CALIFORNIA HIGHWAYS AND PUBLIC WORKS

JUNE 1941

NEW BRIDGE ACROSS KLAMATH RIVER AT ORLEANS, HUMBOLDT COUNTY, ON STATE SIGN ROUTE 96 THAT WON FIRST PRIZE IN NATIONAL DESIGN COMPETITION

(SEE ARTICLE IN THIS ISSUE)

$22,053,979 Total Revenues of Bay Bridge in Fifty-one Months. Total Traffic 47,950,012 Vehicles

STATE ownership and operation of the San Francisco-Oakland Bay Bridge has proved highly successful in every way as a public service undertaking, as is well evidenced by the current report of independent accountants for the California Toll Bridge Authority covering the total traffic and revenues of the bridge from its opening up to February 28, 1941. The report shows total revenues of more than $22,000,000 with an excess revenue of over $10,000,000 above expenses including bond interest despite five successive toll reductions.

Another outstanding exemplification of what State operation of toll bridges can accomplish is the reduction of rates on the Carquinez and Antioch spans purchased by the State last September.

TOLL REDUCTIONS

When the Bay Bridge was opened to traffic on November 12, 1936, the toll for an automobile with driver and four passengers was set at 65 cents. Today the toll is 25 cents.

When the State acquired the Carquinez Bridge the charge for an automobile was 65 cents and 10 cents for each additional passenger. Today the rate is 30 cents per car with no charge for extra passengers.

Truck and bus tolls on all three State-owned bridges have been substantially reduced. In the case of the Carquinez and Antioch spans, truck charges have been lowered approximately 12 per cent; passenger tolls by more than 50 per cent.

The records made by the three bridges are unimpeachable proof of what public ownership can accomplish.

BENEFITS TO PUBLIC

The report of the accountants shows that the total revenues of the San Francisco-Oakland Bay Bridge from the date of its opening to February 28, 1941, amounted to $22,053,979.11, paid principally by motorists.

San Francisco-Oakland Bay Bridge Statistics

Bridge Opened	November 12, 1936
Revenues to February 28, 1941	$22,053,979.11
Expenses Other Than Bond Interest	$142,956.96
Interest on Bonds	$11,430,623.06
Excess of Revenues Over Expenses	$10,480,399.09
Total Bond Retirements	$5,800,000.00
Bonds Outstanding	$67,200,000.00
Bonds Originally Issued	$73,000,000.00
Balance on Hand Cash and U. S. Bonds	$4,790,382.01
Motor Vehicle Traffic	47,950,012
Vehicular Toll Revenues	$20,834,825.00
Railway Passengers Carried	40,938,794
Revenue From Railways	$1,023,470.23
Total Vehicular and Railway Revenues	$21,858,295.23
Other Income (Rents, Interests on Deposits, etc.)	$195,683.88

TOLL REDUCTIONS

February 1, 1937	From 65¢ to 50¢
June 15, 1939	From 50¢ to 40¢
January 1, 1940	From 40¢ to 35¢
May 25, 1940	From 35¢ to 30¢
June 24, 1940	From 30¢ to 25¢

Out of these revenues, expenses other than bond interest totaled $142,956.96. Interest on bonds amounted to $11,430,623.06, leaving a balance of $10,480,399.09, representing excess of revenues over expenses.

This showing was made in spite of four successive toll reductions which were put into effect within a 12-month period by the California Toll Bridge Authority in line with the policy of Governor Culbert L. Olson to let the motoring public reap the fullest possible benefits from State ownership and operation of the span. In reducing automobile and truck tolls on the Carquinez and Antioch bridges the Governor and the Toll Bridge Authority have been motivated by the same principle.

The goal of a 25-cent passenger automobile toll on the Bay Bridge was attained on June 24, 1940. The first reduction was on February 1, 1937, from 65 cents to 50 cents. The second, which was effected by the present Toll Bridge Authority, was on June 15, 1939, from 50 cents to 40 cents; the third on January 1, 1940, from 40 cents to 35 cents; the fourth on May 25, 1940, from 35 cents to 30 cents, and the fifth to 25 cents on June 24, 1940.

INTEREST RATE REDUCED

The reductions from 50 cents down to 25 cents were greatly aided by negotiations in Washington between Director of Public Works Frank W. Clark and attorneys representing the Toll Bridge Authority and Jesse Jones, chairman of the Reconstruction Finance Corporation, which originally loaned the money for the Bay Bridge. These negotiations were concluded in May, 1939, with the result that the rate of interest on the $40,000,000 San Francisco-Oakland Toll Bridge Sinking Fund revenue bonds was reduced from $4\frac{1}{4}$ to 4 per cent. The Toll Bridge Authority was further able to secure a concession from the R. F. C. under which the State was allowed $1,065,000 credit on its share of the sale price premium on the sale of the

