Overpass On Rigid Frame Bents

Frames are of various spans to clear railway tracks in special hip joint project at Sacramento

IRREGULAR SPACING of railroad tracks in the Southern Pacific freight yards at Sacramento, Calif., gave rise to an unusual problem in designing supports for a 24-ft. roadway which it was desirable to carry above the tracks as an overpass approach to the upper deck of the I St. bridge. The problem was solved by the use of two-hinged rigid frames made by cutting away the webs of girders and bending the flanges to conform to the desired curvature, thus making it possible to unite vertical legs and horizontal beams at the hip joint in integral construction. All but one of the frames are made from rolled sections and have spaces of 30, 32 or 39 ft. The one exception is a frame of 69 ft. span in which the members are built up of angles and plates.

The I St. Bridge is a two-level steel structure with roadway above and railroad tracks below, which crosses the Sacramento River on the western edge of the city. On the city side of the river the original approach to the upper deck was built with steep grades and sharp curves before the present day traffic requirements developed. To decrease approach hazards and to provide needed access to up-river points, two new approaches were planned to replace the one now outmoded. One of the new approaches, coming in on a line slightly south of east, is 786 ft. long and is known as the Third St. approach. The other, to which the following data refer more particularly, comes in from the north along the river, has a length of 919 ft. and is known as the Jibboom St. approach. The two approaches join at the eastern or city end of the bridge where the roadway surface is 28 to 30 ft. above street grades. No change is being made in the lower deck approaches.

Both new approach structures consist of steel frame supports with a concrete roadway on which maximum grades are 6 per cent. The two approaches are considered as entirely separate projects; the one leading up from Third St. is being built by the city of Sacramento, and the Jibboom St. approach is a federal aid project constructed at an earlier date and under entirely different conditions. Although both structures involve problems in keeping clear of surface tracks, the Jibboom St. approach is the more complex of the two because of the sharp angle it makes with a considerable number of railroad sidings.

In this approach, irregular span lengths and column spacings were required. Because of the necessity for leaving the tracks undisturbed, the supporting columns were located wherever spaces were available between tracks. For this reason, in a length of less than 800 ft., 12 of the 15 bents required to support the roadway were designed most economically as rigid frames. The other three are ordinary steel trestle bents which could be located where it was feasible to put column supports directly under the roadway. The rigid frame spans had to be designed for eccentric loadings because of irregularity of footing spacings. However, by this means the roadway was carried in the required location without impairing clearances in the switching yard.

The girder and legs of the 69 ft. rigid frame are made up of a 1-in silicon steel web 60 in. deep, with 2 in. of cover plates and $8x8x\frac{7}{8}$ in. flange angles. The same members of the other frames are 33 or 36 in. rolled sections, the latter occurring in a maximum section weighing 250 lb. per foot. Where flanges were separated from webs at the junction of girder and legs, a torch was used to cut away interfering portions of the web to permit bend-

