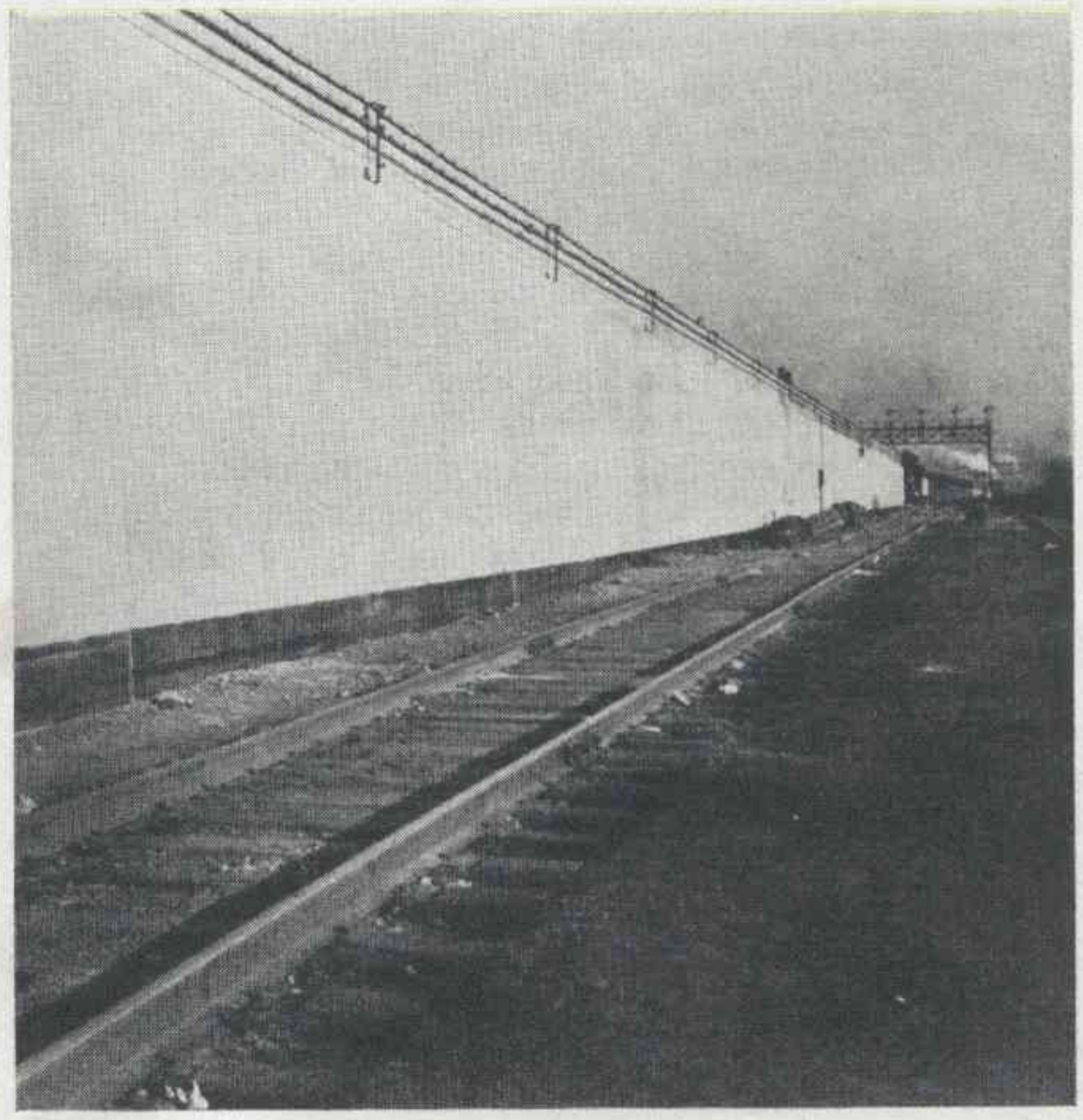
These Concrete Retaining Walls Embody Novel Features

Cantilever-type units built on Erie are supported partly on old walls and partly on piles



A View of the New Retaining Wall Built on the South Side of the Tracks, Looking Toward the East

THE incorporation of existing buried masonry walls in the foundations for new walls that were superimposed over the old structures comprises one of the unusual features of a project recently carried out on the Erie, which involved the replacement of a four-track timber-frame trestle with an earth embankment held between concrete retaining walls. Among other noteworthy features of this project may be mentioned the design of the walls, which was influenced not only by the foundation conditions but also by the necessity for constructing the footings and walls without disturbing the frame bents, and the methods that were employed for anchoring abutments and back walls for street bridges at the ends of the new fill.

