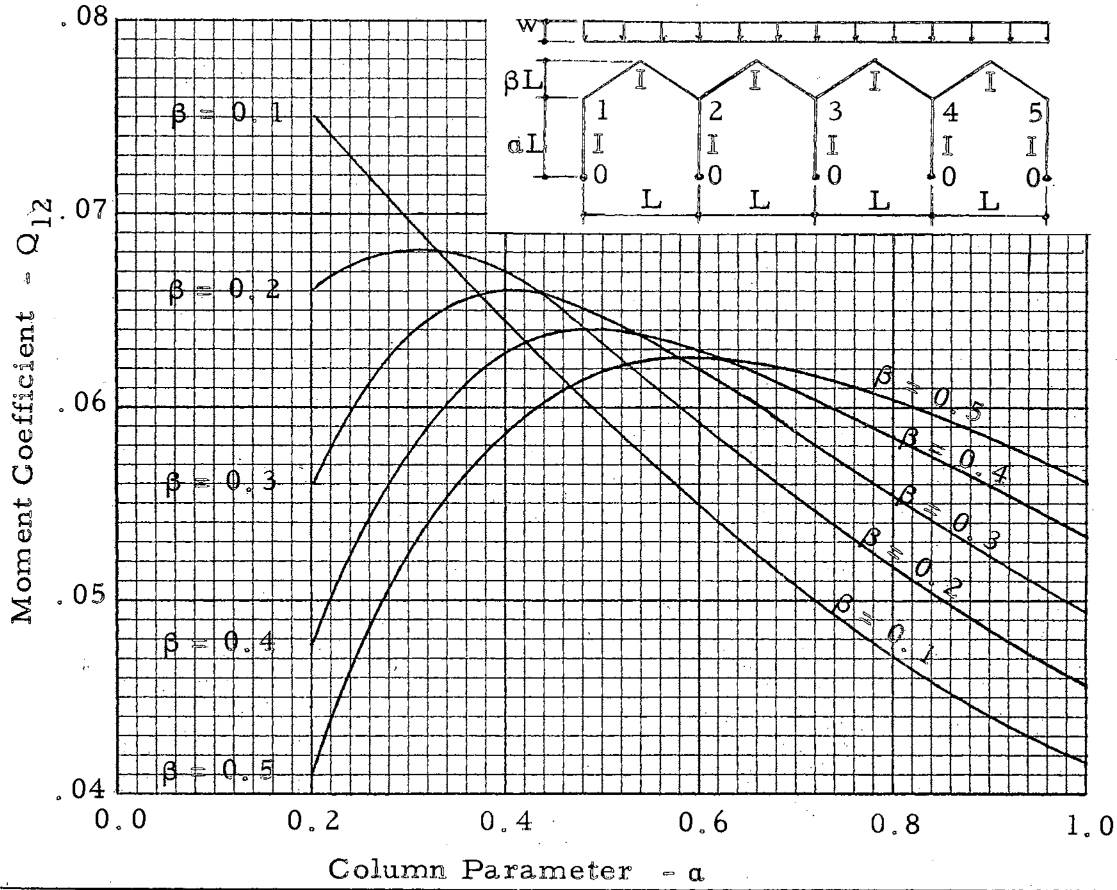
THREE SPAN FRAME BENT GIRDERS CHART A-33