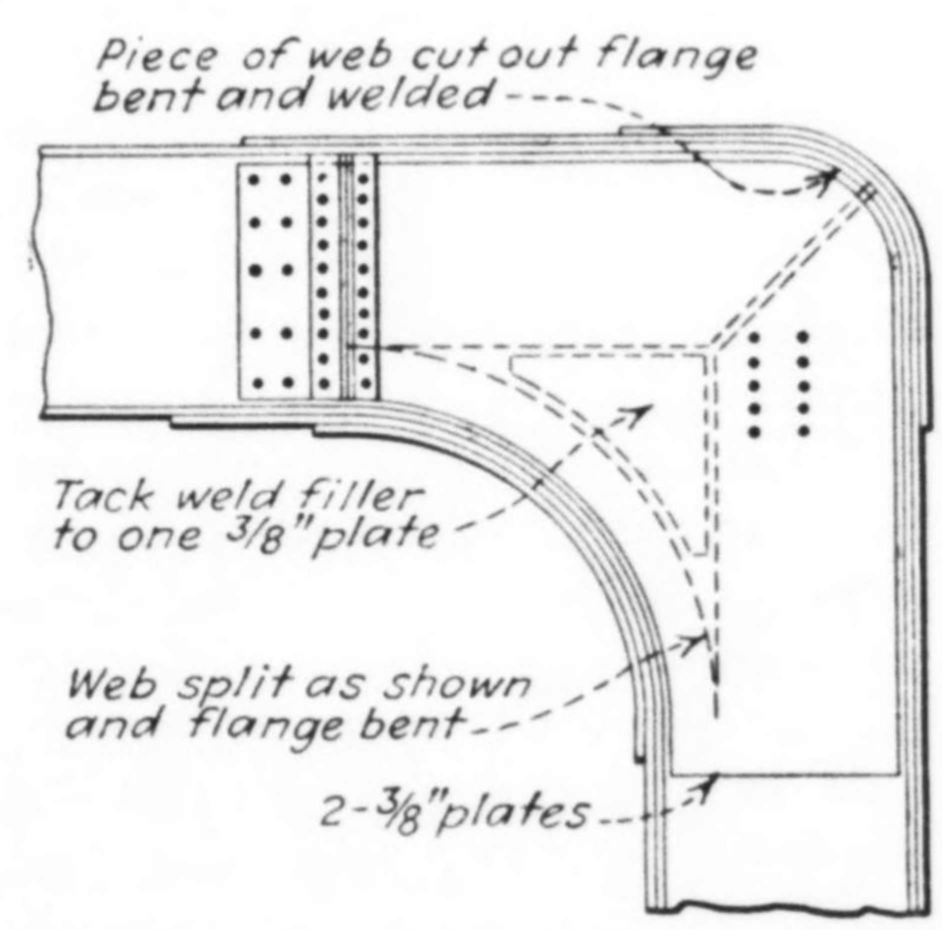

Fig. 2. Hip joint detail of rolled-section rigid frames in which web is cut and flanges bent to curve.

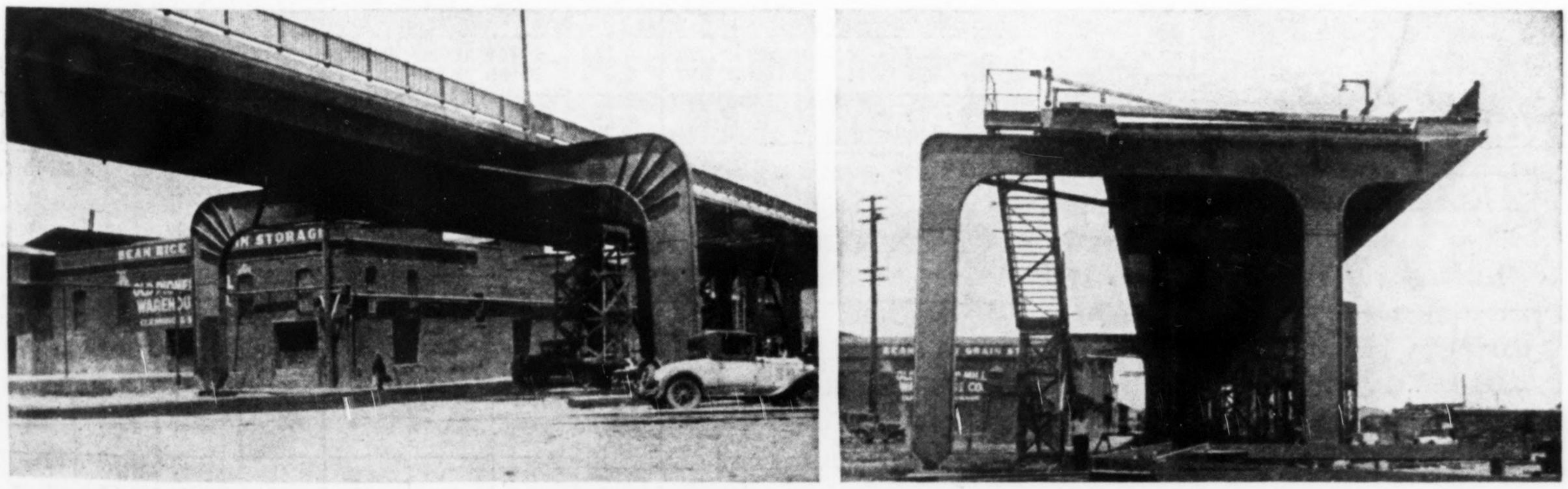

Fig. 1. Two of the twelve rigid frames in the Jibboom St. overpass in Sacramento. Left, frame of 69 ft. span. Right, a special frame of rolled section members. Remainder of frames are of this makeup without overhang.

ing the flange. Where a gore occurred after the lower flange had been bent away from the adjoining web, a triangular fillet was welded in place before the cover plate was put on. The hip joint was strengthened by radial stiffening angles on the 69 ft. span frame. By these simple expedients supports of adequate strength were provided and the cost of the fabrication was kept down to a very reasonable figure.

