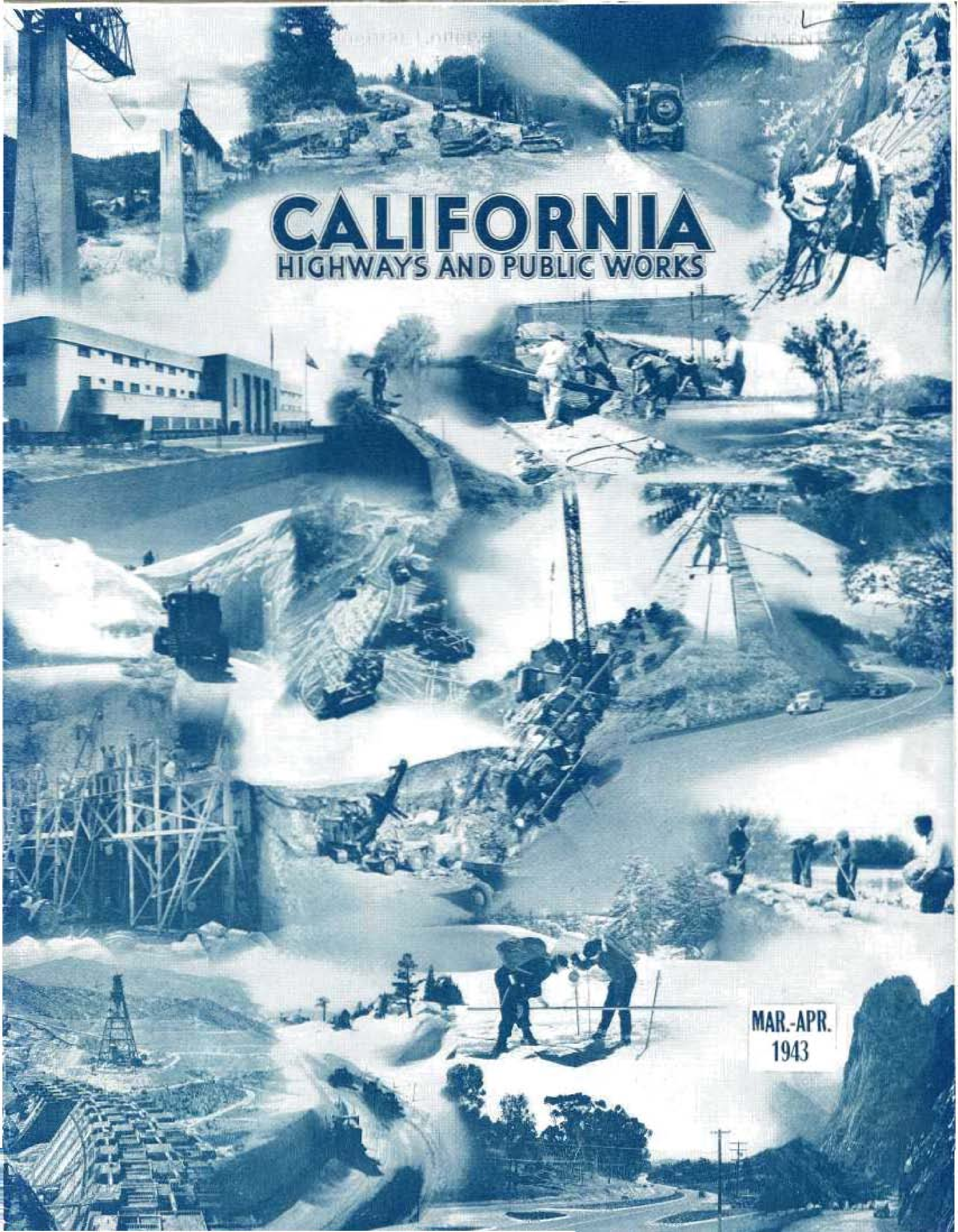
CALIFORNIA
HIGHWAYS AND PUBLIC WORKS



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CALIFORNIA HIGHWAYS AND PUBLIC WORKS

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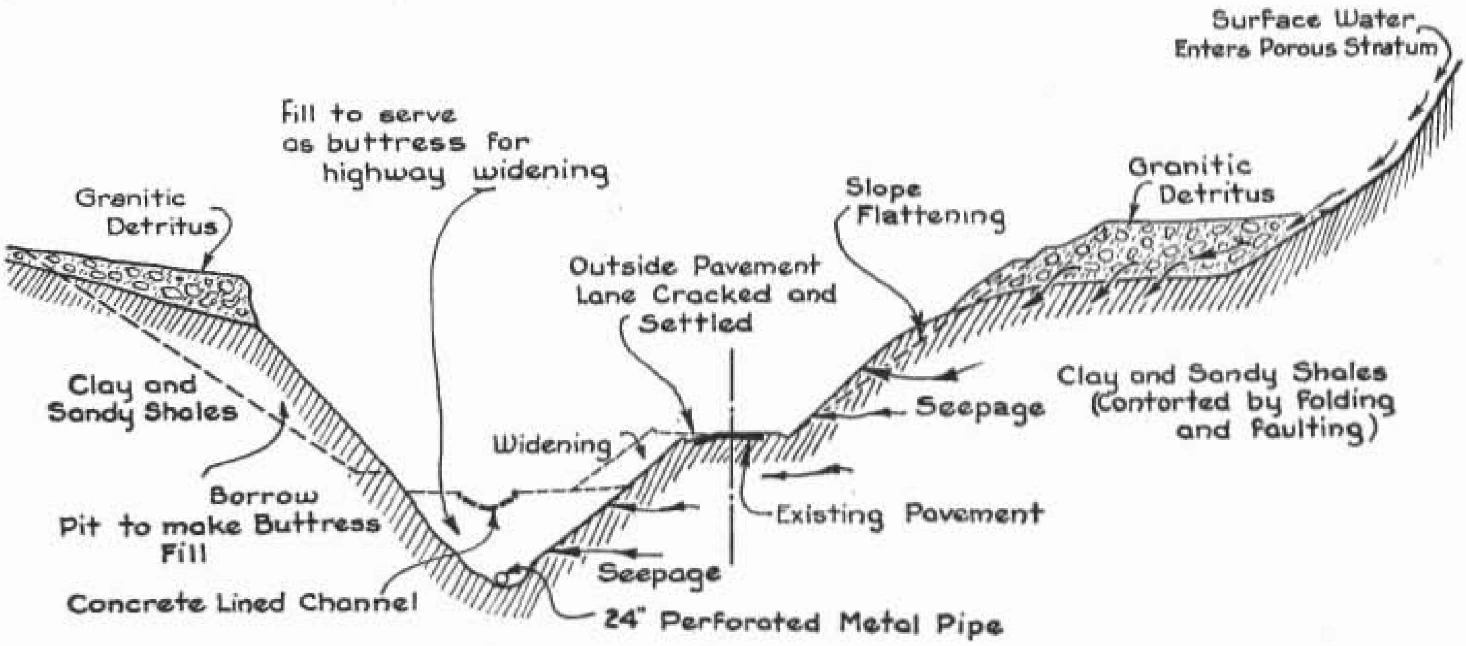
Grapevine Grade Widened to 4-Lane Highway with Center Safety Barrier and Drainage Features

By E. T. SCOTT, District Engineer

THE State's most hazardous stretch of highway, the Grapevine Grade, on the U. S. Route 99 between Los Angeles and Bakersfield, has been widened. Along this six mile length of highway the grade is a continuous 6 per cent. While the 3-lane pavement which existed prior to the widening, would have been adequate, under normal conditions, for the daily traffic of 6,000 vehicles, the differential in vehicle speed, because of the grade made this highway section most hazardous.



Sketch shows plan of widening and drainage operations in Grapevine Canyon

Along this most important transportation route which connects the Los Angeles Metropolitan area with the fertile San Joaquin Valley, an enormous tonnage of produce is hauled by heavy truck and trailer. Of the normal traffic about 20 per cent are trucks and trailers.

These heavily ladened vehicles are required to travel in a low gear at a very reduced speed while winding down the six miles of 6 per cent grade. The passenger vehicles, not hindered by the grade, continue to travel at high rates of speed, and the approach to the rear end of a slow moving truck has been most sudden.

On the old 3-lane pavement the fast moving passenger vehicle could pass the crawling truck provided the center lane of the pavement was unoccupied. Too often the center lane was occupied by a vehicle moving in the opposite direction. Many rear end collisions resulted, and caused the greater percentage of the fatalities.

Runaway trucks taking up the whole width of the 3-lane pavement on their dash down hill, added to the number of deaths resulting from traffic accidents on this six mile stretch of highway. The appalling toll has been from 10 to 14 killed and many more injured each year for the past few years.

It was necessary to more adequately provide for fast moving passenger vehicles to pass slow moving trucks. This was accomplished by widening the existing 30-foot pavement to 50 feet. The result is a 4-lane divided highway with an 11-foot traveling lane and 12-foot passing lane on both sides of a 4-foot median separator strip which divides the opposing lanes of traffic.

To prevent out-of-control vehicles from crossing to the wrong side of the highway, a steel barrier rail mounted on heavy wooden posts, was constructed along the 4-foot dividing strip for a distance of nearly four miles. This metal plate road divider consists of 12-inch convex steel rail, mounted by means of spring supports on two sides of a row of 8 by 8 inch wooden posts.

The steel plates as well as the spring supports and other metal accessories were furnished to the contractor by the State. This material had been purchased by the State a long time in advance of the construction work, months before priority was required on this type of material.

Another safety device installed to aid runaway trucks in retarding their speed, consisted of 3,000 lineal feet of heavy curb. This curb is constructed on the outside edge of the 10-foot plant-mix shoulder on the downhill traffic lane. It is a heavy concrete curb with a 15-inch vertical face. During short time the curb has been in place, at least three trucks out of control in varying degrees, have rubbed against it, with successful results. The curb is awfully hard on the sidewalls of tires but it will slow down the vehicle.

The widening of the Grapevine Grade was accomplished under two contracts, the first of which was completed about a year ago. This contract consisted of grading operation, slide stabilization and besides the usual drainage structures, the construction of a buttress fill of approximately 180,000 cubic yards.

A badly saturated hillside from which many slides have come in on the highway and threatened to carry the roadway into the canyon of Grapevine Creek, has been stabilized. The stabilization consisted of two operations. The interception and draining of water from the hillside above the highway and the buttressing of the highway embankment by filling the canyon below the highway.

At various places along the hillside numerous holes were drilled by hydraugers. Starting at a point two or three feet above the highway gutter grade, the holes were drilled from two or three degrees above horizontal to 20 degrees above horizontal in order that any water encountered would flow freely to the highway gutter.

Holes were drilled for various lengths up to 170 feet. Some of the holes were dry but a great many of them intercepted water and the flow from the holes, which were provided with two-inch perforated pipes, ran from a few drops up to 200 gallons per hour.

To prevent the possibility of the creek cutting out this buttress fill, a concrete lined channel with special

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Public Works Effects Big Car Mileage Saving

DURING the months of January and February the Department of Public Works effected a saving of 576,971 vehicle miles of travel by reducing the usage of passenger automobiles under its jurisdiction.