$$M_{23} = + Q_{23} w L^2$$



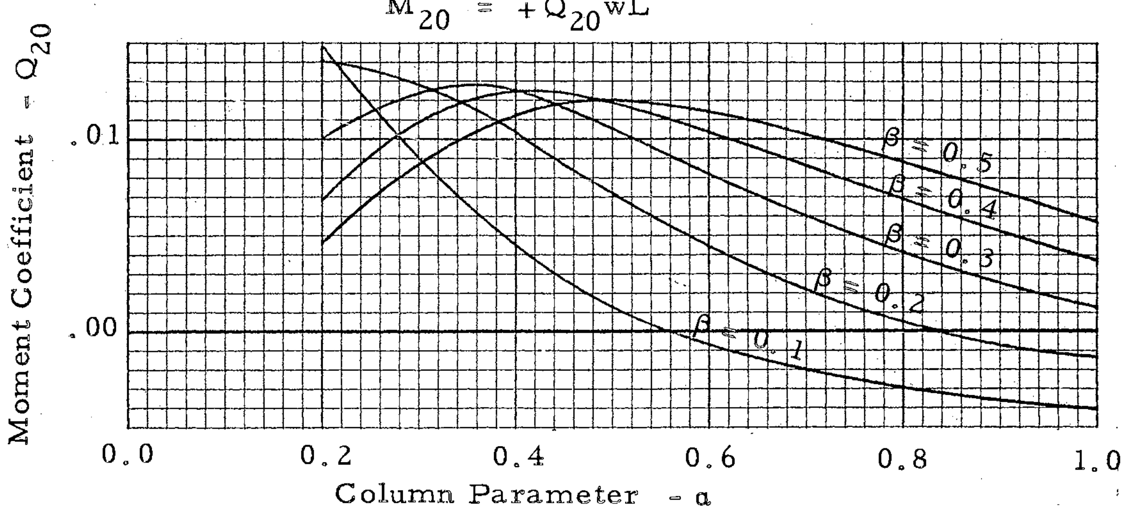
FOUR SPAN FRAME BENT GIRDERS CHART A-40

$M_{12} = -Q_{12} w L^2$



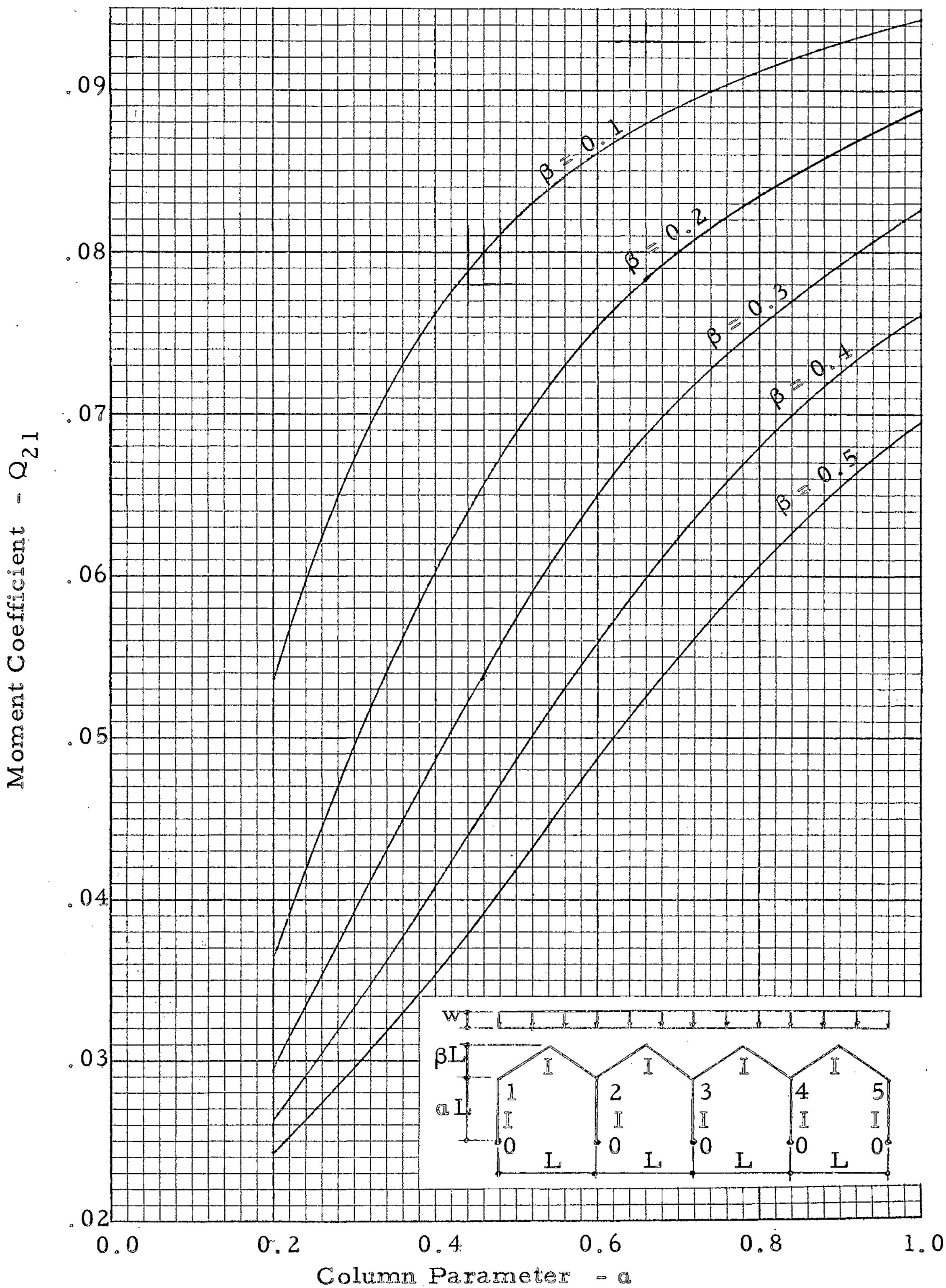