Conventional pin connections were used at the bottom of the columns, and the castings supporting the pins on the piers were designed with a shoulder to take any outward thrust that might occur as a result of the rigid frame design. The pins are 10 in. in diameter. Reinforcing was used in the concrete piers and because the piers had to be supported on piles it was thought advisable to put in a horizontal tie between each pair of piers below track level. These ties consist of 10x1¾-in. eye-bars encased in concrete.

Design of the steel frames was worked out by the bridge department of the California division of highways, F. W. Panhorst, bridge engineer and Harvey D. Stover, designing engineer.

Influence Lines By Moment Distribution

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Simple modification of Hardy Cross method gives necessary influence line ordinates and requires only two distributions for member

Influence lines for the moments at the joints in continuous frames can easily be obtained by the Hardy Cross method of moment distribution. The procedure, here described, is adapted both to structures in which no joint translations occur and to simple cases of structures with joint translations.

When no translations are possible, and only one member of the structure is loaded, the value of the moments outside of the loaded member is dependent upon the magnitude of the end moments of this member. The Cross method of moment distribution provides a simple way of determining joint moments, if the fixed-end moments of the loaded member are known. These fixed-end moments are easily found, but distributing them for all required load positions would make the process of constructing influence lines a tedious one. However, the work is simplified by distributing the fixed-end moments separately.

According to the principle of superposition, the value of any joint moment is equal to the sum of the two joint moments found by separate distribution. Each of these two joint moments represents a certain percentage of the corresponding fixed-end moment, which percentage is constant for any position of the load in the same member. Distribution of unit moments at the two member ends will furnish the percentages for all the joint moments of the structure, and to determine the total influence lines it is sufficient to use only two distributions per member. For every influence ordinate, then, two fixed-end moments have to be reduced to corresponding percentages and added.

For illustration consider the continuous beam in Fig. 1a with four spans of uniform cross-section. The ends *A* and *E* are hinged. The figures