Of this total, the Division of Highways saved 515,906 vehicle miles.

In line with the war program of tire, gasoline and equipment conservation, the department is curtailing automobile travel to the fullest extent consistent with its necessary operational activities. Mileage records of four divisions of the department, were as follows:

	January 1942	January 1943
Highways	841,226	527,710
San Francisco-Oakland Bay Bridge	7,406	3,837
Water Resources	48,733	22,857
Architecture	20,528	9,381
	February 1942	**February 1943**
Highways	634,687	432,297
San Francisco-Oakland Bay Bridge	6,301	10,258
Water Resources	41,539	21,761
Architecture	14,566	9,906

Section of new 4-lane divided highway in Grapevine Canyon, showing metal plate road divider and concrete flume for creek at left.

View of section of completed highway between Bradley and King City on U. S. 101 via Jolon, original route of El Camino Real

Highway Improvement Completed From Bradley to King City via Jolon

By A. N. LUND, Assistant District Construction Engineer

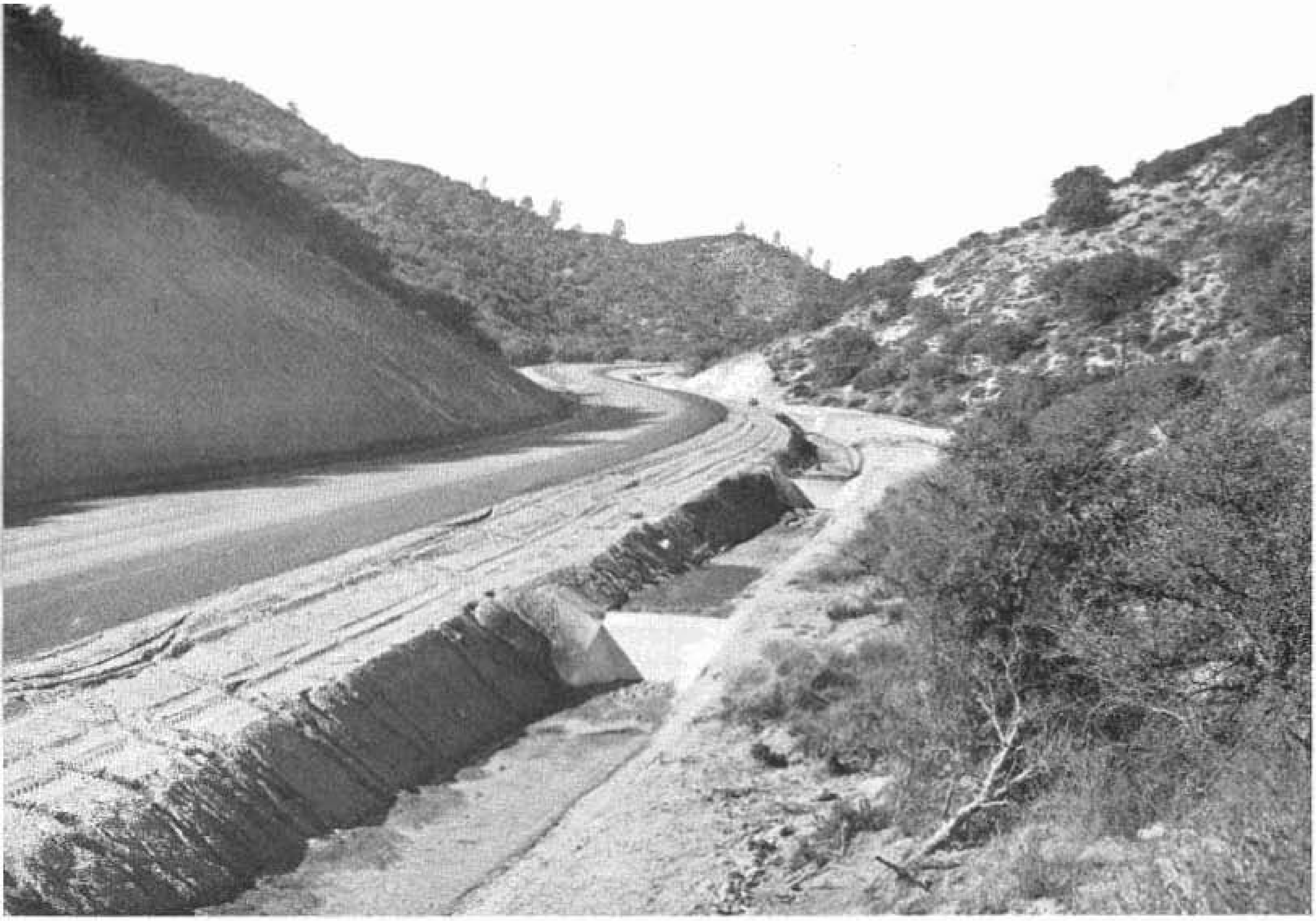
THE original route of El Camino Real has been reestablished from Bradley to King City via Jolon during the past year by the construction of 40 miles of highway.

Beginning near Hames Creek Bridge on U. S. 101 about two and one-half miles north of Bradley, the new highway follows generally the existing county road but with standard alignment and grade, for about 22 miles in a northwesterly direction to Jolon, thence northerly 18 miles to a junction with U. S. 101 on the west bank of the Salinas River near King City. This route is six and three-tenths miles longer than the Coast Highway which follows the Salinas River with crossings at San Ardo and King City.

Jolon, a small settlement consisting of a store and post office, church and remains of adobe hotel, is situated on Jolon Creek, a tributary of the San Antonio River, in the midst of grain and cattle ranches, surrounded by mountains of which Junipero Serra Peak, 5,853 feet in altitude, is the highest point in the Central Coast Range. Mission San Antonio de Padua founded on July 14, 1771, lies six miles westward. Three miles to the south on Rancho Los Ojitos, stand two adobe buildings thought to have been erected in 1778, one of which is reputed to be the oldest dwelling in California.

FIVE UNITS

The project was divided into five units for construction. The first unit from three and one-half miles east to



Section of Bradley-King City highway showing concrete check dams along creek channel to prevent excessive erosion in canyon section

six miles north of Jolon, a length of nine and one-half miles, was undertaken by the Work Projects Administration in May, 1941. The balance of the project was contracted in units of 5.9, 13.1, 3.9 and 5.8 miles in length and contracts were awarded to Louis Biasotti & Son, N. M. Ball Sons, Brown, Doko and Baun and Basich Bros., respectively. Work was begun in 1942.

Operations by Work Projects Administration forces continued through the remainder of 1941 until March, 1942, when they were suspended. During this period roadway excavation, drainage structures, and a portion of the imported borrow were completed. Sufficient funds for completion were made available during the Summer of 1942 and a contract was awarded to N. M. Ball Sons by Work Projects Administration under supervision of the Division of Highways for the completion of imported borrow, cement treated base and plant-mixed surfacing. Two contracts were awarded later by Work Projects Administration, the first to N. M. Ball Sons for the construction of Jolon Creek Bridge, and the second to Brown, Doko and Baun for seal coat.

EROSION PREVENTION

The highway design, which was essentially the same throughout the project, provided for a subgrade of material having a minimum bearing value of 20 per cent, 24 feet x 0.5 foot cement treated base, 22 feet x 0.25 foot plant-mixed surfacing, eight-foot shoulders of imported borrow with penetration application of liquid asphalt, gutters and berms lined with plant-mixed surfacing and a seal coat for the entire width of the roadbed. An exception to this design was made on a two and four-tenths mile section of heavy side hill construction over the summit north of Jolon where the shoulders were surfaced with 3 feet x 0.25 foot plant-mixed surfacing.

An unusual feature of the design provided for the construction of 25 check dams to prevent erosion. The new highway on a two-mile section follows along Hames Creek in a comparatively narrow canyon and it was necessary to confine the creek in a channel parallel to the highway. On account of the friable nature of the soil and the excessive grades of the channel some method was required to prevent the scouring action of the stream. The most practical method of preventing this scour was by the construction of check dams which would maintain a channel grade of 1 per cent. These check dams were constructed of Class "C" concrete and have functioned satisfactorily during the recent storms.

EXCAVATION IN SHALE

Construction problems were not difficult, excavation being in shale and soil cuts that did not require blasting. Local materials were used as aggregates for cement treated base and plant-mixed surfacing. Aggregates for concrete structures and seal coat screenings were imported from commercial plants. As aggregates in this area contain reactive shales and chert, low alkali cement was used in cement treated base on all contracts except for about one-half the 3.9 mile unit under contract with Brown, Doko and Baun on which standard cement was used due to curtailment in production of low alkali cement. The most difficult problem presenting itself was in grading operations during the Spring of the year due to saturated soil conditions.

Across marshy areas to the east of Jolon the soil formation consisted of about two to three feet of loosely compacted shale and clay soil overlying an impervious strata. In advance of constructing embankments, longitudinal side ditches under the toe of slope with 10-foot bottom and 2:1 slopes together with connecting cross trenches of the same dimension at intervals of not more than 400 feet, were excavated and the embankment area allowed to drain. The transverse trenches were backfilled with pervious gravelly material. In this manner subsurface drainage above the hardpan is intercepted and carried away by the side and transverse bleeder ditches. Wherever possible cross drainage culverts were placed with flow line at hardpan elevation which in some cases necessitated outlet ditches up to 1,000 feet in length.

CONSTRUCTION METHODS

During the progress of construction five plants operated concurrently in the production of cement treated base and plant-mixed surfacing. Construction methods for these items varied but little throughout the project. N. M. Ball Sons used two tractor and dozer spreaders in placing cement treated base full width. Basich Brothers employed one tractor and dozer with 24-foot spreader box, which, with some improvements should result in the most economical operation. All plant-mixed surfacing was laid by means of motor graders.

One feature of the construction methods employed by two of the contractors was the use of blade attachments for the construction of the plant-mixed berm and gutter. The device used by Louis Biasotti & Son was capable of three operations: **(1)** Making cut to receive plant-mixed surfacing for gutters in cut section. **(2)** Placing and shaping plant-mixed surfacing in gutters and on slope of cut. **(3)** Shaping and compacting earth berms and covering with plant-mixed surfacing. In one position this attachment performed operations **(1)** and **(2)** and consisted of a curved tool about three feet long of the shape of the gutter with an attached plate adjustable to the slope of the cut. After making the gutter cut, plant-mixed surfacing was placed in the recess and pressed into shape by the tool and the gutter portion rolled by the wheel of the motor grader. The top of the

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Picture of dozer spreader with spreader-box blade attachment constructing plant-mixed berm and gutter

Earth-Loading Factors Affecting Field Installations of Culverts

By G. A. TILTON, Jr., Assistant Construction Engineer
R. L. THOMAS, Assistant Engineer, Surveys and Plans

FOREWORD

This is the seventh of a series of technical abstracts from a joint departmental review of culvert practice of the California Division of Highways, by a committee composed of R. Robinson Rowe, Assistant Engineer, Bridge Department, and Clarence F. Woodin, Assistant Maintenance Engineer, and the writers.

The series continues with a presentation of the factors affecting field installation and the structural stability of culverts without benefit of mathematical analysis. This presentation is offered with the hope that the field engineer will be aided in arriving at quick and sound decisions when unforeseen field conditions are revealed during excavation.