FOUR SPAN FRAME BENT GIRDERS CHART A-42

$M_{20} = +Q_{20} w L^2$



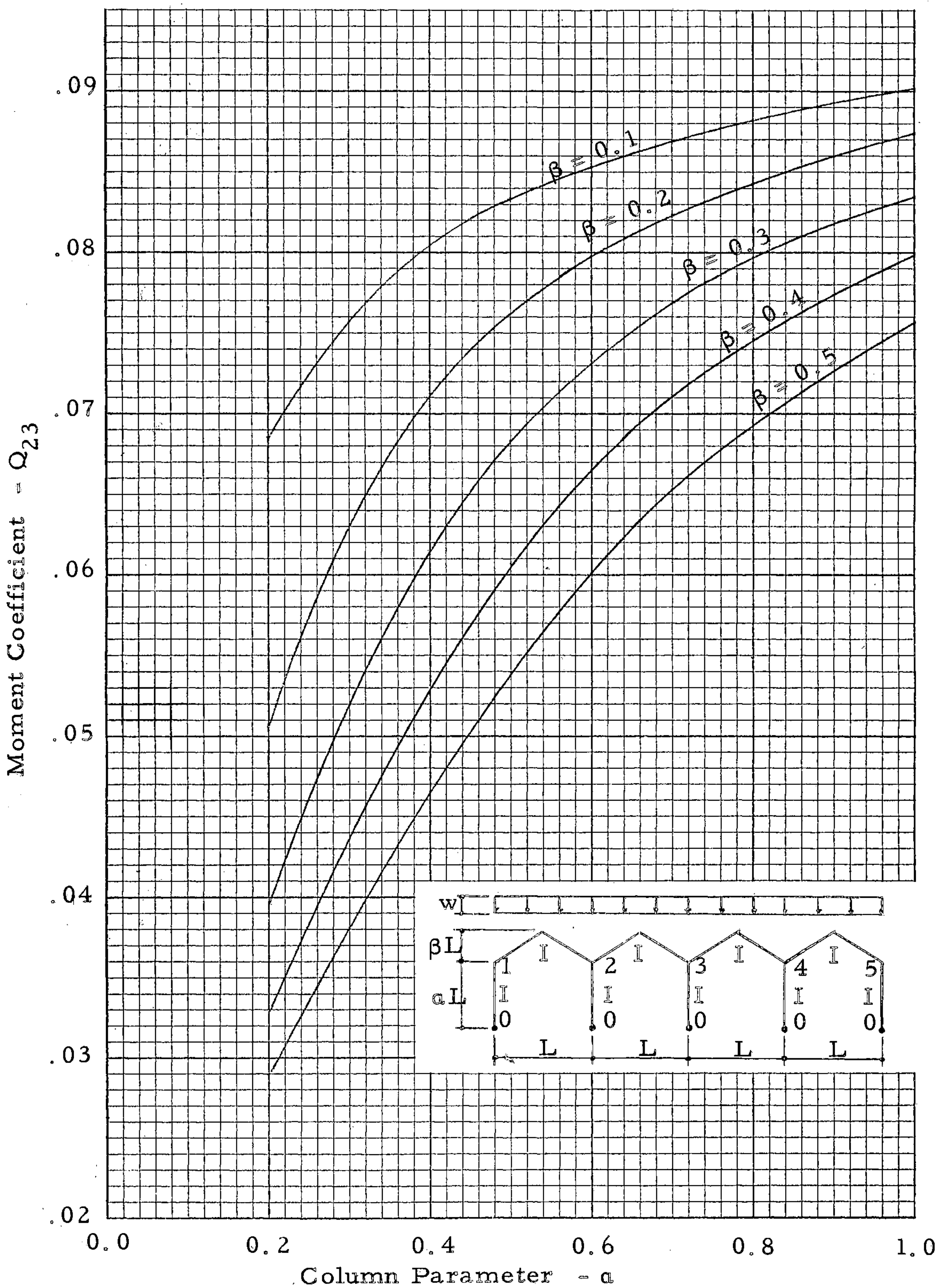
FOUR SPAN FRAME — BENT GIRDERS — CHART A-41