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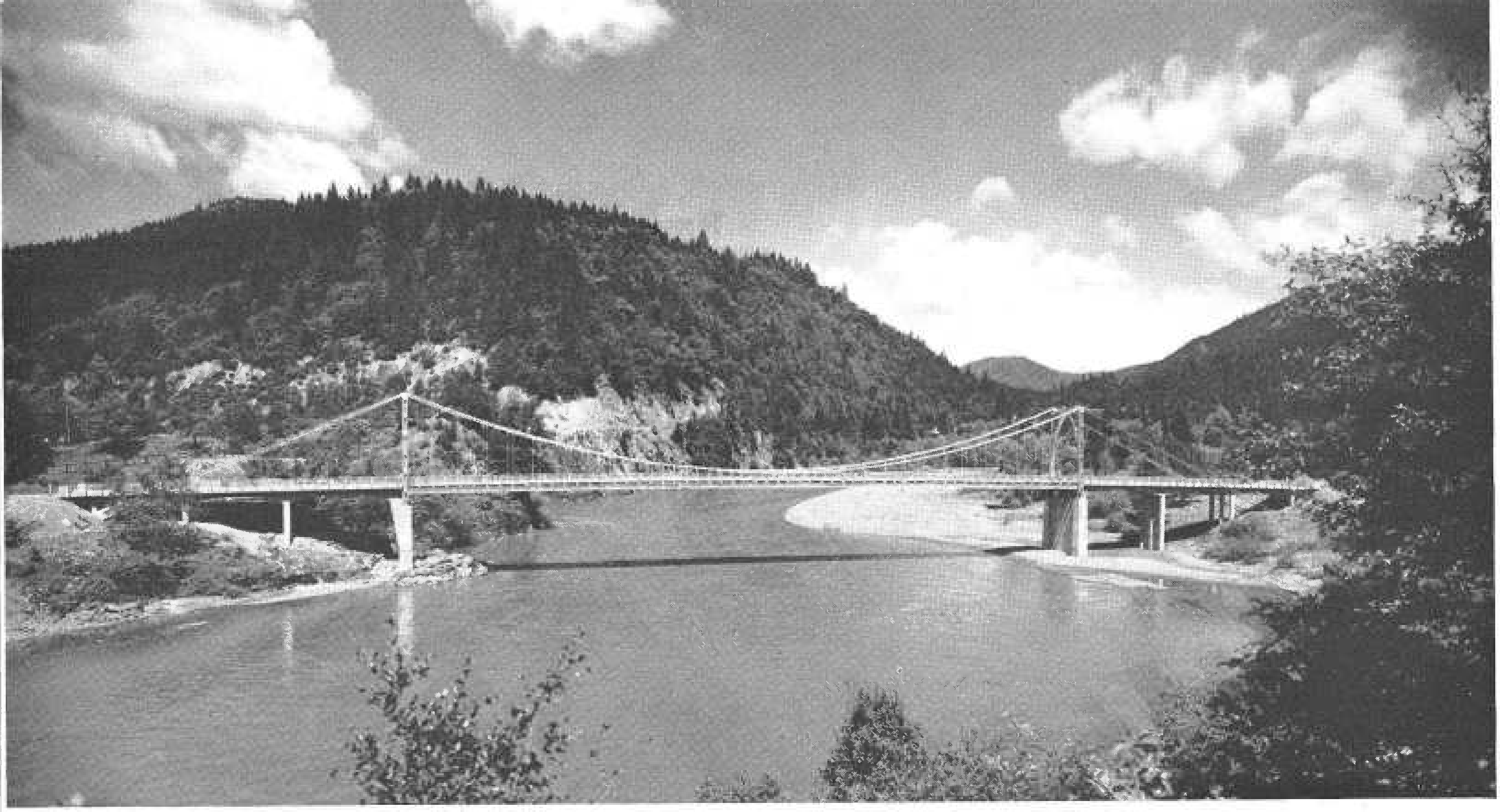

Bridge across Klamath River winner of national award for most beautiful steel bridge costing less than $250,000 built in 1940

Orleans Bridge Wins First Prize in National Design Competition

THE Division of Highways learned on May 22d that the new suspension bridge over the Klamath River at Orleans had received the annual award of the American Institute of Steel Construction for the most beautiful steel bridge in Class "C." All steel bridges costing less than $250,000 and completed and opened to traffic during the year 1940 were eligible to compete for this award.

The structure is located on the Klamath River Road, which is State Sign Route No. 96, and it was built to replace an old suspension span with timber floor and towers that had reached a dangerous condition because of decay. This old structure had an eight-foot roadway width that required all drivers to wait at the end of the bridge until an oncoming driver had crossed.

Because the low water season in this region is very short and the stream is subject to sudden rises, it was considered necessary to avoid constructing falsework in the channel. This decision was further supported by the fact that the falsework piles could not be driven far enough in the stream bed to withstand high water.

It was decided therefore to construct a bridge of either the suspension or cantilever type, and comparative estimates indicated that the former would be the more economical.

The travel over this road is largely recreational and it passes through a rugged, tree-covered country. The beauty of the landscape called for a suitable structure, and that such has been attained is proved by the award.

The suspended span of the new bridge is 360 feet long and there are 135 feet of reinforced concrete girder spans on the west and 170 feet on the east. Although traffic on this highway is comparatively light, it is subject to occasional very heavy loads of machinery, lumber, etc., so it was considered advisable to design it for the heaviest design loading used by the Highway Department. This loading is known as the H20-S12 and consists of 20-ton truck followed by 12-ton trailer axle.