FOR practical reasons, culvert designs are based on hypothetical foundation and loading conditions. As excavations for culvert foundations are opened up, conditions are often encountered that are different than assumed by the designer. Likewise, as roadway excavation develops, the character of material proposed for backfill or embankment over the culvert may be of entirely different character than was anticipated.

Unlike the designer, who has plenty of time to study and analyze the factors of design, the field engineer is required to make quick decisions and exercise independent judgment to avoid unnecessary delay of the work when changed conditions appear.

Committee's Observations

It is the committee's observation that there is need for dissemination of the basic principles of earth pressures transmitted to culverts and the effect of various earth loadings on either flexible and rigid structures upon yielding or unyielding foundations. Presentation in a simple manner without detail involvement of theories and formulae should prove helpful to the field engineer in installation problems. It has also been the committee's view that too great a burden of responsibility for adequate design has been thrown upon the field engineer, particularly location detail and hydraulics.

Basic Principles of Earth Pressures Transmitted to Culverts (2) (3)*

The simple laws of mechanics and certain experiments on culvert pipes indicate that the vertical earth pressure on culverts varies according to the relative deflections of the top of the culvert and the adjacent soil each side—ratio of "e" to "E" (Fig. 44a-b-c).

Fig. 44a illustrates an installation of a rigid culvert on an unyielding foundation. In this case (assuming a fairly high fill) the earth alongside the culvert moves downward relative to the material in the prism over the culvert due to the conduit's rigidity and the unyielding foundation of the culvert. This action causes part of the weight of the outside material to be transferred to the prism over the culvert, and "E" is greater than "e." The pressure on the culvert will exceed the weight of the earth prism over the culvert.

Fig. 44b illustrates a case wherein the culvert settles or deflects downward, an amount just equal to the settlement of the plane of material originally level with the top of the culvert. The load is materially reduced, and "E" may approximate or equal "e." The pressure on the culvert will approximate or just equal the weight of vertical earth prism above the culvert.

Fig. 44c illustrates an installation of a flexible culvert on a yielding cushion or yielding foundation. In this case, again assuming a fairly high fill, the earth prism directly over the structure settles downward relative to the material alongside due to appreciable shortening of the vertical diameter of the flexible culvert and by settlement of the bottom into a

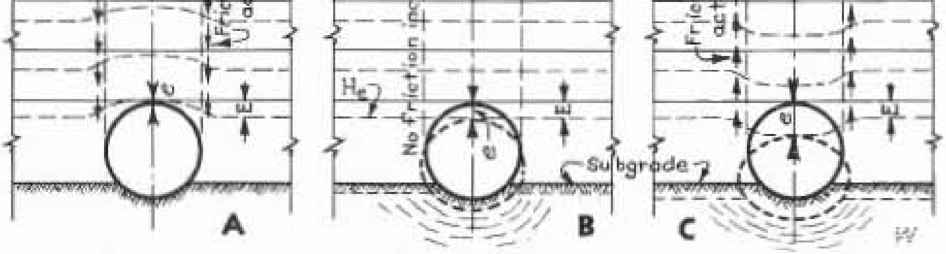


Fig. 44. Three culvert installations, each carrying widely different loads from same height of cover material. Solid horizontal lines represent imaginary planes of embankment before settlement. Dashed lines represent the same planes after settlement has taken place

* Numerals in parentheses refer to bibliography at end of article.

yielding subgrade. "E" is less than "e." The pressure will be less than the weight of the earth prism over the culvert.

Definitions

The qualities "flexible" and "rigid" have been used in a general sense, but Marston (1) has defined them.

Flexible Culvert one whose cross-sectional shape can be distorted sufficiently to change its vertical and horizontal dimensions more than 3 per cent before causing materially injurious cracks.

Rigid Culvert one whose cross-sectional shape can not be distorted sufficiently to change its vertical or horizontal dimensions more than one-tenth per cent without causing materially injurious cracks.

Plane of Equal Settlement (3)

In every embankment sufficiently high, there is a horizontal plane at and above which the compression of the prism over the culvert just equals the compression of the materials alongside (see Fig. 44a-b-c). This condition results when the compression caused by the greater pressure acting through a lesser height within the prism over the culvert equals the compression caused by the lesser pressure acting through a greater height of the material alongside. This plane is known as the "plane of equal settlement" and its height above the top of the culvert is the "height of equal settlement."

In cases V to VIII that follow, the earth loading on a culvert is greatly affected by the "height of equal settlement" which may be above or below the roadway surface (2).

Basic Principles Applied to Practical Installations

Eight standard cases and two special cases commonly encountered in field installations are presented for illustrative purposes:

Case I. Flexible culvert in trench on unyielding subgrade.

Case II. Rigid culvert in trench on unyielding subgrade.

Case III. Flexible culvert in trench on yielding subgrade or cushion.

Case IV. Rigid culvert in trench on yielding subgrade or cushion.

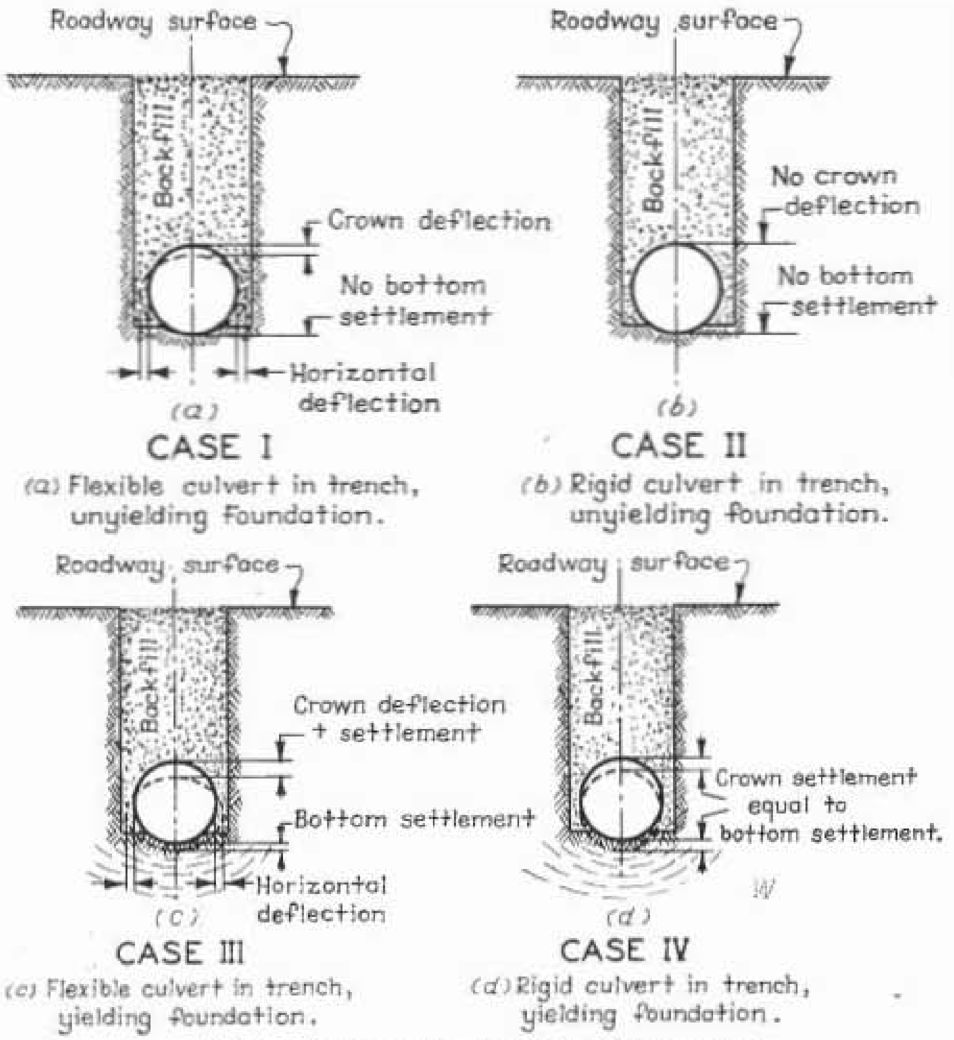


Fig. 45. Four cases of culverts installed in trenches

Case V. Flexible culvert on unyielding embankment subgrade.

Case VI. Rigid culvert on unyielding embankment subgrade.

Case VII. Flexible culvert on yielding embankment subgrade or cushion.

Case VIII. Rigid culvert on yielding embankment subgrade or cushion.

Cases IX and X. Any culvert installed in sidehill location (wrong and right way).

Case I (Fig. 45a). Flexible Culvert Installed in Trench on an Unyielding Foundation

The backfill prism over the top of the culvert in trench tends to move downward relative to the earth alongside, and through frictional resistance and cohesion transfers part of its weight to the soil adjacent to the pipe. In this case the frictional resistance increment acts upward relieving part of the weight of the vertical earth prism over the culvert.

The phenomena have been commonly referred to as "arching action," particularly where rock backfill is used.

If the culvert is of the flexible type further relief of load occurs due to the ability of a flexible pipe to shorten its vertical diameter and lengthen its horizontal diameter.

Case II (Fig. 45b). Rigid Culvert Installed in Trench on an Unyielding Foundation

Action of the backfill prism over the culvert is the same as in Case I, but in the case of a rigid structure, appreciable distortion of the vertical diameter does not occur, resulting in a greater load being carried by the pipe.

Case III (Fig. 45c). Flexible Culvert Installed in Trench on Yielding Foundation or Cushion

The same conditions prevail as in Case I, with a third added. The settlement of the culvert installed on a yielding subgrade further tends to relieve the pressure.

Case IV (Fig. 45d). Rigid Culvert Installed in Trench on Yielding Foundation or Cushion

Settlement of the yielding subgrade or cushion tends to relieve the pressure on the culvert.

As in the case of a flexible culvert installed on excessively yielding subgrades, a highly compacted cushion may be desirable to insure against excessive displacement (see Fig. 48).

Case V (Fig. 46e). Flexible Culvert Installed on Unyielding Embankment Subgrade

In opposition to Case I, there is a tendency for the earth alongside the culvert to move downward relative to the vertical prism over the culvert, causing the frictional increment to act downward and transfer load to the vertical earth prism over the structure. The above is based on the assumption that the materials are homogeneous and that the column of earth adjacent to the culvert moves through a greater height than the column directly over it. As in Case I, some relief of load occurs when the flexible structure deflects.

Case VI (Fig. 46f). Rigid Culvert Installed on Unyielding Embankment Subgrade

The conditions of Case V apply except that the rigid culvert does not deflect sufficiently to appreciably relieve the vertical load. It is the most severe earth-loading condition that will be encountered in the eight standard cases cited. Consideration should be given to some method of relieving the load such as by placing a yielding cushion under the culvert or increasing its structural strength or both.

Case VII (Fig. 46g). Flexible Culvert Installed on Yielding Embankment Subgrade

The same conditions apply as in Case V except that further relief of load may result by yielding of the supporting foundation.

Load is greater than Case III, other things being equal.