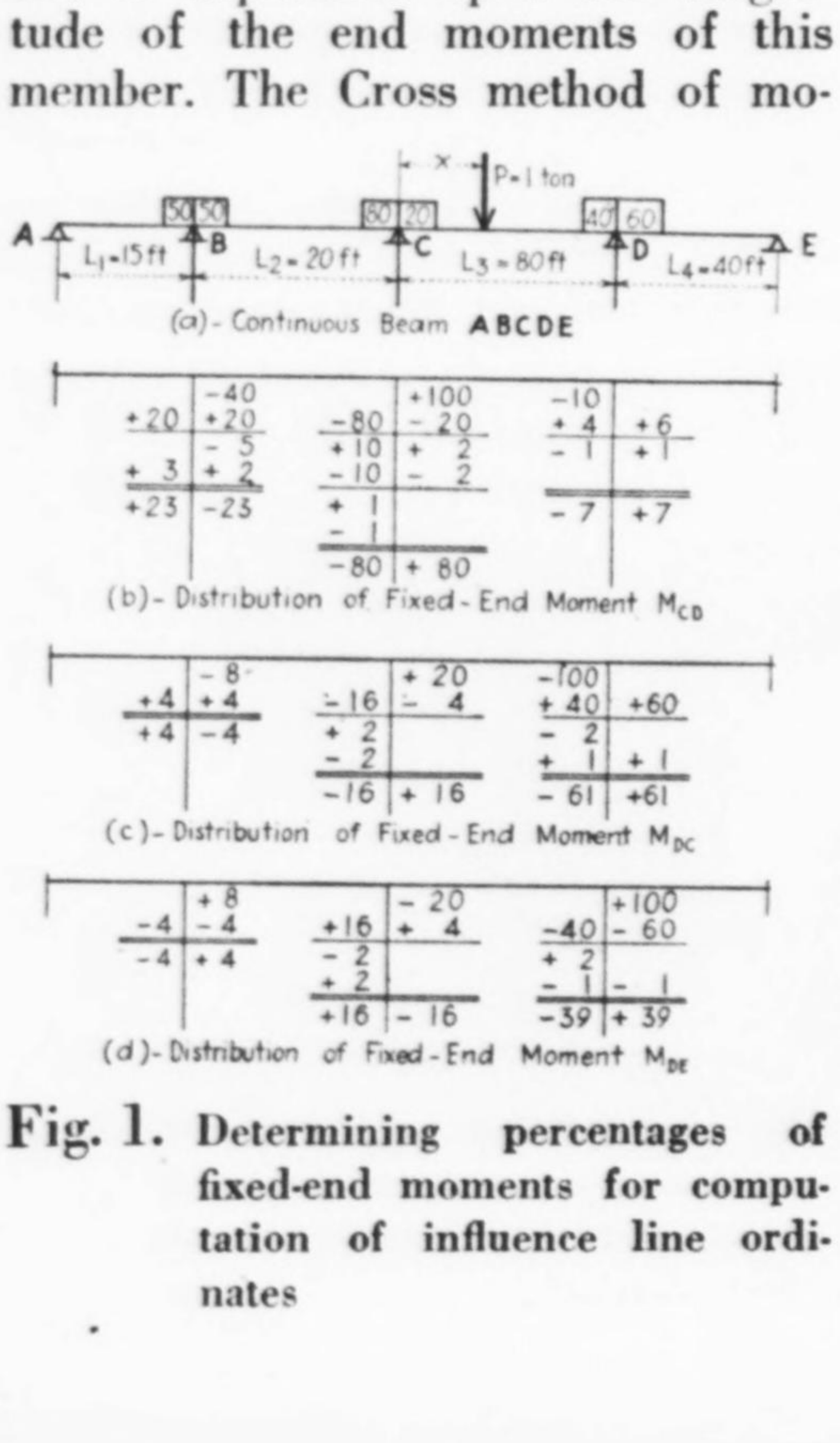

Fig. 1. Determining percentages of fixed-end moments for computation of influence line ordinates

Table I: Influence Ordinates for a Unit Load in Span L_3, Fig. 1.

$\frac{X}{L}$	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	
$M_{CD} = -PL_3 \times$...	0,081	0,128	0,147	0,144	0,125	0,096	0,063	0,032	0,009	
$M_{DC} = -PL_3 \times$...	0,009	0,032	0,063	0,096	0,125	0,144	0,147	0,128	0,081	
$-0,23\ M_{CD} = +$...	1,49	2,35	2,70	2,65	2,30	1,77	1,16	0,59	0,17	Foot-tons.
$-0,04\ M_{DC} = +$...	0,03	0,10	0,20	0,31	0,40	0,46	0,47	0,41	0,26	Foot-tons.
$M_B = +$....	1,52	2,45	2,90	2,96	2,70	2,23	1,63	1,00	0,43	Foot-tons.
$+0,80\ M_{CD} = -$..	5,18	8,19	9,40	9,21	8,00	6,14	4,03	2,05	0,58	Foot-tons.
$+0,16\ M_{DC} = -$..	0,12	0,14	0,81	1,23	1,60	1,84	1,88	1,64	1,04	Foot-tons.
$M_C = -$....	5,30	8,60	10,21	10,44	9,60	7,98	5,91	3,69	1,62	

Table II: Influence Ordinates for Unit Load in L_4, Fig. 1.

$\frac{X}{L} =$	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
$M_{DE} = -PL_4$..........	0,085	0,144	0,178	0,192	0,187	0,168	0,136	0,096	0,049
$M'' = +0,04\ M_{DE} = -$	0,14	0,23	0,28	0,31	0,30	0,27	0,22	0,15	0,08
$M_C = -0,16\ M_{DE} = +$	0,54	0,92	1,14	1,23	1,20	1,07	0,87	0,61	0,31