Each of the main cables consists of four 3-inch 7/37 wire ropes arranged in an open group. These cables were designed for a dead load of 3,475 pounds per lineal foot of bridge and a uniform live load of 45 pounds per square foot of roadway. They were prestressed for one hour at 200 tons, then measured and marked at 100 tons, which load corresponded to approximately the dead load stress in the cables. The positions of the tower saddles and the suspender cables were painted on the main cables to facilitate erection, and a longitudinal stripe was painted on them in their prestressed condition to insure that there would be no untwisting of the cables when erected. All ropes, both main cables and suspenders, were socketed to their prestressed length in the shop, and no adjustment was required for erection.

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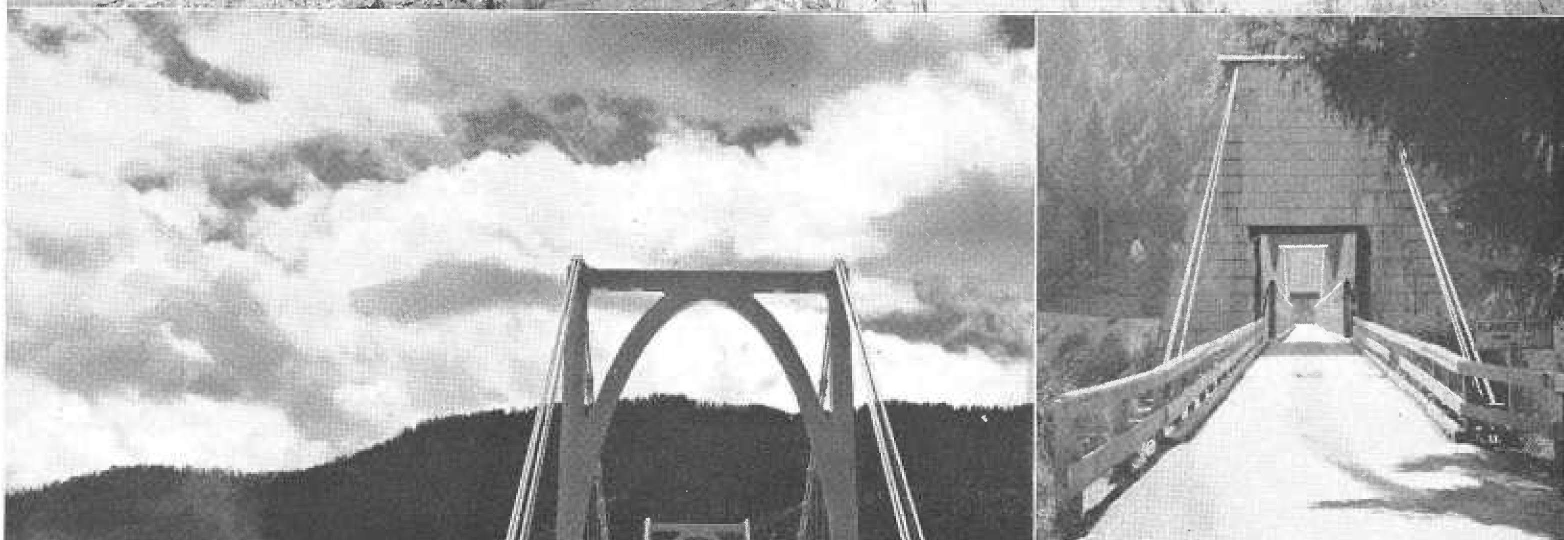

Construction features of the Orleans bridge are the steel towers, each consisting of two columns with elliptically shaped cross braces forming an arch over the roadway, and the prestressed open group cables. Inset shows the old, narrow bridge with timber floor and towers that permitted only one-way traffic

CALIFORNIA HIGHWAYS AND PUBLIC WORKS

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Madera-Friant Cooperative Project Completed and Officially Dedicated

THE hazardous rolling grade on State Highway Route 126 in Madera County extending easterly from Madera on that city's approach road to Friant Dam and Yosemite Valley has been eliminated. The series of blind vertical curves on the old road have been replaced by a modern highway with 36-foot roadway and long, 2,300-foot sight distances.

Over six miles of highway were reconstructed as a Works Progress Administration project sponsored by the State Division of Highways and the State Relief Administration and participated in to a considerable extent by the county board of supervisors.

The completed project, which is a fine example of cooperation of various agencies participating on a single highway undertaking, was officially dedicated on Sunday morning, May 25. Dedicatory ceremonies were held on Cottonwood Creek bridge eight miles east of Madera and ten miles from Friant Dam, one of the major units of the Central Valley Project.

Federal, State, county and municipal officials took part in the celebration. A short program of speechmaking preceded a luncheon served at Bass Lake under the auspices of the Madera County Chamber of Commerce, which arranged for the dedication.

Representing Director of Public Works Frank W. Clark, whose official duties prevented him from attending, Deputy Director Morgan Keaton headed the list of speakers.

"Not only will this highway become a main thoroughfare to and from the Friant Dam unit of the great Central Valley Project," Mr. Keaton said, "but there will be attracted to this route a considerable portion of the recreational traffic to Yosemite, the Big Trees, and the many beauty spots in the High Sierras which lie to the north and east of this section of California."

Short talks were made by Highway Commissioner Iener Nielsen of Fresno; Ralph G. Wadsworth, Deputy Administrator of WPA, San Francisco; Ray Adell, Chairman of the Board of Supervisors of Madera; J. W. Halleen, California State Chamber of Commerce; and Mrs. Charles Moses, who represented Governor Culbert L. Olson and who cut the ribbon stretched across the new highway at the conclusion of the speechmaking.