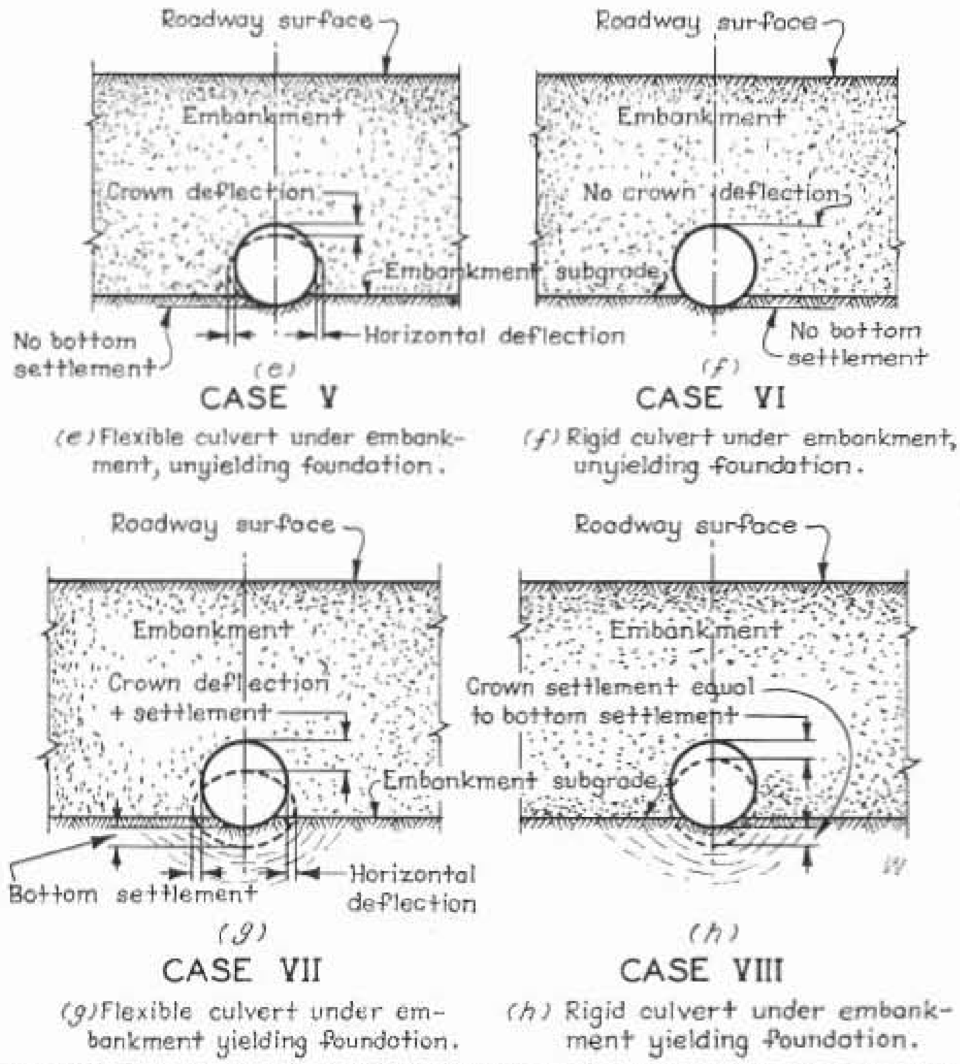


Fig. 46 (e, f, g, h). Four cases of culverts installed on original embankment subgrade

Case VIII (Fig. 46h). Rigid Culvert Installed on Yielding Embankment Subgrade

Case VI applies except that relief of the vertical load results from yielding of the foundation support.

Cradles may be desirable in extreme cases. Tests indicate (4) that supporting cradles under concrete pipe will develop a supporting strength from 1½ to 2 times that which the pipe develops, when not cradled, but this increase in supporting value may be entirely neutralized if the cradles act to reduce the amount of bottom settlement that would normally occur.

Load is greater than Case IV.

Case IX (Fig. 47i). Wrong Method.
Case X (Fig. 47j). Right Method.

Any type of culvert installed in sidehill location.

California experience with culverts placed in the topsoil stratum of sidehill * location has proven to be highly disastrous (**Fig. 47i**). Culverts so installed are subject to a shearing action that takes place in the topsoil stratum between the settling embankment and the firm material back of the overburden.

Culverts have been completely collapsed in many sidehill location cases such as to be rendered useless. **Fig. 47j** indicates the recommended installation.

Field Installation Considerations

Flexible pipe culverts and rigid pipe culverts are designed structurally to resist average earth pressures expected from certain maximum heights of fills. As every field engineer knows, varied conditions are encountered continuously, including rock foundations, marshy ground, unsatisfactory backfill material, caving

* See November, 1942, issue of California Highways and Public Works.

trenches and many conditions too numerous to list herein.

It is the function of the field engineer to interpret the effect of these various conditions and decide whether the proposed culvert will be subjected to greater or less pressures than average condition designed for and make such changes in the installation as may be necessary to insure structural stability of the culvert.

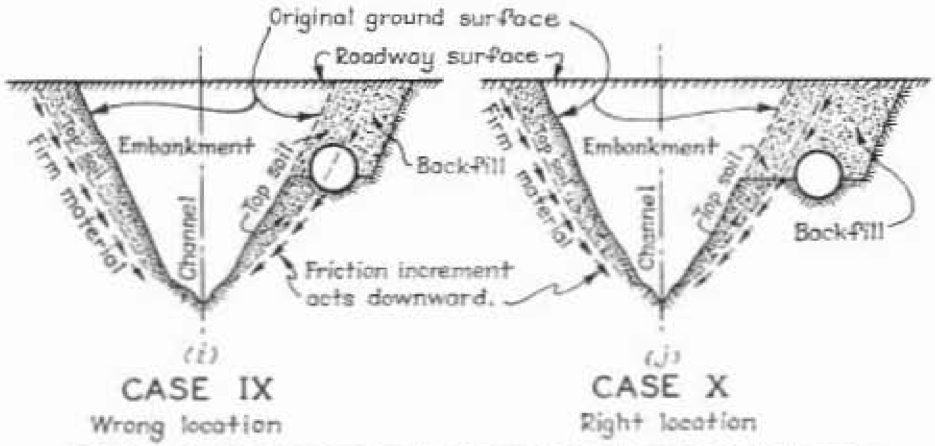


Fig. 47 (i, j). Right and wrong way of installing culverts in sidehill location

Unyielding Foundations

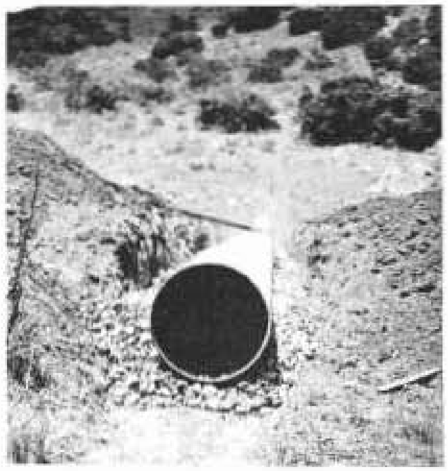
Unyielding foundations vary from solid rock to dry hardpan.

A cushion placed under a culvert on unyielding foundation serves the dual purpose of insuring uniform distribution of pressure on the bottom and permitting settlement which relieves the load as described heretofore in Cases I, II, V, and VI.

California 1940 Standard Specifications satisfactorily provide for a cushion as follows (Sec. 56e):

"Where solid rock is encountered, it shall be removed below grade and the trench backfilled with suitable material in such a manner as to provide a compacted earth cushion with a thickness under the pipe of not less than one-half inch (½") per foot of height of fill over the top of the pipe, with a minimum allowable thickness of eight inches (8")."

Compaction should be uniform, ranging from a fairly high degree of compaction under low fills (to limit undesirable settlement in the roadway surface) to a low degree of compaction under high fill (to permit settlement).



Above—Fig. 49. Rock cushion and bedding in lieu of high compaction backfill

Left—Fig. 48. Rock cushion on yielding subgrade for reinforced concrete arch culvert

Below—Fig. 50. Crusher run backfill placed and jetted by contractor in lieu of compaction backfill

Bedding and Backfill Practice

It is the view of the committee that adequate bedding for pipe culverts can not be uniformly obtained by specifying that the trench bottom be shaped to fit the bottom of pipe culverts.

The specification is difficult to enforce for various practical reasons as years of experience on California highways has shown. The bottom rounding specification was removed from standard specifications in 1940 and provision made for compaction of backfill from the bottom of the trench in thin layers, with the option of ponding or jetting granular material in lieu of thin highly compacted layers (see Figs. 49 and 50).

The same difficulty in obtaining proper backfill to culverts has been experienced as in the case of rounding the culvert trench to fit the bottom of pipes. Backfills compacted to a 90 per cent relative compaction are

exceedingly difficult to obtain where hand tamping is used unless layers of backfill are tamped in 2 or 3 inch layers with optimum moisture content and the tamping head is sufficiently small. Hand-tamping processes are a tedium to the workmen and the contractor alike, requiring most rigorous inspection to insure specification compaction. The same applies to mechanical tampers; unless the tamping head is sufficiently small and the workman applies his weight to the tampers to keep them from bouncing too much, which the average workman is not prone to do, poor compaction results.

Yielding Foundations

Yielding foundations vary from marshy ground containing a high percentage of moisture to low-density spongy topsoil.

In order to insure uniform distribution of pressure on the bottom and sides of a culvert on yielding foundation a layer of gravel or other material of high bearing value should be placed under and on the sides of the structure.

California 1940 Standard Specifications provide for yielding foundation conditions as follows (Sec. 57e):

"Where a firm foundation is not encountered due to soft, spongy, or other unsuitable material, all of such unsuitable material under the pipe and for a width of not less than one (1) diameter on each side of the pipe shall be removed and the space filled with gravel or other suitable material."

Thickness of gravel support is dependent upon the width of structure and nature of supporting subgrade.

Bedding and Backfill

Rounding of culvert trenches to fit the bottoms of pipe culverts has been abandoned in California practice, for reasons previously stated. Replacing the old rounding-of-the-bottom specification, is a provision for placing backfill under and around pipe culverts in thinly compacted layers containing optimum moisture with an in-lieu specification permitting use of ponded or jetted granular materials.

Section 121 of the 1940 Standard Specifications provides as follows:

BACKFILL SPECIFICATION: "Backfill shall be placed in horizontal layers not exceeding four inches (4") in depth before compaction. Each layer shall be moistened and thoroughly tamped, puddled, rolled, or otherwise compacted until the relative compaction is not less than ninety per cent (90%), as determined by the compaction test specified in Section 6, Article (d) of these specifications."

Fig. 51a. Flexible culvert on embankment subgrade covered with earth. Not recommended

Fig. 51b. Rigid culvert on embankment subgrade covered with earth. Not recommended

IN-LIEU SPECIFICATION: "Should the contractor elect to furnish sandy or granular material for backfill, the layer construction may be eliminated and compaction obtained by ponding or jetting. Ponding or jetting will not be permitted where the backfill material is not of a sandy nature nor where the foundation material is such that it will soften when saturated * * *."