Location and History

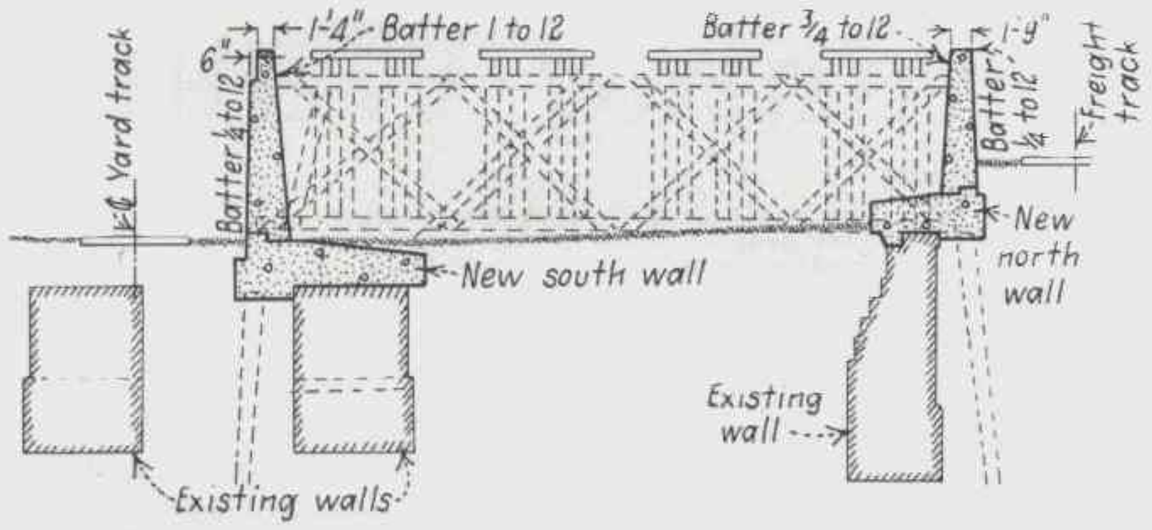
This project is located in Jersey City, N. J., a short distance west of the Erie's passenger station and terminal on the west bank of the Hudson river. Paralleling the river several miles to the west is a high ridge, known as Bergen Hill, which is pierced by a double-track tunnel that carries the Erie's main freight tracks. Years ago passenger as well as freight business was handled through this tunnel. Originally the tracks crossed intersecting streets at grade between the station and the tunnel but in 1898 the grades were separated by elevating the tracks on an embankment held between retaining walls. At the time the grades were separated it was contemplated that at a later date the passenger tracks would be further elevated on a viaduct to bring them up to the level of a cut that it was planned to construct through Bergen Hill, and to serve as footings for the proposed viaduct two parallel masonry walls of substantial cross section were constructed and then covered over by the new embankment.

About ten years after the completion of the grade separation project the plans for constructing the cut and the approach viaduct were carried out, both the cut and the viaduct being designed to carry four tracks. Since that time passenger business has been handled through the cut, while freight trains have continued to use the tunnel. For much of its length the approach viaduct is of steel construction but for a short distance at its extreme easterly end it consisted of a framed timber trestle. The masonry footing walls that were constructed in 1898 were not utilized in the construction of the viaduct.

The principal part of the frame trestle section of the viaduct extended between Jersey avenue (on the east) and Coles street, a distance of about 390 ft., and was superimposed on the original fill. Directly under the northerly side of the trestle was located the northerly retaining wall which, subsequent to its construction, had been entirely buried by the placing of a fill along its face. Under the southerly side of the trestle was located one of the masonry substructure walls that had been constructed in 1898. These walls were, of course, entirely buried in the fill. The embankment on the north side of the trestle carries several freight tracks, while that on the south side carries a number of yard and thoroughfare tracks.

The several tracks extend across Jersey avenue and Coles street at the different levels on steel bridge spans. The bridges carrying the four passenger tracks and the low-level tracks on the south side are supported on masonry abutments at the street lines. However, the street bridges to the north of the passenger tracks have pile-trestle approaches which are of such length that the toe of the embankment in each case falls at or near the sidewalk line. Hence, it is apparent that short lengths of the old northerly retaining wall were partially exposed to view at both Jersey avenue and Coles street.

The frame trestle carrying the four passenger tracks



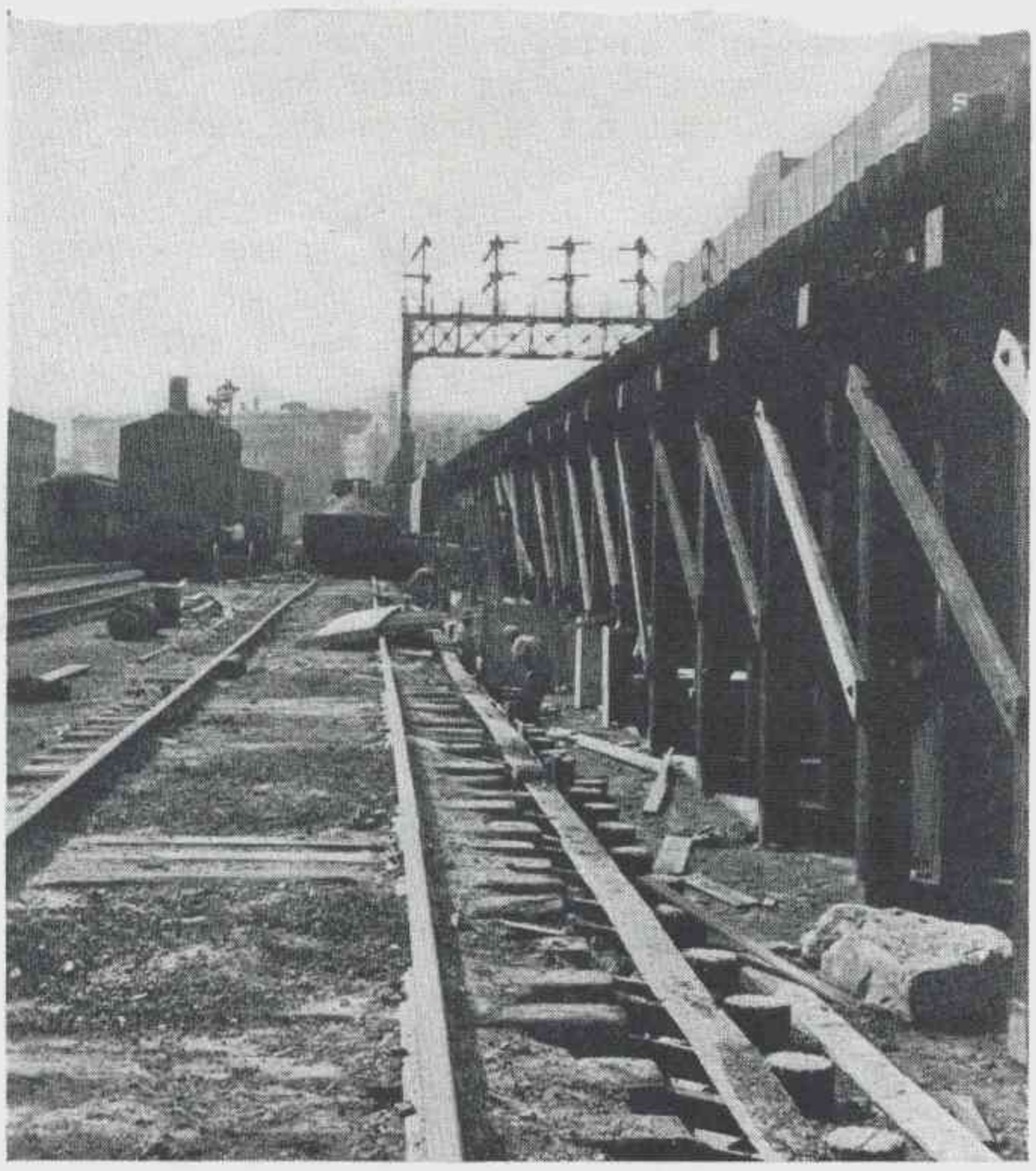
Cross-Section Through the New Retaining Walls, Showing How They Are Partially Supported by the Old Walls