WPA SUPPLIED LABOR

W. S. Hillis, Chairman of Madera County Chamber of Commerce Road Committee, presided at the dedication and introduced the speakers.

Plans, specifications and all other engineering and inspection work on the project were furnished by the Division of Highways. The Works Progress Administration furnished the labor and a portion of the equipment and nonlabor items.

For men taken off of relief work on this project the State Relief Administration contributed at the rate of $6 per man month. With 150 to 300 men of this status the SRA's contribution made available a considerable sum, for the purchase of materials and supplies as well as for the rental of equipment.

Appreciating the importance of this road to the community, every supervisor in Madera County loaned equipment fully supplied and operated, to the job. They furnished

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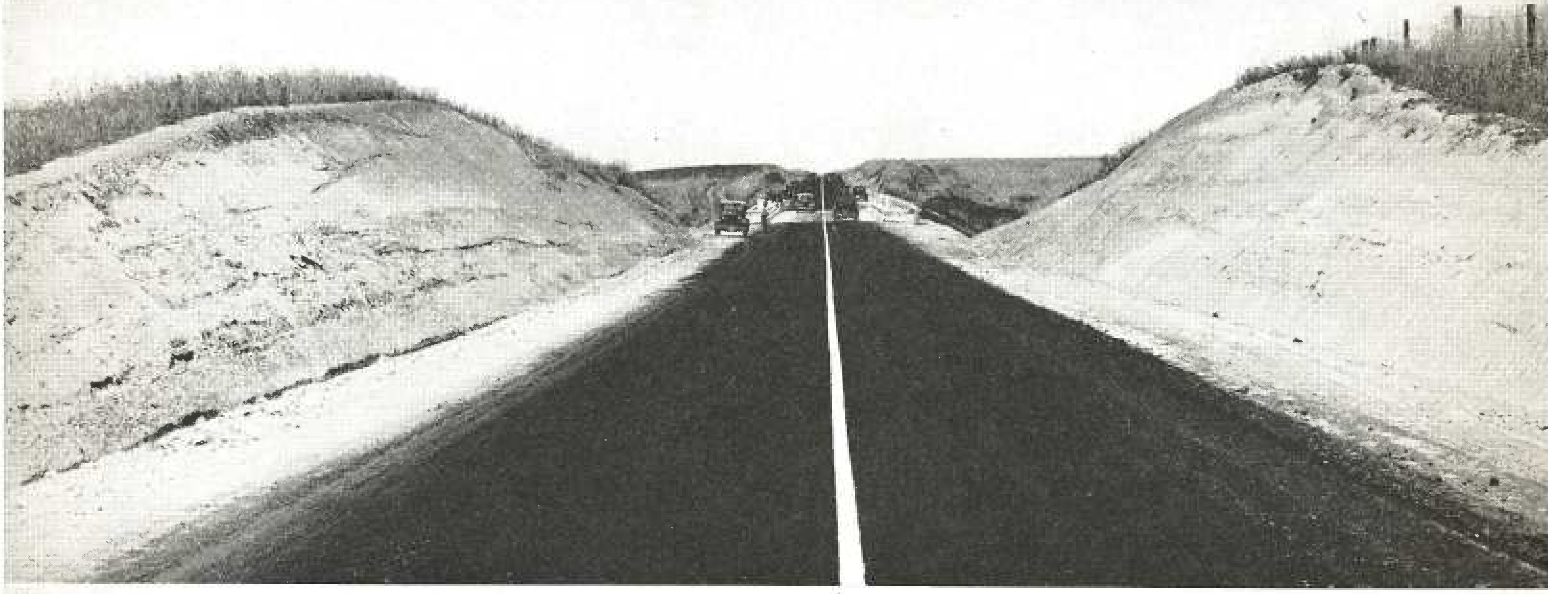
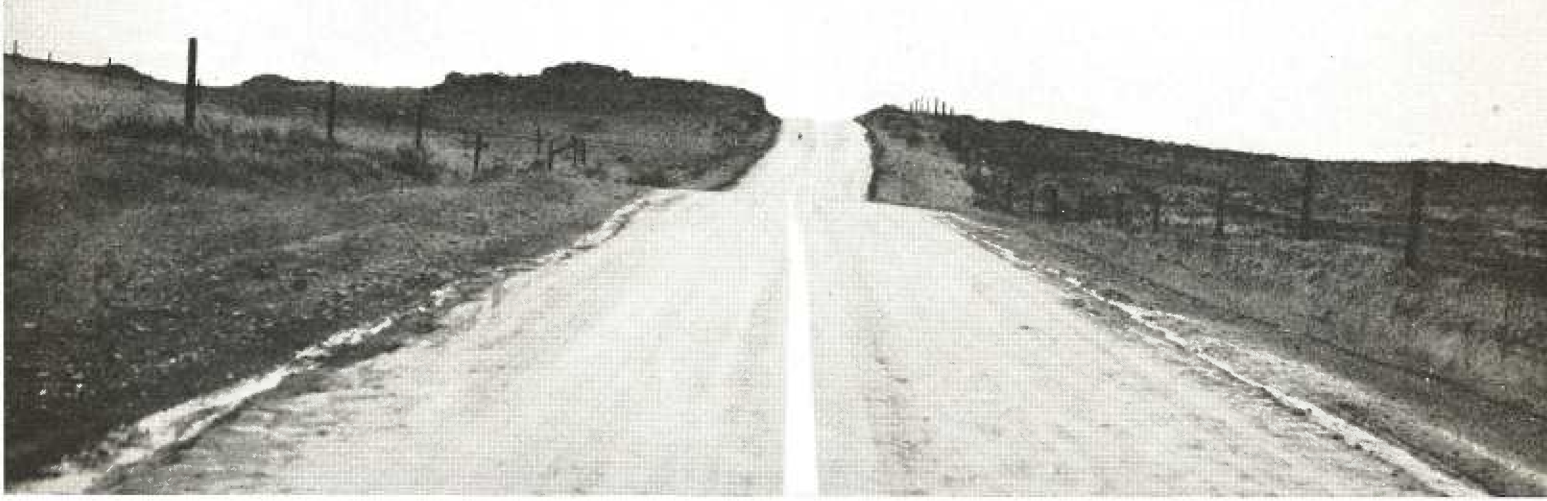
Complying with W.P.A. regulations dirt was moved by wagon trains filled by hand labor and hauled by tractor