Culverts Installed in Trenches

Test results (5) indicate that, as the width of trench increases, other conditions remaining constant, the load upon the culvert increases, until projection condition is reached (culvert projecting above the subgrade under embankment).

Although there is no definite specification limiting the width of trenches, excessive width is discouraged by the specifications by disallowing payment for structure excavation and backfill outside vertical surfaces one foot (1') each side of the external dimensions of pipes or one foot (1') outside the neat lines of concrete structure footings.

Culverts Installed on Subgrade Under Embankment (Projection Condition)

As stated in Cases V, VI, VII, and VIII, culverts installed on embank-

Fig. 52. Left—Masonry arch culvert under construction. Right—Same culvert unequally loaded by end-dumped material on one side (material to be rehandled to a lower level for compaction).

ment subgrades generally sustain more earth load than when installed in trenches, as outlined in Cases I, II, III, and IV.

To reduce the load transmitted to culverts under new embankments, specifications provide for construction of the fill to a point above the top of the culvert and then excavating a trench.

1940 Standard Specifications accomplish this as follows (Sec. 57e):

"In the case of pipes twenty-four inches (24") or less in diameter, the roadway embankment shall be constructed to an elevation of six inches (6") above the grade proposed for the top of the pipe, after which the trench shall be excavated and the pipe installed.

"In the case of pipes more than twenty-four inches (24") in diameter, up to and including pipes ninety inches (90") in diameter, the roadway embankment shall be constructed to an elevation of thirty inches (30") above the grade proposed for the bottom of the pipe, after which the trench shall be excavated and the pipe installed.

"In the case of pipes more than ninety inches (90") in diameter, the roadway embankment shall be constructed to the elevation of the third point of the diameter of the pipe (measured from the grade line proposed for the bottom of the pipe) after which the trench shall be excavated and the pipe installed."

A frequent practice adopted by contractors in order to comply with the above specification consists in construction of a mound and then excavating a trench in the mound for installing the culvert (see Fig. 51a-b).

This practice should be discouraged since it tends to defeat the purpose of the specification. The committee recommends that specifications provide for construction of compacted embankment as provided for in the above specification at least five diameter each side of the proposed installation before trench excavation is made.

Structures projecting above the surface of the embankment subgrade should be backfilled evenly on both sides (Fig. 52 depicts an improper method).

Recommendations

It is the opinion of the committee that the present height-of-fill limitations for the various types of culverts are not sufficiently flexible to be economically adapted to the various field conditions encountered, and that there is a need of a study for the purpose of establishing limiting heights-of-fill for various loading conditions for flexible and rigid structures that take into consideration the effect of highly consolidated modern highway embankments and high compaction backfill.

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List of Articles Already Published in California Highways and Public Works

Traffic Actuated Signal System in San Diego Solves Congestion Hazards

By R. B. LUCKENBACH, District Traffic Engineer

A RECENTLY completed contract between Market and Couts Streets on the Pacific Highway in the City of San Diego, concludes a series of projects under direction of the State Division of Highways, which render a greatly improved traffic service.

This road is a portion of the State Highway system—U. S. 101—and is the principal entrance to the city. In addition to heavy trucking and through travel, it also carries a very heavy volume of local traffic.

Starting in the fall of 1940, the expansion of war industries and military activity, resulted in serious congestion by increasing the volume and introducing heavy pedestrian movements, with constant turning, stopping and intersection conflicts resulting from proximity of large parking areas, in addition to curb parking.

CONGESTION FROM DELAYS

The four-lane highway proved inadequate under the conditions and loads, and delays of 10 minutes to the mile were not uncommon, with resulting accumulated masses of vehicles extending the congestion to all adjacent areas when they were released.

A series of improvements were planned, with uniform traffic movement as a goal, combined with a minimum of delay and increased safety for pedestrians and cross traffic.

The highway was widened to six lanes, with a parking lane on each side and a six-foot-wide curbed center division, with openings generally restricted to the major city street crossings. Pedestrian overpasses were constructed at three locations of heaviest concentration, and vehicular separations built at three locations where the most serious vehicular conflicts occurred.

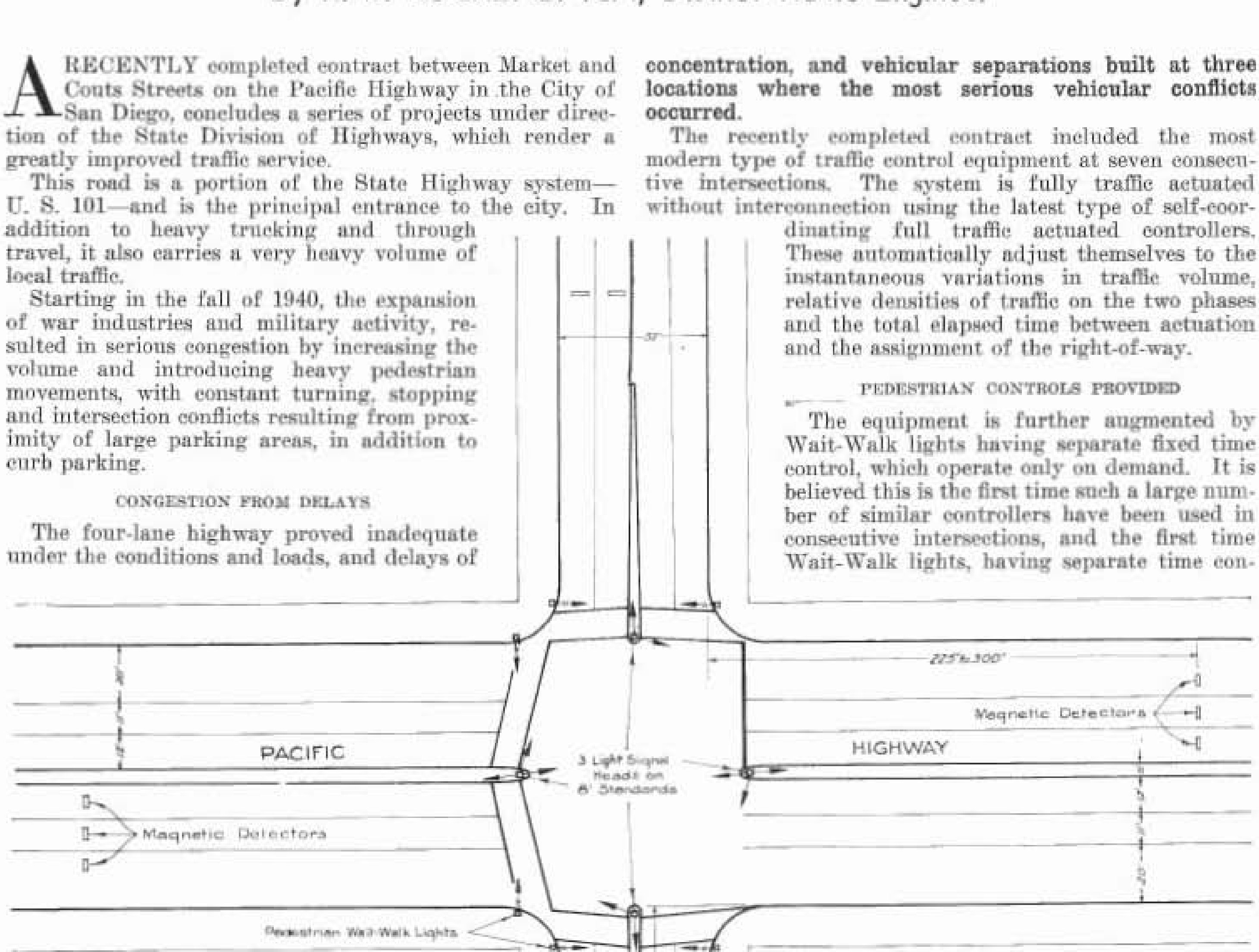
The recently completed contract included the most modern type of traffic control equipment at seven consecutive intersections. The system is fully traffic actuated without interconnection using the latest type of self-coordinating full traffic actuated controllers. These automatically adjust themselves to the instantaneous variations in traffic volume, relative densities of traffic on the two phases and the total elapsed time between actuation and the assignment of the right-of-way.

PEDESTRIAN CONTROLS PROVIDED

The equipment is further augmented by Wait-Walk lights having separate fixed time control, which operate only on demand. It is believed this is the first time such a large number of similar controllers have been used in consecutive intersections, and the first time Wait-Walk lights, having separate time control, have been combined with them. The intersections from south to north are by name, Broadway, Ash, Cedar, Grape, Laurel, Sassafras and Harasthy. The distances between intersections, in the same order, are: 1,512, 760, 980, 1,902, 2,755 and 2,513 feet, respectively.

Each intersection has different traffic characteristics and patterns with special turning and pedestrian problems, and each is subject to a wide variation of intermittent loads on the approaches, with a consistent volume of 20,000 to 30,000 vehicles per day on the main highway. The Harasthy Street intersection

(Continued on page 14)



Plan of automatic signal system in San Diego actuated by traffic and pedestrians

Scenes at automatic traffic signal in San Diego. Top left—Electric brain that receives messages from magnetic traffic detectors and operates signals. Top right—Pedestrians on safety island awaiting effect of push button signal. Center—Market and Pacific intersection. Bottom left—Pedestrian "Wait-Walk" signal. Bottom right—Left turn signal and magnetic detector coil buried in pavement has three railroad track crossings with preempting track circuits, all of which are used extensively.

COLLISIONS WERE PREVALENT

Prior to reconstruction, there were fixed time controllers at Broadway, Cedar and Sassafras Streets, the latter two being operated only on demand, by a pedestrian push button, or a contactor in the street. Overtaking collisions were prevalent at these intersections, and one or more property damage accidents occurred nearly every day.

Likewise, vehicles frequently ran the red lights, seriously endangering the pedestrians and requiring constant police patrol. Police direction was required during peak periods at several locations. Crossing was very hazardous, both for pedestrians and vehicles, particularly for single pedestrians. Speeds averaged 25 to 35 miles per hour.

PEDESTRIAN ISLANDS BUILT

In addition to the six-foot, curbed center island for the entire length of the project, small tapered islands were included at each approach to the signalized intersections. Regular three-light traffic signals were placed on eight-foot standards, with a raised base on each center island for vehicular indications.

Two-light "Wait-Walk" signals on six-foot standards were used for pedestrian indications. Pedestrian push buttons were placed on each "Wait-Walk" standard, and on the center standards in the wide highway.

HIGH PEAK TRAFFIC COUNTS

Traffic counts taken during two days in February, 1943, show 15 minute volumes entering the Laurel Street intersection as follows:

P. M.	Thursday	Friday
3:00-3:15	469	484
3:15-3:30	591	385
3:30-3:45	657	663
3:45-4:00	852	570
4:00-4:15	492	664
4:15-4:30	635	770
4:30-4:45	548	485
4:45-5:00	599	555
Peak hour	2,636	Peak hour 2,767

INTERVALS TIMED BY TRAFFIC

Observed operation of the signals show a wide variation in timing as the traffic pattern changes.