was of conventional construction, embodying bents placed on 12-ft. centers, which were supported in the fill on timber sills. Because of its age and for other reasons, this trestle had become expensive to maintain, and it was decided several years ago to replace it with an earth fill held between concrete retaining walls.

New Walls Founded on Old Masonry

Because of their obvious advantages for such locations, walls of the cantilever type were chosen for this installation. Since the new wall along the northerly side of the trestle is located directly over the old retaining wall and that on the south side is placed directly over the buried substructure wall, it was only logical that the old masonry should be incorporated in the foundations of the new walls and in both cases the footings of the latter rest directly on the tops of the old structures.

However, because the toes of the new walls overhang the faces of the old masonry by varying amounts in both cases, it was necessary to employ supplementary means of support at these points, this support consisting of a single row of concrete piles under the toe of each new wall, the individual piles ranging in length from 25 ft. to 35 ft. These piles, which are driven on a slight batter to aid in restraining the walls against outward movement, embody steel shells filled with cast-in-place concrete. These shells are of the fluted type and are tapered, the small end being fitted in each case with a welded steel tip.



Looking West Along the South Side of the Frame Trestle, With the Concrete Train in Background. Note Tops of Bearing Piles for the New Wall and Top of Old Wall Under Bents

Because of differences in the elevations and dimensions of the tops of the old walls, the new walls are not identical as to their height and the width and cross sections of their base slabs. The old wall under the northerly side of the trestle is somewhat higher than that on the other side; hence, since the tops of the new walls are at the same elevation, that on the northerly side is not as high as the other. Specifically, while the height of the southerly retaining wall, measured from the top of the existing wall, varies from 16 ft. at Jersey avenue to 21 ft. at Coles street (the track grade being 1.2 per cent), the height of the northerly wall is about 11 ft. at Jersey avenue and increases to about 17 ft. at Coles street.

The top of the old wall along the southerly side of the project varies from 8 to 9.5 ft. in width, while the width of the new wall footing ranges from about 9 ft. 6 in. at the east or low end of the wall to 16 ft. at the other end. Thus, the extent to which the footing rests on the existing masonry varies from point to point along the wall; for a considerable distance at the east end of the project the footing does not extend all the way across the top of the old wall, while elsewhere it overhangs the inside face of the old wall for distances ranging from 4 ft. to 6 ft. 6 in.

On the northerly side of the tracks, the top of the old wall is 3 ft. wide, while the footing of the new wall varies in width from 8 ft. 6 in. to 10 ft. Here the heel of the new wall footing overhangs the rear face of the old wall for distances varying from 2 ft. to 3 ft. 6 in., and on the underside of the overhang a longitudinal lug is provided, which extends down to a shelf in the old wall 1 ft. below its top surface. Thus a key is provided which acts as a means of helping the wall to resist thrust in the outward direction.

This key was considered necessary because of the narrow width of the old footing, which resulted in only a limited amount of frictional resistance between the old masonry and the bottom of the new wall footing. Because of the greater width of the other old retaining wall and the natural keying effect provided by irregularities in its upper surface, it was considered unnecessary to incorporate a key in the footing of the new wall on the south side of the trestle.