At top—Cottonwood Creek bridge on new Madera-Friant highway. Center—Long, straight stretches with perfect visibility are typical of the new highway. At bottom—Narrow road before reconstruction was a series of sharp vertical curves

Development of Bridges to Meet State Highway Traffic Demands

By STEWART MITCHELL, Senior Bridge Engineer

WHY bridges?

For crossing rivers is the most obvious answer. Bridges are still needed for this time-honored purpose but the use of structures has been extended so that they now aid the engineer in surmounting many other obstacles that he encounters in highway construction. And along with more extensive uses we find that the conditions to which structures must be adapted have become exceedingly complex.

In moving himself and his belongings from place to place, man always has been faced with the necessity of overcoming obstacles presented by the terrain; obstacles that are often aided and abetted by the elements. The passage of large rivers has ever been one of his most serious problems and we find mention of bridges in our earliest records. Every schoolboy knows that some bridge in the days of Rome was defended single-handed against her enemies by a lad named Horatius; and London Bridge, the Brooklyn Bridge and lately our own San Francisco Bay Bridges are familiar milestones in bridge history.

INNUMERABLE MINOR BRIDGES

Of course, large structures like the Bay Bridges are the prima-donnas that can hold the spotlight. Wherever they choose to stand, traffic is led to their portals by the most convenient and expeditious method that can be found. However, let us think of the multitude of humble structures that cross innumerable creeks, ravines, arroyos, washes, or what have you—obstacles to be taken in stride by the smooth-curving, high-powered highways that today carry automobile traffic with the minimum of inconvenience over endless miles. We must also consider prosaic structures such as those usually found in more populous areas helping to separate streams of cross traffic and railroad grade crossings.

Now, while any one of these relatively minor structures can produce an engineering headache as well as can the construction of a large one, in the aggregate they present just as serious an economic headache as the most monumental single structure ever built. Undoubtedly they are lacking in news appeal but they are not entirely devoid of glamour. They serve to carry precious lives around dizzy precipices with safety as well as to substitute for a lowly dirt fill when the terrain can not be trusted to carry a heavier load.

The part that bridges have taken in the development of highway traffic is an interesting part of California history. Within the relatively short period which it covers, rapidly changing economic conditions together with constantly accelerated improvement in means of transportation and in methods of highway construction, present a kaleidoscopic picture. It can only be touched on in the space allotted here.

EARLY DAY STRUCTURES

First we picture the days of the pioneer and the Spanish rancho. Then came the gold mining era which, in time, merged with a great industrial and intensively agricultural development to form the political and economic body that is California today. Modes of travel were first the ox or mule team and the Conestoga wagon of the emigrant, then the Concord stage coaches and long-drawn-out teams straining ahead of heavily loaded freight wagons. The coming of the railroads in the '70s relegated roads to a secondary role and retarded their further growth until the advent of the auto, development of which is largely a matter of the past two decades.

The highway locator of the early '50s sought for what he called good "natural" road since funds available for construction were pitifully small viewed in the light of present day expenditures. They were only sufficient to permit improvement of some of the worst places by removal of rocks and trees and perhaps to level off a few places where side hills could not be well avoided. Streams usually had to be forded. Then gold brought increased wealth and more people and it became necessary, as well as profitable, to spend more for building and maintaining roads and bridges. The usual method of financing such works was through private capital which was reimbursed through the right to collect tolls, and it is stated that the first bridge over the South Fork of the American River at Coloma cost $20,000 and paid for itself in 90 days. That apparently was the heyday of "rugged invididualism."

FIRST STATE BUREAU

With the completion of the Central Pacific Railroad across the Sierras and a decline in the gold mining orgy, there began a "dark age" of road building whose renaissance was inaugurated by the formation of a State "Bureau of Highways" in 1895. The bureau, which existed from 1895 to 1897, collected data and made what are now seen to be some very intelligent suggestions as to a future road program in this State.