A typical timing of consecutive green indication during the peak volumes, are as follows:

A Phase, Secs.	B Phase, Secs.	A Phase, Secs.	B Phase, Secs.	A Phase, Secs.	B Phase, Secs.
31	18	32	18	26	19
30	24	57	22	25	20
24	24	47	19	17	16
25	23	40	17	30	22
33	13	32	15	27	14
63	22	39	19	35	19
46	20	25	12	38	23
26	17	35	14	36	21
32	27	37	25	37	20
37	23	40	15	34	25
36	20	30	14	34	26
40	22	59	11	32	29
40	24	20	15	50	23
51	23	36	20	31	24
33	23	31	19	33	24
32	20	55	16	24	18
47	22	30	18		

MAGNETIC DETECTORS USED

Vehicle detectors are a magnetic type that operate by the passage of a car, inducing a small current in a coil placed under the pavement, which, in turn, is amplified by an electronic relay unit to operate the controller relays. A four-foot detector was used in each lane of travel on the Pacific highway, or a total of six at each intersection.

One or two six-foot detectors were used on the side street, depending on the volume of right turns. Two amplifying relays were used for the six detectors on the main highway, the two outside ones on one approach, being connected in series with the center one on the opposite approach.

PUSH-BUTTON SIGNALS

Separate pedestrian interval timers were used on each phase. These timers consist of a small synchronous motor and necessary relays to operate the "Wait-Walk" light. The pedestrian indication rests in the "Wait" position until a call is received from a pedestrian push button, and does not change from vehicle actuations. The pedestrian call also registers a single vehicle actuation, so that at the next change in phase, the "Walk" light comes on with the vehicle green. "Walk" periods of 11 to 15 seconds were used with a protection period of 4 to 7 seconds, plus the amber time, which varies from $2\frac{1}{2}$ to $3\frac{1}{2}$ seconds.

The synchronous motors have various cycles and will repeat after a full cycle, providing no call has been registered in the opposite phase. The minimum green without pedestrian actuation is 6 to 10 seconds.

Two of the intersections have only one side approach. Both have very heavy pedestrian movements, with vehicular traffic on the side street being principally right turns from east to north, and corresponding left turns from north to east. Pedestrian indications were used only on the southerly cross walks of these intersections, and southbound left turns are permitted against the main highway red indications by use of a green arrow signal mounted five feet high on the center posts.

A pressure sensitive vehicle detector was placed in such a position that the left turn vehicles would cross it and hold the signal to permit several such turns. Due to the elimination of many center curb openings, "U" turns are permitted at these intersections. The left turn movement is made by crossing a normal westbound left turn, but no trouble has been observed from this minor conflict.

During peak periods, when the interval is held by the pedestrian movement, this device operates very effectively and safely, as the left turns can be made without conflict with either the major flow of vehicles or pedestrians.

SATISFACTORY RESULTS ACHIEVED

The installation may be said to be thoroughly satisfactory in that it accomplished the desired results. Vehicular movement is remarkably uniform and smooth. Delays are short and infrequent, and the entire system can often be traversed without stopping.

Pedestrian observance is rather poor on the side street "Wait" lights, but quite good across the main highway. The pedestrians are observed to walk much faster, group better, and stragglers are greatly reduced, so that traffic is seldom held up at the end of the red period, due to pedestrian interference. The few stragglers or persons desiring to walk abnormally slow, can take refuge on the center island, with safety, where they will not hold up vehicular movement.

The signals are equipped with blackout shields, and operate 24 hours a day.

Rufus: "How are you getting along with your arithmetic?"

Susan: "Well, I've learned to add up the oughts, but the figures still bother me."

Effects of New Asphalt Rationing and Restrictions on Highway Work

By H. B. LAFORGE, Assistant Office Engineer
J. G. MEYER, Assistant Office Engineer

TWO recommendations (or orders) have been issued by the Office of Petroleum Administrator For War which have considerable effect upon agencies charged with the responsibilities of public road construction and maintenance.

Recommendation No. 45 (Amended October 5, 1942, to include California and 9 other Western States) prohibits the use of road oil for road work. It restricts the use of other asphalt products to road and street projects considered necessary to the successful prosecution of the war. The latter phrase is interpreted to include essential civilian traffic.

Recommendation No. 61 was dated November 17, 1942, and restricted the manufacture of asphaltic products to certain listed grades. The principal object of this restriction apparently was to release storage facilities for other purposes.

REQUIRES A CERTIFICATE

Operation of Recommendation No. 45 requires an asphalt certificate authorizing each proposed use. The recommendation effectively places in the hands of the Federal Public Roads Administration the responsibility of administration and of applying the certification to approved applications.

The various State Highway Departments are required by the recommendation to assist in administration by reviewing all applications which involve public roads and forwarding them to the Public Roads Administration with recommendations relative to approval or a statement of pertinent facts concerning the particular application.

In California this review is handled by the several State Highway District Engineers who, being familiar with their territories, are best able to accomplish this and with a minimum of time.

The application form B-1 is designed to assist the applicant in making a proper showing for the work he considers essential and to support the quantities requested. These applications should be completed in full and forwarded to the District Office of the Division of Highways covering the geographic area in which the proposed work lies.

APPLICATION COVERAGE

Application paper work has been reduced by permitting combinations of specific requirements. The ordinary maintenance requirements of cities and counties may be handled in one to three applications, depending upon the nature of the work and its magnitude.

One application may be submitted covering an entire city's or county's general maintenance or day-to-day patching requirements for a calendar year. This should include a statement of the miles or area in square yards of bituminous roads to be maintained and a tabulation of the quantities of asphaltic material used for similar work in the previous year.

The application need not be accompanied by detailed maps and can include material to be used in remixing short sections of oil-treated roads throughout the system without a definite commitment from the applicant as to the specific portion to be repaired by this method. The estimated use by quarterly periods should be indicated.

A second application may be submitted covering the annual requirements for maintenance work covering large scale seal coat work and retreading or blanketing. This application should also be on an entire city or county basis, and should be accompanied by maps which indicate by number the locations of the several projects. These numbers should tie in with an attached tabulation showing for each project the termini, the gross and net miles, the type of work, the width, the kind of asphaltic product to be used and the thickness or rate of application.

The amount of asphaltic material used in the preceding year for similar work should also be shown.

It may be desirable to submit a third application for the heavier blanketing work rather than include such among the lighter blankets and seals in the second application.

YARDSTICK FOR PROJECTS

Projects which will result in material improvements and cannot be classed as replacement, restoration or reconditioning are considered construction projects and require separate applications for each unrelated project.

The yardstick by which proposed work is reviewed is here given and is arranged commencing with the type of work most likely to receive favorable action and ending with the type of work which must receive much careful study both by the applicant and the final reviewer.

(1) Maintenance.

(a) Patching work, where feasible, should be undertaken in preference to surface treatment.

(b) Surface treatment should be substituted for reconstruction.

(c) Intensive or unusually heavy maintenance should be undertaken in preference to new construction.

(2) Construction.

Only those construction projects which would be eligible for a preference rating order such as P-19e should be considered for construction. On these proposed construction projects as distinguished from maintenance projects consideration should be given

(Continued on page 16)

Elimination of Rindler Creek Bridge Bottleneck on American Canyon Road

By C. J. TEMBY, District Office Engineer, District X

IN the latter part of 1936, the American Canyon Cut-Off, in Solano County, extending from Carquinez Bridge to west of Cordelia on U. S. Route 40, State Highway Route 7, was completed and opened to traffic as a two-lane paved highway, excepting about 1.3 miles of three-lane pavement between the Vallejo junction and the Benicia Road.

At that time the volume of traffic was about 4,500 vehicles per day. Since then the traffic has shown a steady increase up to 1941, when the Sunday traffic census showed for a 16-hour period that the volume of traffic was approximately 9,900 vehicles. In 1942, the Sunday traffic fell off to about 8,700 vehicles, or a decrease of about 12 per cent.

With the constant increase of traffic, the two-lane highway through the American Canyon became crowded. Because of the topography and country involved, long grades were necessary for portions of this road.

HAZARDOUS TRAFFIC PROBLEM

The volume of truck traffic over this route is large and the speed of the heavy vehicles is slowed down very much on the long grades. This created a serious traffic problem and resulted in several accidents. To remedy this condition, it was necessary to provide additional traffic lanes and widen the roadbed.

A construction project in 1941 eliminated about 2.3 miles of the two-lane pavement through the widening to a four-lane pavement. This work was described in an article by Robert E. Pierce, appearing in the California Highways and Public Works in December, 1941, issue.

Because of the limited funds available at that time, widening of the portion across Rindler Creek bridge and the fill approaches to the bridge was omitted. With the completion and opening to traffic of the four-lane units on each side of the bridge, a bottleneck was created by the narrower portion of the road.

Rindler Creek bridge was built in the original construction of the American Canyon project as a temporary timber structure with a 34-foot roadbed and about 55 feet in height, measured above the natural ground level.

SLIDES PROVIDE FILL MATERIAL

After studying several methods of correction which involved, (1) widening the existing bridge, (2) constructing a new bridge, or (3) removing the existing bridge and replacing it with a fill, it was decided to follow the last plan.

Cut slides in the American Canyon about one-half mile in both directions along the highway from Rindler Creek have been moving and causing considerable concern for several years. The unloading of these slides will provide sufficient material for constructing the fill thereby "killing two birds with one stone," viz, eliminate the bottleneck and reduce, if not overcome, the slide difficulties. These slides have required a great amount of maintenance attention and expense since the original grading project of the American Canyon highway.

CULVERT THROUGH FILL

Rindler Creek is a natural drainage for the adjacent area and in removing this bridge, provisions have been made to carry the drainage through the fill in a field-assembled plate culvert 105 inches in diameter, 270 feet long.

The proposed work will consist of removing the existing bridge, installing the field-assembled plate culvert and constructing a graded roadbed 48 feet in width, with a Portland cement concrete base 44 feet wide thickened at edges and intermediate quarter points.

The thickness of the Portland cement concrete base will be 0.50 foot, increasing to 0.75 foot in 2 feet at edges and quarter points. This concrete base will be covered with an asphaltic concrete pavement 44 feet wide by 0.25 feet in thickness.

The approaches to this described improvement will consist of widening the existing 20-foot pavement to 44 feet by constructing two 12-foot Portland cement concrete widening strips 0.50 foot thick at the center, increasing to 0.75 foot thick at the outer 2 feet. These widening strips will be surfaced with asphaltic pavement 0.25 foot thick.

DETAILS OF WORK

Involved in the proposed work is approximately 89,000 cubic yards of excavation for placing in the new fill, 700 tons of asphaltic concrete pavement, 775 cubic yards of Class "B" Portland cement concrete base, 270 l. f. of field-assembled plate culvert, and several other miscellaneous items of work. The total length of the proposed project is 0.5 of a mile long and is under contract by L. Biasotti & Son at an approximate cost of $145,000.

Because of the inclement weather making the ground unworkable, the construction activities have been suspended and will be resumed as soon as weather and ground conditions permit. Mr. A. K. Nulty is resident engineer in charge of construction for the State.

New Asphalt Rationing

(Continued from page 15)

to an increased thickness of untreated base to permit of a minimum of asphaltic material in the surface. However, designs based on normal factors of economy and traffic service are acceptable if asphaltic materials are available, and the transportation problem is not sufficiently acute to control use.