$$M_{21} = + Q_{21} wL^2$$



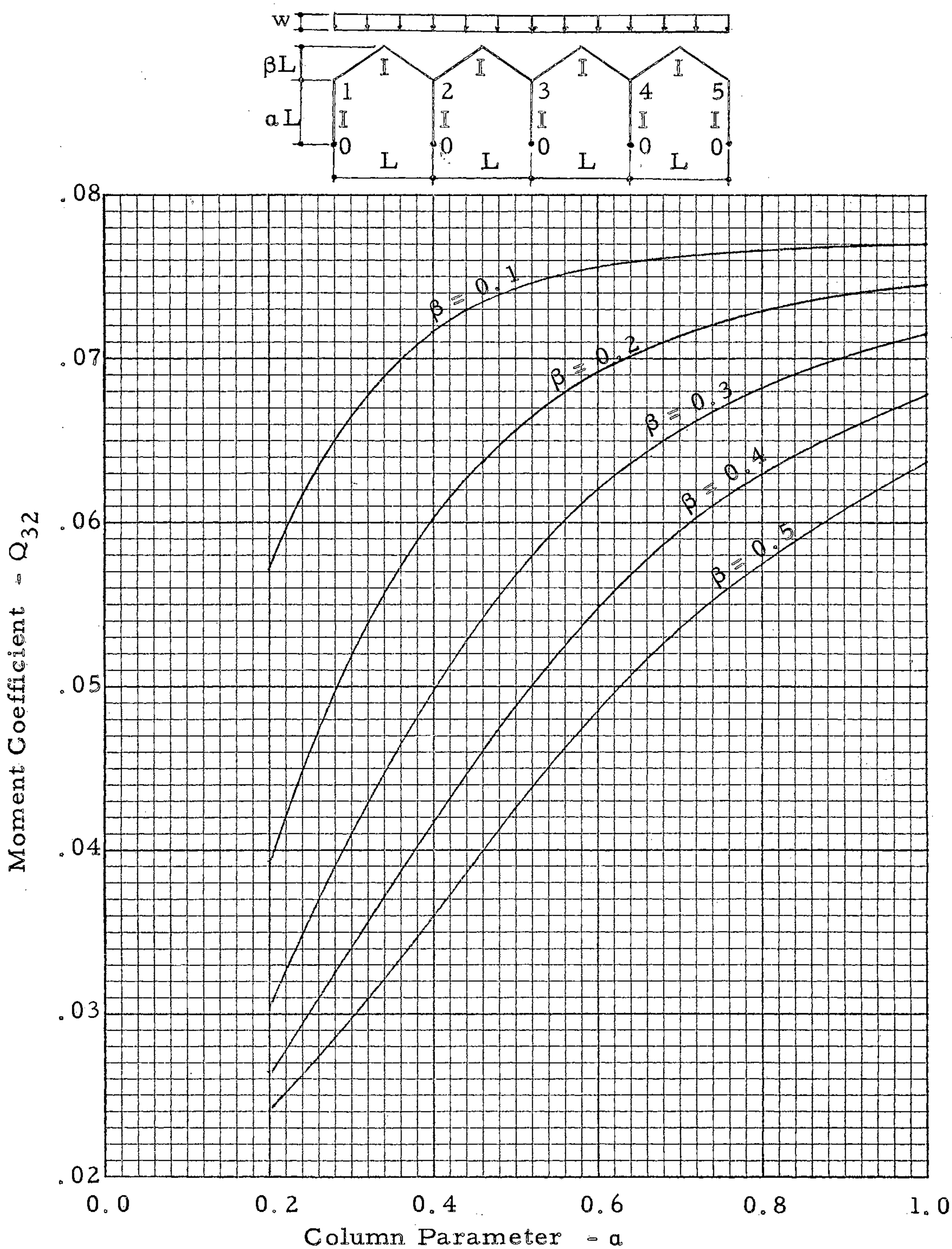
FOUR SPAN FRAME | BENT GIRDERS | CHART A-43