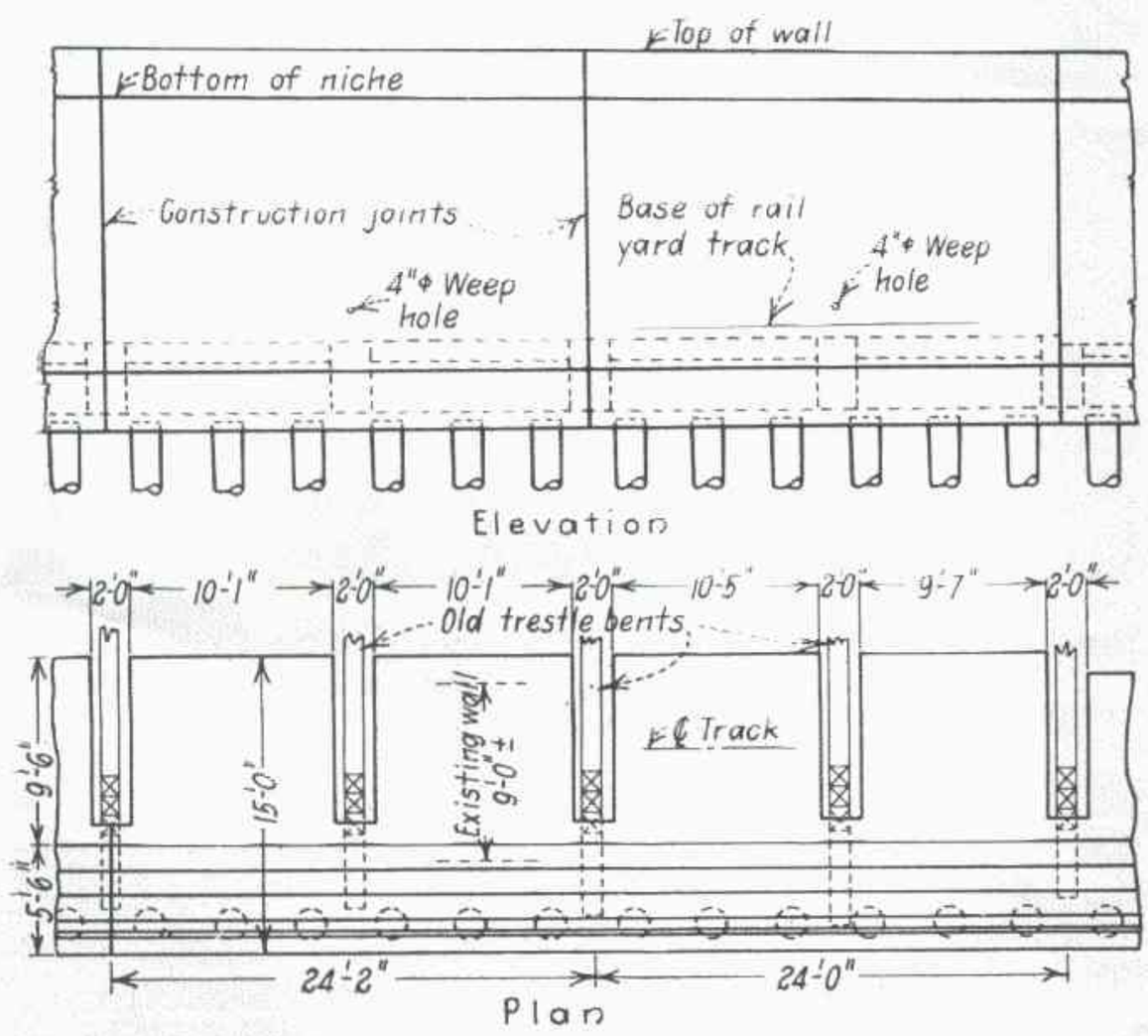
The new walls are built with a batter of ¼ : 12 on the outside faces, while on the back faces the batter is 1 : 12 for the south wall and ¾ : 12 for the north wall. The latter wall is 1 ft. 9 in. wide at the top, but the width of the south wall at the top is reduced to 1 ft. 4 in. by a niche in the outside face, 6 in. wide and 2 ft. 6 in. deep, which was provided for carrying signal cables. At both ends of the northerly wall, where the old masonry was exposed under the approach trestles, the overhanging toe of the new wall footing was extended down as necessary on a stepped slope corresponding with the embankment slope to conceal the face of the old wall and to avoid exposing the foundation piles.

Footings Recessed for Bents

To permit the construction of the retaining walls without unduly disturbing the trestle, the footings of the new walls were designed with mortise-like recesses to receive the frame bents. These recesses are 2 ft. in width and of varying lengths, depending on the width of the

footings and other conditions at the different bents. By designing the footings in this manner, it was possible to construct them without removing the bents, the only work required on the latter in preparation for constructing the walls being the resetting of the outside posts and the cutting back of the caps and sills to provide the necessary clearance. At alternate recesses in the footings, keyed construction joints were provided in each wall, these joints being generally about 24 ft. apart.

When the four passenger tracks were raised on the viaduct in 1910, the height of the abutment at Coles street was increased the necessary amount by means of a reinforced concrete extension, to provide a bridge seat for the street spans at the higher level. Also a back wall was provided above the new bridge seat, on which



Plan and Elevation of a Typical Section of the Southerly Retaining Wall

were supported the ends of the stringers of the adjacent span in the trestle. At Jersey avenue, however, where the raise in the grade that was made in 1910 was considerably less than at Coles street, the end of the street span is supported on steel columns superimposed on the bridge seat of the existing abutment, and no back wall was provided. Hence, at this end of the project it was necessary, as a part of the recent undertaking, to provide a means of restraining the new fill above the abutment, and to this end a concrete back wall was superimposed on the old abutment, the steel columns being left in position for carrying the ends of the steel spans.