Nothing happened except that certain existing county roads and some new roads in the mountainous regions, where building and maintaining roads was considered to be beyond the financial ability of the counties, were put under the jurisdiction of the State by legislative acts. Appropriations for work on these roads were small, and the magnitude of the bridge construction carried on at the time may be judged from the following extract from the report of the Lake Tahoe Wagon Road Commissioner in 1902: (This road reached from Placerville to the State line.)

"The Legislature of the State, at the regular session in 1901, appro-

A multi-purpose structure involving problems of horizontal and vertical clearance, super elevation and intricate construction

priated the sum of $9,200 for the salary of the commissioner and maintenance of the highway for the two years beginning July 1, 1901.

''By exercising the strictest of economy, the appropriation is sufficient to keep the road in repair until the end of the fiscal year, and as a result of the expenditures so far made, I have been able to keep the road in good shape, while in addition I have constructed **four new bridges, 27 stone culverts, and repaired a number of retaining walls.**

''I was also compelled to expend nearly $500 of this appropriation in order to complete the stone bridge at Riverton.

''Some of the present structures in the shape of bridges are very old, and I earnestly solicit the consideration of the proper authorities to the necessity of granting a somewhat larger appropriation at the next session of the Legislature for the purpose of improvement along the line indicated.''

Under the Savage Act of 1907, several counties bonded themselves for road improvement and in 1910 the first bond issue amounting to $18,000,000 was voted for the construction of a State highway system. The automobile was then getting to be a factor in ''good roads'' movements and those events may be said to mark the beginning of modern highway development in California.

At the start, automobiles were low in power and few in number. They had great difficulty in climbing the hills found on the roads of that era and their maximum speed was unimpressive under the best of conditions. In consequence, highway locations were predicated on obtaining a favorable gradient, not to exceed a very modest maximum, and were satisfied with comparatively low standards of alignment and sight distance.

In building a bridge, the most favorable and shortest crossing in the immediate vicinity was chosen, with practical assurance that the road could be curved and twisted to meet it.

SUBSIDIARY TO ROAD

However, automotive equipment increased in power and number so there was a drift toward high-speed alignment requiring long sight distance and easy curves, even if somewhat steeper grades were required to get it. The public's growing demands in this respect, and its willingness to pay the cost, has resulted in standards of highway location that relegate bridges and other structures to a subsidiary role. They have become but parts of the roadbed—admittedly very expensive parts.

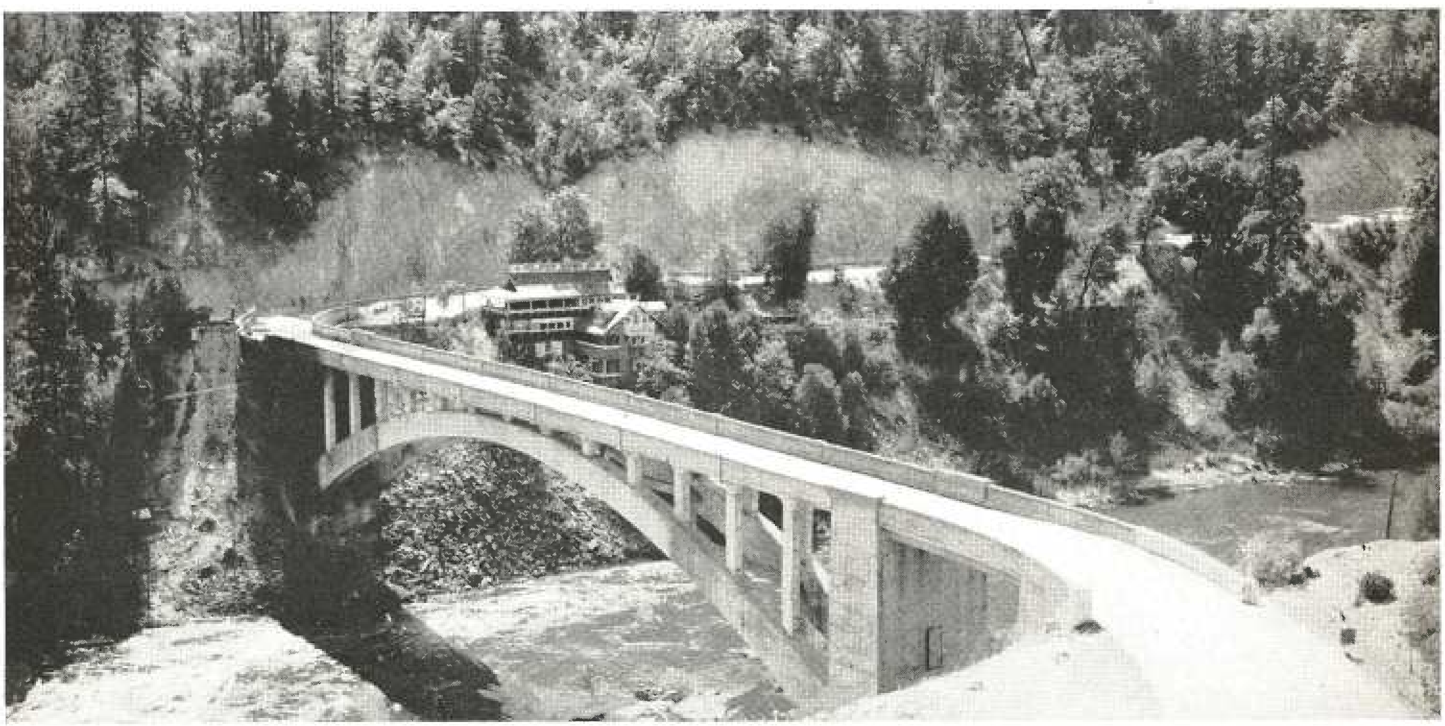
The ''cost per mile'' for structures on the highways seems to increase as time goes on. During the days of the Spanish occupation, traffic up the San Joaquin Valley followed the barren foothills of the Coast Range. Here crossing the dry stream beds of the small arroyos offered no obstacles to travelers of that day except for very short and infrequent periods during winter storms. The emigrant after crossing the high passes in the Sierras followed the high snowy ridges wherever it was possible on his way down to the valley. He took a chance on having to travel through snow rather than face greater difficulties connected with the crossing of canyons and streams that go with following the lower country along the rivers. Likewise, the old ''Stockton-Los Angeles Road,'' a part of which was used by the Butterfield Stages, followed the base of the hills along the east side of the San Joaquin Valley, crossing the large Sierran streams before they spread out into the numerous channels and sloughs of the valley floor. (Note: For those geographically inclined, this road is now marked by the cities of Porterville and Reedley, the site of old Millerton soon to find a watery grave behind Friant Dam, and the Merced-Mariposa County line.)