$$M_{23} = -Q_{23}wL^2$$



FOUR SPAN FRAME BENT GIRDERS CHART A-44

$$M_{32} = + Q_{32} w L^2$$



PART IV

ILLUSTRATIVE EXAMPLES

Two examples are cited: one having values of α and β that correspond to those in the tables and one that will illustrate the use of moment coefficients obtained by interpolation. The flexural rigidity EI is assumed to be constant for all members. All values are given in feet, kips, or kip-feet.

Example 1

A three span gabled frame as shown in Fig. 3 will be analyzed by the tables and compared with the results obtained by moment distribution. Values of α and β are chosen to correspond to tabulated values.

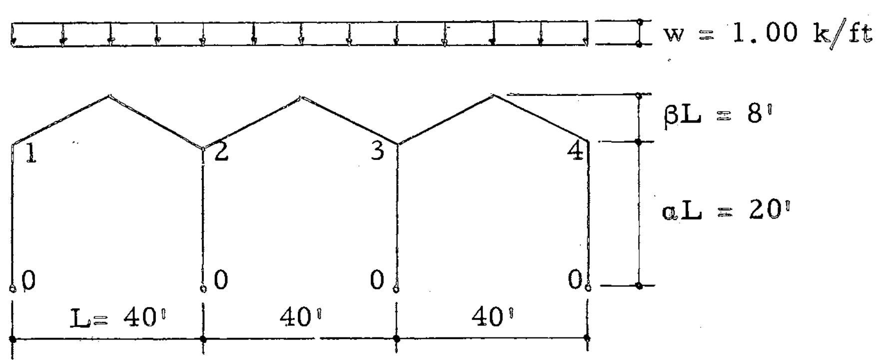


Fig. 3
Three Span Gabled Frame

$\alpha = 0.5$ $\beta = 0.2$ $wL^2 = 1600$

	From Table A-3	Moment Distribution
M_{12}	$= - .05990 \times 1600 = - 95.84$	$- 96.77$
M_{21}	$= + .07314 \times 1600 = + 117.02$	$+ 115.42$
M_{20}	$= + .00069 \times 1600 = + 1.11$	$+ .53$
M_{23}	$= - .07383 \times 1600 = - 118.13$	$- 115.95$

The difference in these results are due to the approximations made in the moment distribution procedure.

Example 2

A four span gabled frame with dimensions and loads as shown in Fig. 4 is analyzed[2]. The tables and charts will be used for interpolation.