End Walls Are Anchored

At both Jersey avenue and Coles street it was desired to protect the existing abutment walls against the additional surcharge imposed by the new fill and also to provide means for causing each abutment and the adjacent ends of the retaining walls to act as a unit. To serve these ends, a transverse anchor or "deadman" was placed at the footing level some distance back from each abutment, with a series of ties extending to the latter and with several transverse ties being placed in the space between the anchor and the abutment. At Jersey avenue the deadman is 30 ft. from the abutment while the corresponding distance at Coles street is 33 ft. 6 in.

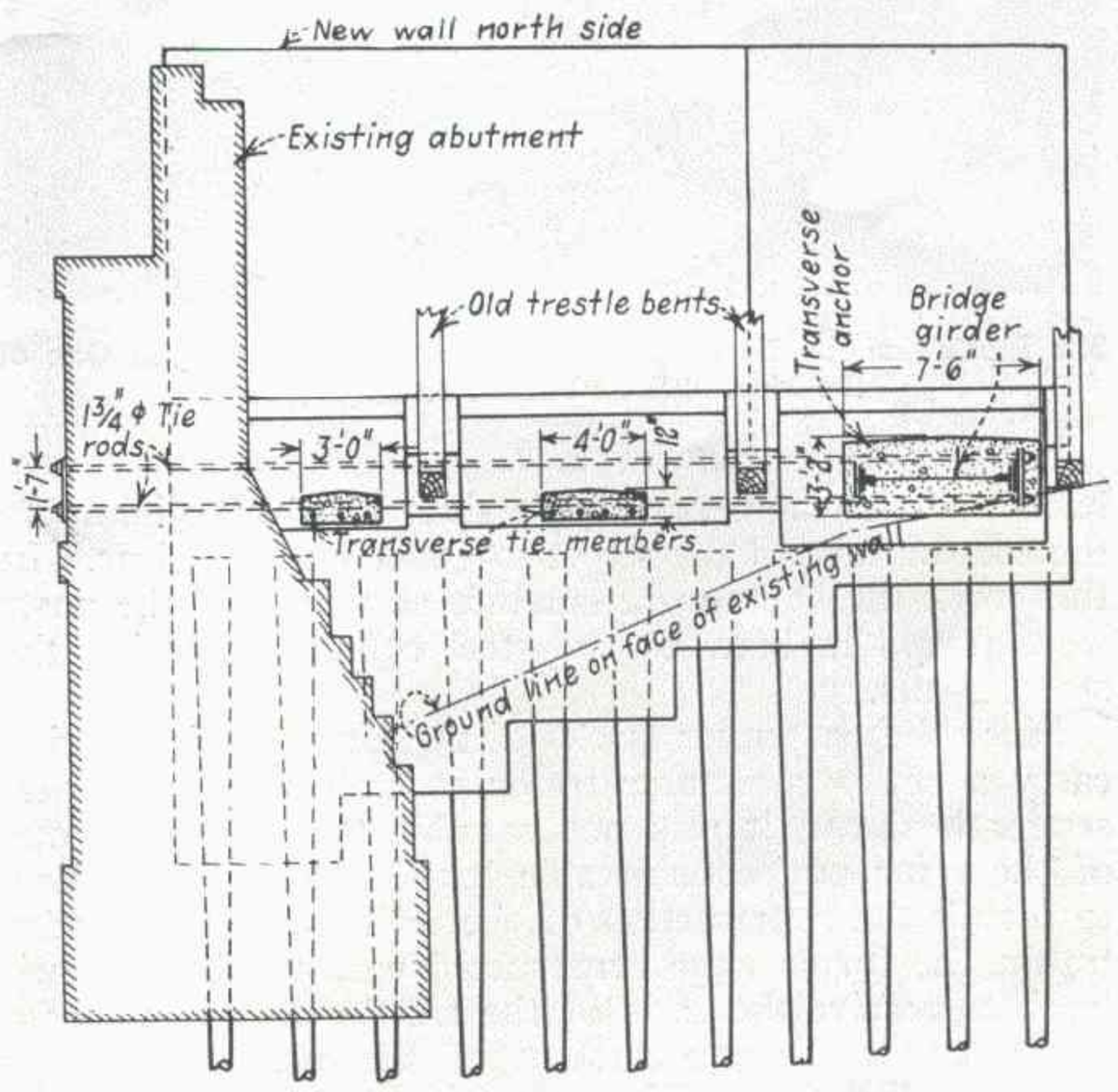
In each case the anchor consists of a second-hand plate girder from a bridge span, complete with flange angles, cover plates and stiffener angles, which was placed in a position at right angles to the tracks, with the web in a horizontal plane and with the ends embedded in the retaining wall footings. Both girders are encased in concrete and, to facilitate the placing of the encasement, three lines of 6-in. holes were cut in the web of each girder, the holes in each line being spaced 3 ft. apart.

At Coles street there are eight evenly-spaced tie members, by means of which the abutment wall is anchored to the girder. These ties consist in each case of two 1¾-in. rods which extend entirely through the abutment in drilled holes, the protruding ends on the outside face of the abutment being fitted with nuts and washers from which pressure is transmitted to the masonry by a metal plate. At their opposite ends, the rods in each tie extend to the rear face of the plate girder, one being above and the other below this member, where they extend through a yoke plate. These ends of the tie rods are, of course, embedded in the concrete encasing the girder, and throughout their lengths the rods are likewise covered with concrete, the encasement for each pair being 9 in. by 2 ft. 6 in. in cross section.