A bridge on high speed alignment at a favorable location but nevertheless it had to be skewed and super-elevated

The growth of farming and the building of railroads made it necessary to build roads across the valley plain. There was also a demand for more nearly ''all-year'' roads, all of which meant more bridges—or ferries on the larger streams serving until a bridge could be built. At first the bridges were built short and with inexpensive foundations, limited only by the builder's willingness to gamble on the probable high water of the next winter or two. He built the cheapest bridge that he felt had a chance of lasting long enough to return him his investment, and bring him a maximum of profit from tolls in proportion to its cost. The economic principles followed in that day were simple and concerned themselves only with the crude ideas of out-of-pocket cost and probable cash return.

Let us skip over to the revival of highway building which, as already mentioned, is associated with the growing use of automobiles. At first, the only noticeable difference was in the building of a better class of bridges than heretofore, and a more comprehensive use of smaller drainage structures like pipes and box culverts.

There began to be built modest structures separating the grades of highways and railroad tracks, cross-



An older bridge located so as to obtain the most economical crossing but with little regard for highway alignment

A "dry land" bridge on a summit used in place of a more expensive fill with retaining walls

ing at right angles and at physically favorable locations only. Engineers then grew bolder and in order to preserve the desired alignment, designed their structures to cross the rivers and railroads at a considerable angle, or even on a curve! Now the requirements of modern stream-lined location are likely to demand such a sharp angle of crossing that the bridge engineer is hard put to decide when, if ever, he has reached the opposite bank and can stop his bridge. Furthermore it is now often necessary to locate a crossing where the terrain is less favorable or the foundation material is less solid than it is at some other point nearby.

MODERN EXACTING REQUIREMENTS

As roadways grow wider, so must the structures be widened or duplicated. To get better alignment it may be necessary to cross over a stream and back again when there is better ground on the opposite side, or side-hill viaducts may be built to get by a stretch of rugged terrain. In the heavily populated areas, highway separations, with necessary provision for traffic interchange, are needed more and more. All of this tends to sky-rocket the cost of structures in proportion to the mileage of highways.

The more exacting requirements of modern highway construction have brought about many structural and economic problems which were of negligible importance when less pretentious standards were in vogue. In order to fit the smooth and easy riding roadways it is often necessary to design structures all or partly on curves with the floor tipped to conform with the complicated requirements of super-elevation.

Rigid requirements may fix the grade of the roadway and require a structure with a minimum depth of slab and girders in order to provide proper stream, railroad or roadway clearance. Bridge designers have had to resort to many ingenious schemes for doing this in a way that would not overstep the rules of good engineering practice. A little thing like a $\frac{1}{8}''$ sag in spans repeated with sufficient regularity will make a floor rough riding at certain speeds and contrary to common opinion, structures are not the rigid ''immovable bodies'' they may seem to be. Warping, shrinkage and temperature can progressively alter their shape to a noticeable degree, whether of steel, concrete or wood.

DIFFICULT PROBLEMS

Probably the most difficult problem is that of unequal settlement of the structure itself, or differential settlement between the structure and the adjacent road. This is particularly serious because of the deep cuts and high fills that are now common. Fills at the end of a bridge or over culverts can be so constructed, through present day techniques, that they are thoroughly compacted and stable. It is Mother Earth beneath the fill that is the problem child.

The materials composing a large part of California are such that settlement or movement under the weight of a high fill is considerable, and if it be moist clayey material, this settling may be a matter of months or years. The various detailed problems that arise because of this are too numerous and involved to go into here. They can be made the basis of an interesting story by themselves.

If there is a moral to this story, it is that bridges and the adjoining road can no longer be considered as separate structures. They are so intimately related that poor designing of the combination can nullify the best design practice applied to each of them separately. The only answer is proper understanding of each other's problems by the bridge and highway engineers and complete cooperation in solving them.

Doctor: "Humph! I can't quite diagnose your case. I think it's drink."