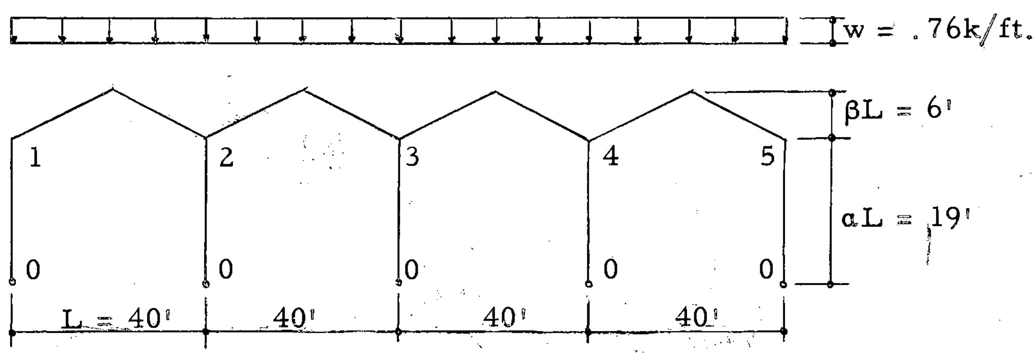


Fig. 4
Four Span Gabled Frame

$\alpha = 0.475$ $\beta = 0.15$ $wL^2 = 1216$

	From Charts A-4	From Reference 2
M_{12}	$= -.0625 \times 1216 = -76.00$	-76.34
M_{21}	$= +.0738 \times 1216 = +89.74$	$+89.73$
M_{20}	$= +.0050 \times 1216 = +6.08$	$+6.55$
M_{23}	$= -.0789 \times 1216 = -95.94$	-96.27
M_{32}	$= +.0690 \times 1216 = +83.90$	$+84.25$

From Table A-4

$$M_{12} = -.06235 \times 1216 = -75.82$$

$$M_{21} = +.07379 \times 1216 = +89.73$$

$$M_{20} = +.00506 \times 1216 = +6.15$$

$$M_{23} = -.07885 \times 1216 = -95.88$$

$$M_{32} = +.06899 \times 1216 = +83.89$$

PART V

SUMMARY AND CONCLUSIONS

The primary objective of this study was to develop tables and charts for the preliminary analysis of continuous rigid frames with bent members.

The slope-deflection Equations (1a) and (2a) were expressed in terms of the column and gable height parameters α and β resulting in Equations (1b) and (2b). From these equations and the conditions for static equilibrium, matrices for two, three, and four span frames were formulated in Tables 1, 2, and 3 respectively.

The matrix constants were evaluated numerically for $\alpha = 0.2$, $0.4(0.1)0.8$, 1.0 and $\beta = 0.1(0.1)0.5$ and read into the IBM 650 digital computer with a program for solving simultaneous linear equations. The deformation equivalents obtained from the IBM 650 output were then used in the slope-deflection equations to compute the moment coefficients.

The use of these moment coefficients which are tabulated in tables and plotted on charts offer a fast and accurate method for computing the end moments and should result in a considerable reduction in the time required for the preliminary analysis of this type structure.

Two examples illustrating the use of the tables and charts and comparing the results with those obtained by other means are included.

These tables and charts are applicable to symmetrical gabled frames having: a constant cross-section, columns pinned at their base, and a uniform load.

A SELECTED BIBLIOGRAPHY

1. Hedges, F. "Moment Distribution in Frames with Bent Members." (Unpublished M. S. Report, Oklahoma State University, 1956).

2. Tuma, J. J., Havner, K. S. and Hedges, F. "Analysis of Frames with Curved and Bent Members." Proceedings of the American Society of Civil Engineers, Vol. 82, 1958.

3. Vasquez, A. "A Method of Analysis of Structures with Symmetrical Members." (Unpublished M. S. Report, Oklahoma State University, 1955).

VITA

James William Gillespie

Candidate for the Degree of

Master of Science

Title: TABLES AND NOMOGRAPHIC CHARTS FOR THE PRELIMINARY ANALYSIS OF CONTINUOUS RIGID FRAMES WITH BENT MEMBERS

Major Field: Civil Engineering

Biographical:

Personal Data: Born near Choctaw, Oklahoma, January 30, 1935, the son of J. W. and Bernice Gillespie

Education: Graduated from Choctaw High School in 1953; received the Bachelor of Science degree from the Oklahoma State University, with a major in general engineering, May, 1957; completed requirements for the Master of Science degree in August, 1958. Now Junior Member of A. S. C. E., member of O. S. P. E., and N. S. P. E.

Professional Experience: Surveyor, Chief Manufacturing Co., Kansas City, Missouri; Highway Engineer, Hudgins, Thompson, Ball, and Assoc., Oklahoma City, Oklahoma.