Transverse Ties

In the space between the anchor and the abutment at Coles street two transverse ties are provided which are of reinforced concrete poured integrally with the abutment wall footings. In each of these ties the reinforcement consists of 1¼-in. square rods which extend well into the retaining wall footings. One of the transverse ties, that nearest the anchor, is 10 in. by 4 ft. in cross section and contains four rods, while the other is 10 in. by 3 ft. in section and embodies three rods, the long dimensions being horizontal in each case. As to elevation, the transverse ties are so placed at a level slightly below that of the longitudinal ties that these members overlap each other at their points of intersection and at such points they are cast integrally with each other.

At Jersey avenue the method of anchoring the abutment wall differs in a number of details from that employed at Coles street. Here there are only four longitudinal ties, each of which consists of four 1¼-in. rods



Section Through the Existing Abutment at Coles Street, Looking North, Showing the Wall Anchorage System

arranged in a square and encased in concrete. As at Coles street, these rods are fastened at one end to the deadman, but at the other end they are embedded in the footing of the new wall that was superimposed over the old abutment, this wall being of cantilever construction with the footing keyed into the rear face of the existing abutment. Two transverse ties are also provided at this location, which are substantially similar to those at Coles street.

All concrete placed on this project was mixed on a concrete train embodying two ⅙-yd. mixers. When pouring the footings, this train operated from the low-level tracks adjacent to the walls, but for placing concrete in the walls proper it operated from the outside tracks on the viaduct. Because of traffic conditions, the latter phase of the work was carried on at night. The concrete placed on this job embodied a 1 : 2¼ : 3½ mix (dry rodded), with 5½-gal. of water for each sack of cement. To enhance its workability, an admixture was used and, in addition, the concrete was consolidated with internal vibrators. Plywood forms were employed and a damp-proofing treatment was applied to the rear faces of all walls, the top surfaces of the footings and at other points where it was deemed necessary.

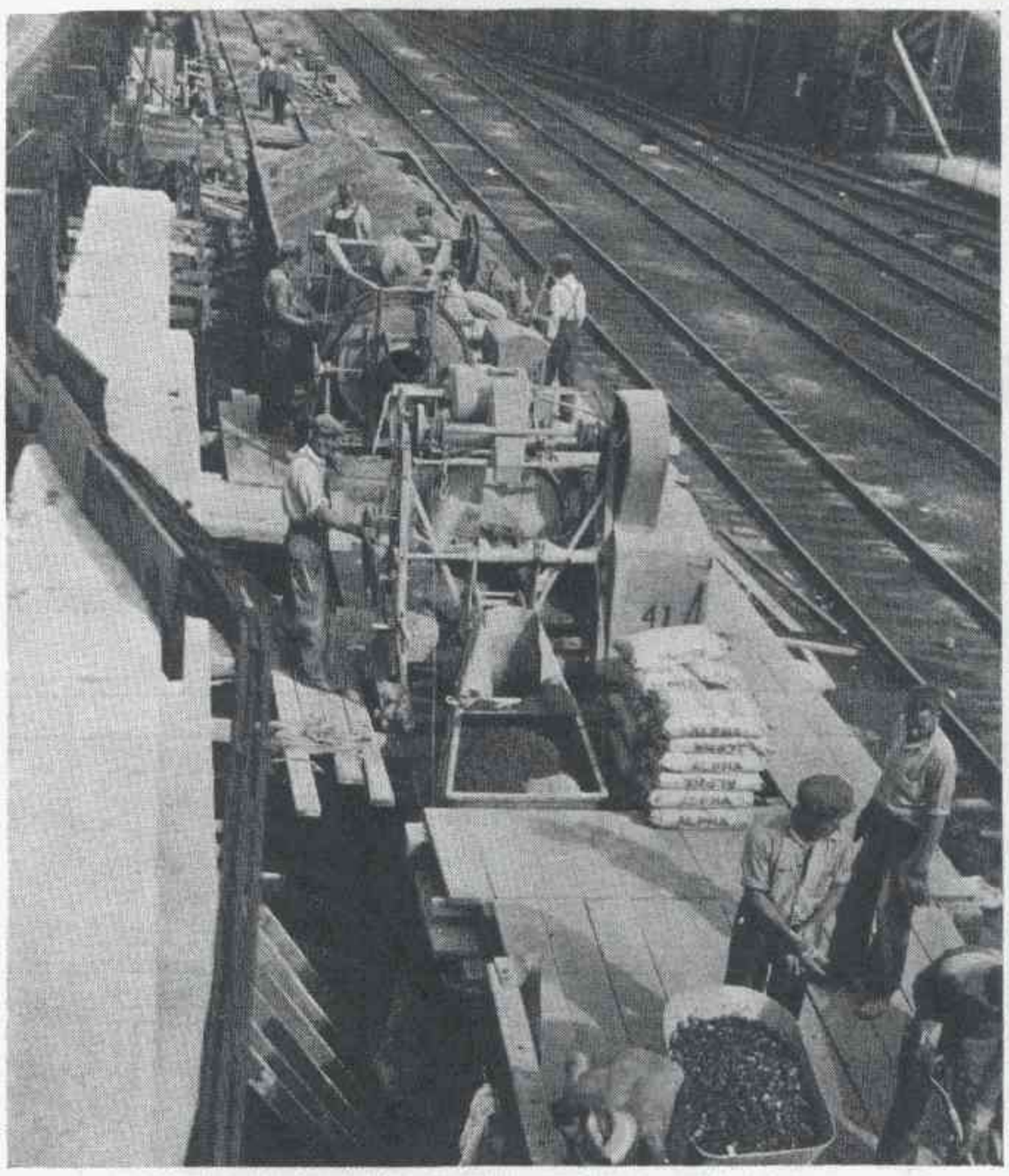
Most Difficult Operation

Probably the most difficult phase of the concreting operations was that involved in placing the new back wall on the Jersey avenue abutment. At this point the end bent in the trestle was supported on the bridge seat and, as one of the preliminary steps in constructing the

The Placing of the New Back Wall at Jersey Avenue Was One of the Most Difficult Phases of the Project

back wall, it was necessary to shift this bent slightly to the east or toward the street to get it into the clear. In this work the bents were cut into sections and the posts were placed in between the steel columns carrying the street spans.