Completion of street work within bona fide housing projects have been

considered as essential, although in many cases reduction in thickness of bituminous surface from the original plans have been made.

It should be noted that the issuance of an asphalt certificate does not relieve the recipient of complying with other Federal Regulations, such as Conservation Order L-41.

It can be readily understood that the transportation problem by rail and, to a lesser degree, by truck, is more serious than the availability of asphaltic products, excepting the road oils.

During the war it is necessary to restrict the use of labor, equipment and material to the fullest possible extent, and only the most essential work, which can not be postponed, should be attempted. In general, an effort is being made to limit the quantity of asphalt used to not more than one half of the amount consumed in normal years.

The second order referred to, or Recommendation No. 61, restricts the manufacture of asphaltic products to the following few grades:

ASPHALT CEMENTS:

PENETRATION RANGES—50-60, 85-100, 120-150, 150-200, 200-300. Federal Specifications—SS-A-706a (November 26, 1940) and SS-R-406a (April 25, 1942). The new 200-300 penetration asphalt is an attempt to provide an equivalent for SC-6.

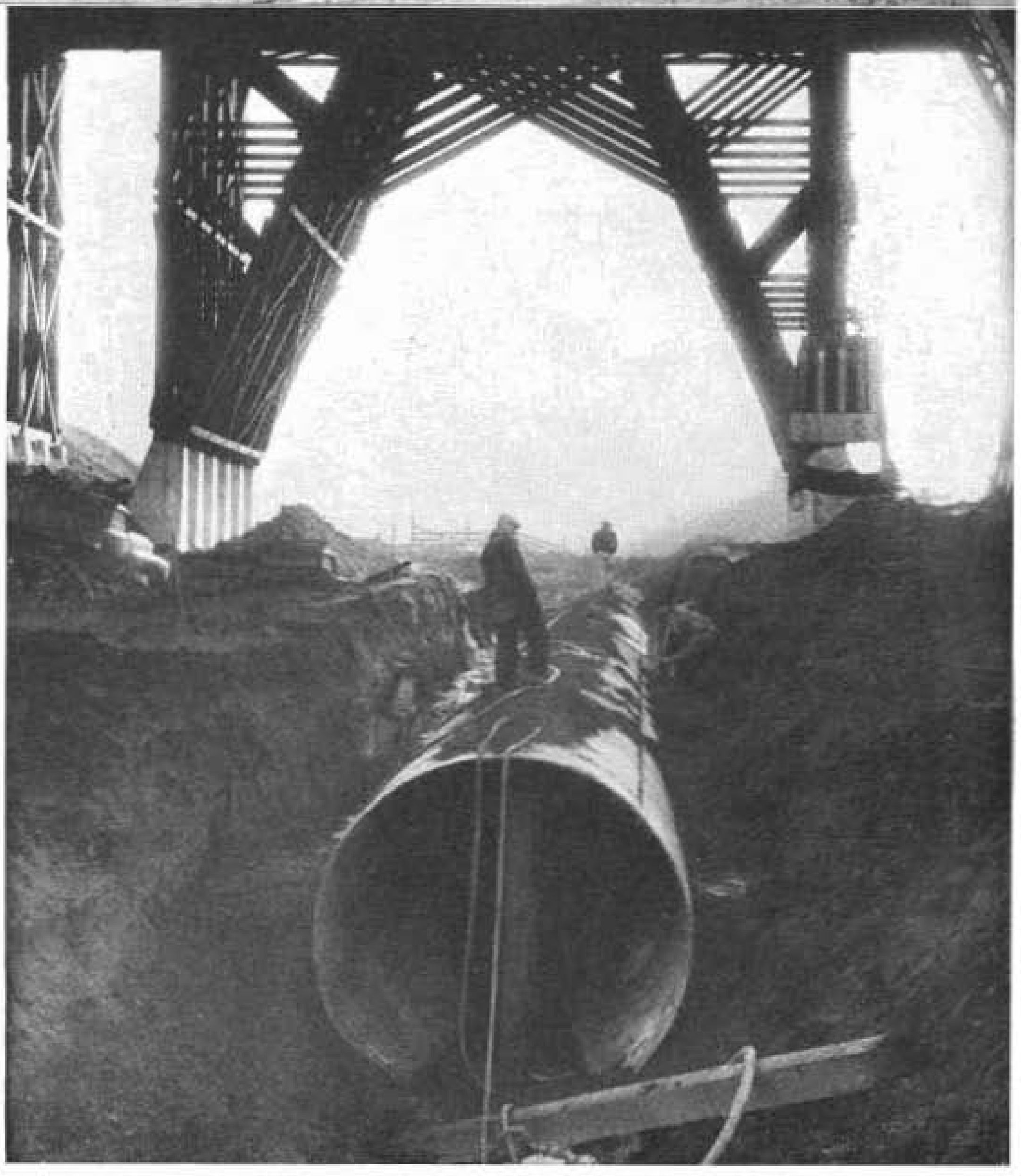
MEDIUM CURING CUTBACK ASPHALTS:

MC-1, MC-2, MC-3, MC-5. Federal Specifications—SS-A-671a (June 20, 1941) and SS-R-406a (April 25, 1942).

RAPID CURING CUTBACK ASPHALTS:

RC-1 * * * * *, RC-2, RC-3, RC-5. Federal Specifications—SS-A-671a (June 20, 1941) and SS-R-406a (April 25, 1942).

(Continued on page 20)



Top—Picture of Rindler Creek bridge in American Canyon to be replaced by fill, and below, large metal culvert being placed to carry creek waters through fill

New Freeway Structures Show Twisting and Turning Designs

By L. C. HOLLISTER, Bridge Design Engineer

THE Pomeroy and Soto Streets traffic interchange structures now nearing completion in Los Angeles give the highway user a glimpse of many interesting things to come in the shape and form of freeway bridges. These structures for the freeways of tomorrow will take on odd shapes and new appearances as they twist and turn with the interchange lanes which must weave in and out, under and over, in order to provide for an endless flow of uninterrupted traffic.

These structures are a part of the Ramona Freeway which some day will extend from the Aliso Street Bridge in Los Angeles to the east. This freeway is typical of many others needed in California today and on which it is hoped construction can start at the close of the war.

INTERCHANGE TRAFFIC

The Pomeroy and Soto Streets structures provide for the interchange of traffic between Soto Street, an important traffic artery, and the Ramona Freeway. Traffic headed north on Soto Street may turn west toward the city onto Ramona Freeway by using the Pomeroy structure, and city bound Ramona traffic may turn south onto Soto Street by using the Soto Street structure.

Highway structures have been built before to provide for curved alignment but few if any have ever been made to provide for the twisting curvature, with reversing superelevations represented in these latest designs. Construction methods previously used have always been mean to build and abortive in appearance when completed. Realizing that the freeway of the future would have many structures with similar demands, a more satisfactory solution was sought.

Reinforced concrete girders built to conform to the sharp curvature and changing superelevation of the interchange lanes seemed a reasonable solution structurally as well as aesthetically. Each of the structures, which are about 400 feet long, was constructed of four concentric lines of continuous curved girders from one end to the other. The girders were boxed in providing a smooth surface top and bottom giving the structure as a whole the appearance of a continuous ribbon of concrete bent and twisted to the desired shape.

In addition to the horizontal curvature, the bridges conform to a vertical curvature, and a changing superelevation up to 7 per cent. The superstructures, therefore, resemble elevated box culverts which curve vertically to conform to the highway grade, tilt sideways to conform to roadway superelevation, and curve horizontally to conform to the highway alignment.

REVERSE AND COMPOUND CURVES

Each structure has four lines of girders spaced at 10 feet, and although the spans vary from 40 to 70 feet a constant girder depth of four feet is maintained throughout. One structure has girders built on reverse curves of 200-foot (29-degree) and 615-foot radii. The other structure has girders built on compound curves of 200-foot and 1,360-foot radii.

Because the foundation conditions required the footing pressure to be held to two tons, and because the open column bents appeared more flexible than usual, there was at first some concern for the possible effect of the combination of temperature, shrinkage, and torsional moments on a continuous curved girder design. Consideration during preliminary design stage was, therefore, given to simple span, straight girder construction for that portion with the 70-foot span on a 29-degree curve.

DESIGN CONCLUSIONS

The conclusions arrived at by a comparison of the two types were as follows:

(1) The simple span straight girder type was found to cost considerably more.

(2) For the straight girder layout the development of the members for the sharp curves, with abrupt changes in grade, and superelevation would have been difficult and awkward, would have required more head room, and would have been less resistant to external side loads.

(3) While the construction of girders curved in a horizontal plane was somewhat unusual, there appeared to be no forces, moments, or torsions that could not be adequately provided for by reinforcement and proper construction details.

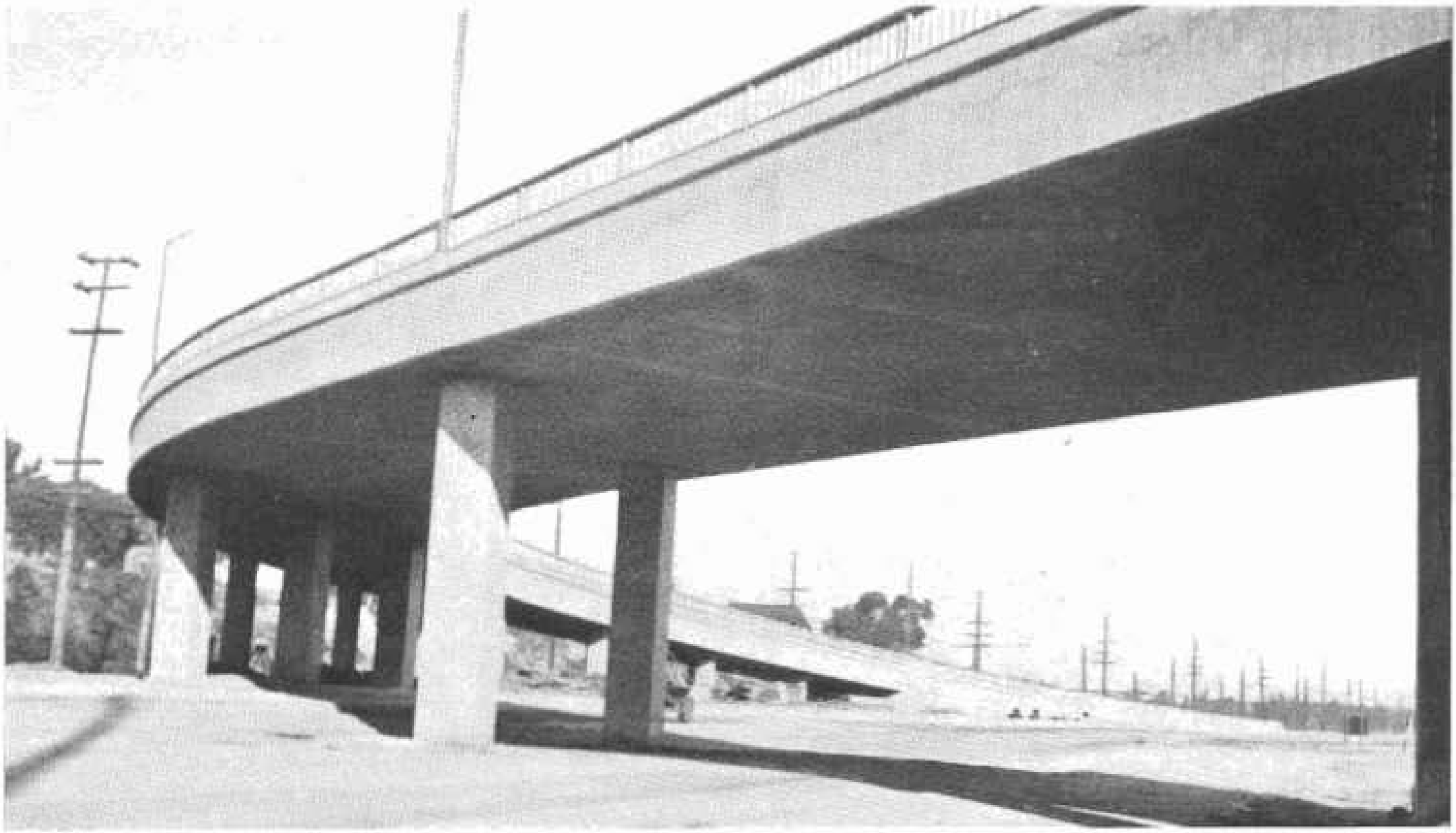
HORIZONTAL CURVE COMPENSATIONS

(4) It was further concluded that the difficulty of forming the girders to a horizontal curve would be more than compensated for by the simplification of other details, such as: Constant distance between girders, constant depth of girders, and constant overhang outside of girders.