Since the passenger tracks of the Erie at this location carry a heavy commuter traffic as well as regular passenger business, it was not possible to "kill" even one of them for any considerable length of time. Hence, to permit the construction of the wall as a whole under traffic, the forms were constructed with notches at each track to receive the ends of the trestle stringers. As a final step in the construction of the wall, these gaps were filled under traffic with high-early-strength concrete. For pouring the concrete in this wall, the train



The Concreting Operation During the Placing of the Footing for the South Wall, as Seen From Top of Completed Section of Wall

was spotted on the adjacent freight track at Jersey avenue at a point where the floor of the flat car containing the mixer was about even with the higher track level. The concrete was placed with two-wheel hoppers operating on platforms and walkways at the track level.

In arranging for drainage, advantage was taken of the presence of existing catch basins behind the existing walls. There are four such catch basins behind each of the old walls and at each of these locations a backing of loose stone, 10 ft. wide and 1 ft. thick, was placed against the rear faces of the new retaining walls and the upper surfaces of the footings. Also three similar stone drains were placed behind the new back wall at Jersey avenue, these basins feeding into a 6-in. corrugated pipe placed transversely at the base of the wall.

This project was first undertaken in the fall of 1938, and at that time all of the northerly retaining wall and 79 ft. of the southerly wall at the west end were built, the work then being suspended The remainder of the south wall and the back wall at Jersey avenue were built during the fall of 1939. In the latter phase of the project the concreting operations were started on August 28, and, since it was desired to finish the job before the onset of cold weather, the work was expedited with all possible speed, being completed on October 21. During this period 1,163 cu. yd. of concrete were poured with the two ⅙-yd. mixers. Following completion of the retaining walls, the fill was placed with bottom-dump cars. Except for the stringers, which were removed, the frame bents were left in position.

As part of this general project a relatively short section of frame trestle at the extreme lower end of the ramp grade immediately east of Jersey avenue was also replaced with a fill. This phase of the work also involved the construction of retaining walls but they are much lower and shorter than those west of Jersey avenue.

The design and construction of the new retaining

walls was carried out under the general direction of G. S. Fanning, chief engineer of the Erie, with the design supervised directly by F. A. Howard, engineer of structures, and the construction work by I. H. Schram, engineer maintenance of way of the Eastern district, at Jersey City, and F. C. Kronauer, division engineer of the Terminal division (now chief engineer of the New York, Susquehanna & Western). All the construction work on the walls between Jersey avenue and Coles street was done by company forces.

Railroad Construction Indices for 1939

WASHINGTON, D. C.

THE Engineering Section of the Interstate Commerce Commission's Bureau of Valuation has issued its Railroad Construction Indices for 1939, showing that last year the cost of railroad-building was exactly the same as for the preceding year. Based as usual on the 1910-1914 costs as 100, the 1939 index for the country as a whole was 149—down four points from 1937's 153, but still up 16 points from the 1933 post-war low of 133. The peak was reached in 1920 when the index stood at 226.

In an accompanying notice I. C. C. Secretary W. P. Bartel pointed out that the indices are "unique in that while other construction indices generally limit their coverage to a few items, or types, or localities, these cover the costs of thousands of items of construction and construction costs in an industry that penetrates all parts of the country and draws on all types of material and labor." They record, he points out, the relationships to the base and indicate trends, and have been developed over a period of 30 years as the 1914 base incorporates consideration given to prices prevailing in the period 1909-1914 and corrected for conditions reaching back to the beginning of the century.

Indices Indicate Trends

Furthermore, the compilation's "General Notes" point out that the indices "represent territorial index factors and are of value in indicating trends. They are not necessarily applicable for use in the determination of reproduction costs upon individual railroads. . . ." The general indices for the country as a whole (given in the accompanying tabulation) are broken down in the Bureau's compilation into eight regional sets.

In his notice Mr. Bartel called attention to the fact that for the country as a whole, the 38 composite roadway accounts, including engineering, but excluding lands and rights of way, stood at 137 in 1939, a slight drop from the preceding year, and from 142 in 1937. The peak of these accounts, which cover approximately 73 per cent of the total cost, excluding lands and rights, was reached in 1920 when it stood at 214, and the valley was reached with 127 in 1933.

The indices reveal, he said, a decided drop in the cost of Account 3—Grading. Grading shot up from a base of 100 in 1914 to 250 in 1920. The displacement of men and mules by machines and the improvement of those machines has been reflected by a precipitate falling in grading costs until 1934 when the index was back to 100; in 1939 it dropped to 90, or 10 points lower

REGIONS I TO VIII, INCLUSIVE

Tabulation of Indices by Years and by Accounts
Applicable to the Entire United States

Acct.		*Per Cent	1915	'16	'17	'18	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39
ROAD																											
1	....	2.83	101	110	134	159	178	214	175	157	171	171	166	166	164	161	160	152	143	131	127	131	131	133	142	138	137
3	....	18.19	100	110	130	165	190	250	170	143	160	164	149	153	143	135	133	123	118	106	98	100	101	99	103	93	90
4																											
5	....	1.51	103	109	128	150	183	208	179	165	179	179	179	178	169	155	155	143	130	119	111	122	120	130	139	141	140
6	....	9.41	105	111	146	162	178	206	165	160	176	173	171	170	168	164	163	150	134	122	122	136	135	141	155	150	149
7	....	0.04	102	124	169	177	184	210	150	153	173	171	168	165	163	163	162	154	144	129	122	136	136	137	158	150	149
8	....	5.58	100	100	112	133	170	201	189	157	177	175	172	173	175	176	175	170	155	144	139	149	147	150	159	154	158
9	....	8.57	101	106	121	148	152	168	158	144	145	145	144	144	144	144	144	144	144	140	134	123	123	124	143	139	136
10	....	3.39	99	129	198	210	203	209	192	161	182	179	177	177	177	177	170	169	165	163	158	150	147	150	169	169	170
11	....	4.09	103	107	114	140	150	207	191	176	175	175	174	175	176	176	176	168	159	146	146	141	139	140	143	143	143
12	....	4.35	100	100	130	163	175	218	174	165	188	188	188	188	188	188	188	182	175	164	157	159	165	165	169	167	165
13	....	0.51	100	122	142	178	194	204	189	177	179	179	176	175	175	175	173	171	164	147	135	140	140	138	143	144	139
14	....	0.08	103	108	119	165	199	280	197	194	212	200	201	201	204	204	204	198	188	125	126	140	140	140	155	155	155
15	....	1.18	104	108	137	161	182	208	171	164	178	175	171	169	166	165	165	161	153	131	127	139	137	139	152	145	142
16	....	4.42	101	115	135	154	185	215	192	180	194	193	188	184	189	188	187	182	165	141	145	151	151	157	166	166	166
17	....	0.51	100	115	136	156	185	216	192	178	196	196	189	187	192	191	190	186	166	140	145	150	150	150	162	162	162
18	....	0.82	101	120	159	170	191	213	185	178	187	187	186	182	185	186	184	177	161	147	151	155	155	156	166	166	166
19	....	0.26	101	120	153	160	190	212	181	166	185	185	182	180	183	183	183	174	159	144	149	154	154	153	159	159	159
20	....	2.16	102	118	141	159	188	216	191	180	193	192	188	185	189	188	187	176	161	137	142	147	147	155	165	165	165
21	....	0.09	100	110	128	150	185	214	190	184	197	197	193	190	195	193	193	182	165	137	142	147	147	156	164	164	164
22	....	0.04	100	115	135	155	185	210	193	178	198	198	193	189	193	191	191	184	165	137	142	147	147	154	166	166	166
23	....	0.53	100	114	133	152	178	204	167	158	175	175	174	177	178	178	178	172	158	136	141	146	146	149	153	153	153
24	....	0.44	101	117	145	155	184	204	170	159	176	176	174	174	176	176	176	172	157	136	142	147	147	151	153	153	153
25	....	0.01	108	122	148	175	194	213	194	176	188	189	186	185	188	189	189	178	163	145	148	176	176	178	178	177	179
26	....	0.34	103	124	147	158	164	192	191	162	187	179	163	157	163	165	165	150	138	121	119	124	128	131	135	129	129
27	....	1.49	94	106	132	152	165	175	163	158	165	164	162	169	158	155	154	147	138	130	130	133	136	138	143	143	143
28	....	0.01																						151	149	149	149
29	....	0.14	104	122	141	158	189	218	197	184	196	196	191	186	191	191	189	177	162	138	143	148	148	152	167	167	167
30	....	0.01	101	117	137	156	187	218	194	180	197	197	192	188	193	191	190	176	161	137	142	147	147	138	164	164	164
31	....	0.03	115	166	190	181	186	176	145	132	142	136	140	141	137	142	150	136	116	98	98	103	105	108	123	110	110
32	....	0.51	109	148	178	192	189	205	172	163	178	172	175	176	175	178	181	173	148	144	144	148	151	152	155	149	149
33	....	0.06	106	116	145	169	194	230	208	179	209	203	185	183	198	199	209	200	172	147	147	150	153	148	157	152	152
34	....	0.01	101	110	119	172	206	250	228	214	220	215	220	216	219	219	217	215	175	175	175	180	184	185	185	185	185
35	....	0.04	101	117	137	156	186	217	192	179	195	195	190	186	191	190	189	182	164	141	146	151	151	154	161	161	161
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37	....	0.08	105	113	127	146	158	170	162	149	151	151	151	151	151	149	148	147	144	138	138	147	147	147	161	153	154
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44	....	0.95	115	126	155	192	200	210	198	173	183	185	185	186	187	189	191	176	166	155	155	179	179	179	198	200	202
45	....	0.26	115	126	155	192	200	210	198	173	183	185	185	186	187	189	191	176	166	155	155	179	179	193	206	199	205
46	....	0.07	115	126	155	192	200	210	198	173	183	185	185	186	187	189	191	176	166	155	155	155	150	145	149	151	150
Wtd. Ave. 1-46	....	73.09	101	110	134	159	178	214	175	157	171	171	166	166	164	161	160	152	143	131	127	131	131	133	142	138	137