(5) The straight girders in contrast with the sharp curvature would result in an unsatisfactory appearance with varying dimensions and awkward cut-up details. The curved girders on the other hand presented a structure with pleasingly continuous lines and surfaces.

Design analysis indicated that although the middle ordinates of the 70-foot curved beams were approximately three feet, the torsional moments could easily be counterbalanced by: (1) Special reinforcement of girder webs, (2) by the use of diaphragms at about 15-foot centers rigidly tying together the four lines of girders, and (3) by the great stiffening effect of the top and bottom slabs of the box girder construction.

The torsional reinforcement was composed of two groups of diagonal stirrups inclosing the four surfaces of each beam. The bars in the vertical surfaces were tipped at an angle



View of wide swinging curve of Soto Street traffic interchange structure nearing completion on Ramona Freeway in Los Angeles

of 45 degrees, pointing upward toward the center of the beam on the concave side, and downward toward the center on the convex side.

At the ends of the girders the torsional moments were received by heavy bent caps which transferred the torque to the columns and eventually to the footings. Torsional reinforcement added but a fraction of 1 per cent of the cost of the structure.

During construction the alignment of the girders was accomplished by lowering plumb bobs through small holes bored in the bottom slab forms to an exact layout of the girders previously made on the ground.

To give the outside girders a smooth curved surface, five-eighths-inch plywood extending the full depth of girders was used. Bolts at 16-inch centers drew the forms into place and held them firmly in line. Forms for the inside girders and fillets that are hidden from view were built on short chords.

Pomeroy Street overhead, a companion traffic interchange structure to Soto Street, shows a twisting reverse curve alignment

SETTING OF SCREEDS

Since no wearing surface was placed on the concrete deck considerable care was used in finishing to a smooth grade. Longitudinal 2-by-4-inch screeds located at each gutter line with laps spliced for continuity were supported by adjustable bolts at six-foot intervals. The bottom edge of the screed was thus constantly maintained at the elevation of the finished concrete deck. Screeds were set to provide for one-half inch of camber in the 40-foot spans and three-fourths inch of camber in the 70-foot spans.

California has constructed other reinforced concrete girders on horizontal curves as listed in the following table:

Date	Name	Radius of curvature, feet	Maximum span length, feet
1938	San Francisco-Pacheco Creek	2,000	44
1938	Pacheco Creek	2,000	67
1939	Funston Avenue	299	78
1940	San Rafael Viaduct	1,050	40
1940	Schooner Gulch	800	120

Asphalt Rationing

(Continued from page 17)

Rapid curing cutback asphalt RC-1 may be manufactured only when this product is to be transported from a refinery to a terminal via barges.

EMULSIFIED ASPHALTS:

TYPES I, II, III, V. Federal Specifications—SS-A-674 (May 7, 1935) and SS-A-674 Amendment—1, (March, 1936).

Unfortunately, the order did not take into consideration the difference in methods, materials, and climatic conditions in the different geographical areas of the United States, having apparently been written with Eastern practices in mind.

The elimination of the lighter SC-oils has worked great hardship on western road agencies who have found it necessary to maintain earth roads by the process of discing, retempering and relaying.

Another very serious effect of this restriction was the elimination of ROMC-3, which along with SC-3, previously eliminated, were the most widely used in the preparation of pre-mix in California.

The most practical, permissible substitute for ROMC-3 for pre-mix is the MC-3. However, MC-3 without modification, is not considered entirely satisfactory for this purpose. In order to partially solve the pre-mix problem, the base asphalt used in the manufacture of the MC-3 must be as soft as possible within the range of residual penetrations permitted by the controlling Federal specifications.

Representatives of several oil companies have indicated that it will not be difficult to produce such a material within the residual penetration ranges of 225 to 300, which it is hoped will provide a softer product nearer to ROMC-3 characteristics.

Recommendation No. 61 also limits the grades of emulsified asphalt which may be manufactured. It is no longer possible to secure the California Division of Highways' Specification asphaltic emulsion, penetration type with the SC-6 base, except for stocks which the manufacturer may have had on hand. Assuming that no modification can be made, this leaves available only the 150-200 penetration base type which is not considered satisfactory for all uses requiring penetration type emulsion.

Bids and Awards

ALAMEDA AND CONTRA COSTA COUNTIES—Diesel oil to be applied to roadside vegetation for a length of about 61 roadside miles. District IV. Sheldon Oil Co., Suisun, $2,400. Contract awarded to Close Building Supply, Hayward, $2,264.

LASSEN COUNTY—Across Long Valley Creek about 13 miles north of Doyle, timber bridge to be constructed to replace bridge recently washed out. District II. Frank George, Sacramento, $10,892; A. Soda & Son, Oakland, $12,660. Contract awarded to J. D. Proctor, Inc., Richmond, $9,952.

LOS ANGELES COUNTY—Across Los Angeles River and the tracks of the Southern Pacific R. R. and the Los Angeles Railway at Figueroa Street in the city of Los Angeles, a portion of the superstructure of a bridge to be constructed. District VII, Route 165, Section L. A. Robert R. Hensler, North Hollywood, $17,610; E. G. Perham, Los Angeles, $18,610; The Contracting Engineers Co., Los Angeles, $19,280; Oberg Bros., Inglewood, $20,270; Bonadiman-McCain, Inc., Los Angeles, $21,736; Carlo Bongiovanni, Hollywood, $27,634; Fred E. Potts Co., Los Angeles, $29,388. Contract awarded to United Concrete Pipe Corp., Los Angeles, $16,370.

MARIN COUNTY—Near Waldo Point, about 0.4 mile to be graded and surfaced with plant-mixed surfacing on imported rock base and a reinforced concrete grade separation structure to be constructed. District IV, Route 1, Section D. A. G. Raisch, San Francisco, $84,947; Heafey-Moore Co., Oakland, $86,520; Macco Construction Co., Oakland, $89,483; Guy F. Atkinson Co., San Francisco, $98,272; Parish Bros., Sacramento, $99,280; Louis Biasotti & Son, Stockton, $99,924; Contract awarded to N. M. Ball Sons, Berkeley, $82,912.

MARIN, NAPA AND SONOMA COUNTIES—Diesel oil to be applied to roadside vegetation for a length of about 113.1 miles. District IV. Sheldon Oil Co., Suisun, $4,050. Close Building Supply, Hayward, $4,500. Contract awarded to Pacific Truck Service, Inc., San Jose, $4,035.

SACRAMENTO COUNTY—Between State Highway Route 3 and Camp Kohler, about 0.6 mile to be graded and surfaced with plant-mixed surfacing. District III. McGillivray Construction Co., Sacramento, $22,822; J. R. Reeves, Sacramento, $23,544; M. E. Whitney, Bakersfield, $23,576; Hemstreet & Bell, Marysville, $25,494. Contract awarded to A. Teichert & Son, Inc., Sacramento, $21,398.

SAN DIEGO COUNTY—For constructing traffic signals on Route 2 at Juniper Street in San Diego. District XI. C. D. Draucker Co., Los Angeles, $3,000. Contract awarded to Econolite Corporation, Los Angeles, $1,275.

SHASTA COUNTY—Between west entrance Redding Airdrome and Route 20, about 3.9 miles to be graded and surfaced with plant-mixed surfacing. District II. A. R. McEwen, Sacramento, $78,659; Hemstreet & Bell, Marysville, $78,884; M. W. Stanfield, Los Angeles, $82,850; Brown, Doko & Baun, Pismo Beach, $87,268; A. Teichert & Son, Inc., Sacramento, $89,914; J. P. Brennan, Redding, $126,976. Contract awarded to M. J. Ruddy & Son, Modesto, $77,972.

SOLANO, CALAVERAS, SAN JOAQUIN, AMADOR, MERCED, MARIPOSA AND STANISLAUS—Oiling roadside vegetation at various locations in District . Awarded to Sheldon Oil Co., Suisun, $4,556.

A man is not paid for having brains, but for using them.

Grapevine Canyon Grade Divided Highway Widened

(Continued from page 3)

spillway at the lower end was constructed. Some 3,800 cubic yards of reinforced concrete were used and provided a channel capable of handling 3,000 second-feet of water. It has been said by persons dwelling on the hill above the highway, that since the buttress has been completed, ground vibrations previously felt when heavy trucks pass on the highway, have ceased.

FLUME CARRIES CREEK

In addition to the buttress fill there were 428,000 cubic yards of roadway excavation. A concrete flume constructed over the buttress placed in the canyon along the highway, to carry Grapevine Creek, required 3,800 cubic yards of reinforced concrete. The contract price for all work under the first contract was $385,638. Griffith Company was the contractor.

The same contractor was the successful bidder for the pavement widening on Grapevine Grade. This job provided for the widening to 50 feet of the exising portland cement concrete pavement, plant-mix shoulders and the installation of over 20,000 lineal feet of metal plate road divider. The contract price on the second contract was $384,951.

Paving work and the installation of the road divider was carried on under the supervision of Associate Engineer Fred W. Howard, with W. E. Bertken acting as Resident Engineer.

Bradley-King City Highway

(Continued from page 5)

surfacing on the slope was then trimmed to a uniform height with the blade.

EARTH BERMS

By reversing the device on the moldboard it was then in position to be used in shaping berms and consisted of a shape of the berm cross-section, adjustable for height, and tapering from a larger opening at the front to a smaller one at the rear.

The resident engineers for the State were F. R. Pracht and V. E. Pearson.

State of California
EARL WARREN, Governor

Department of Public Works
Headquarters: Public Works Building, Twelfth and N Streets, Sacramento

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A. H. HENDERSON, Assistant Director

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