Patient: "Oh, I see. Now, look here, doctor. Would you like me to come again when you're sober?"

Gross Weight Provisions of Vehicle Code as Revised by Legislature

THE Legislature passed and Governor Olson signed Assembly Bill No. 1268 which revises the provisions of the Motor Vehicle Code regulating the gross weight of vehicles. The purposes of the revisions are to regulate the weight of heavy vehicles in a manner that will conform to the carrying capacity of our highway bridges.

The previous restrictions of the Vehicle Code were formulated and modified from time to time without regard to the structural strength of the bridges, and were fundamentally wrong in that the gross load which any given type of vehicle or vehicle combination could carry, was the same regardless of how concentrated were the axle loads.

It did restrict the allowable gross load on single vehicles to a reasonable degree, but it permitted loads of close coupled combinations that stressed the structural members of the bridges far above that contemplated in their design.

ENDS VEXATIOUS QUESTION

The adoption of the revised weight limit provisions ends a long series of studies and conferences involving the Department of Public Works, manufacturers, truck operators and the Highway Patrol. It is hoped that it will end a vexatious question and set a standard that the department and vehicle manufacturers can hold and build to for the future.

Back in 1932 the American Association of State Highway Officials adopted a recommended uniform code for regulating the maximum weight and size of highway vehicles. In this code the weight was governed by a maximum axle load and a formula which was W = c (L plus 40) where:

- W = total gross weight, with load, in pounds;
- c = a coefficient to be determined by the individual States;
- L = the distance between the first and last axles of a vehicle or combination of vehicles, in feet.

They also stated that: "a value of 700 is recommended for "c" as the lowest which should be imposed, but this should not be construed as inhibiting greater values."

ENGINEERS PROPOSE CHANGE

The Association consists of State Highway Engineers of all the states, as well as representatives of the Public Roads Administration (known as the Bureau of Public Roads at that time) and the latter were largely instrumental in developing this formula.

About six years later the Western Association of State Highway Engineers, comprising highway officials of the 11 western states and of the Public Roads Administration, agreed that the value of the coefficient "c" in the formula should be 650 when applied to any and all groups of axles when the distance between the first and last axle was 18 feet or less. For greater distances between axles the coefficient should be 750.

The Division of Highways of California, after a further intensive study of the actual vehicles in use in the State, the conditions under which they had to operate and the structural strengths and service life of standard highway bridges built during the past 15 or 20 years, decided that the coefficients could be raised to 700 and 800, respectively. In doing this they had in mind a reasonable value which would protect the public investment in the bridges and highway and at the same time not depreciate unnecessarily the large investment in commercial hauling equipment.

MODIFICATIONS RECOMMENDED

Their recommendations were submitted to the Motor Vehicle Advisory Committee and, after considerable study and discussion by all the interests concerned, it was decided that some modification of the recommended restrictions would have to be made in order to amortize the investment in equipment constructed in good faith and operating in accordance with an existing law which had been in effect for many years.

A period of 10 years has been allowed for this purpose but even with these provisions, it will be necessary for some of the very short coupled combinations developed during the past year or so to reduce their loads or lengthen their axle spacings. It may be practicable to operate some of these under special permit on certain sections of the highway where there are no bridges, or only bridges of very short span, or where bridges have been designed for the heavier loadings only recently adopted by the department.

It must be noted that the revised restrictions were not necessary because of the sub-standard bridges alone. They are based on structures designed for the so-called "H-15" loading which has been used for the design of bridges throughout the United States for 20 years or more. Replacement of all "H-15" structures is impractical and it is of interest to note that the War Department has designed its equipment to conform with this standard.

MANY BRIDGES POSTED

There are many of the older bridges on the highway operating under a reduced safety factor at the present time whose service life, in consequence, is being shortened by the present allowable loads. These will get only partial relief under the new restrictions. There are other bridges posted for reduced load limits because the factor of safety has been reduced to the vanishing point under legal loads.

Unfortunately the latter must continue as posted bridges with little change in the degree of posting in most instances because the present postings were based on vehicles now in use and on a safety factor reduced considerably below that allowed in the design of new structures. The only remedy in their case is the expenditure of funds to strengthen or replace them, which, under present conditions, will be a matter of several years.

The following is a brief resumé of the new regulations and changes in the existing law:

Sections 702 and 703, which covered the gross load limitation on two-axle and three-axle vehicles, has been deleted and the weight on vehicles is to be regulated by the formulas and the maximum axle load. They are also limited by the fact that loads on a front axle can not normally exceed 9,000 pounds because of construction and steering difficulties.

Section 704, which covered the allowable load on one-axle and on one or more wheels supporting one end of an axle, has been changed to permit 18,000 pounds on one axle but only 9,500 on a wheel instead of the previous 10,000. The exemption for vehicles registered prior to January 1, 1930, which expires December 31, 1942, is left unchanged.

Section 705 has been completely revised and the following is a synopsis of the new regulations:

1. Applicable to vehicles registered on or after January 1, 1942, except as noted below, and to all vehicles, regardless of date of registration, on or after January 1, 1952.

(a) The gross weight on a vehicle, in combination or otherwise, or on any combination of vehicles shall not exceed that given by the formula,

W = 800 (L + 40)

Where, W = the gross load in pounds on the vehicle or combination.

(b) The gross weight on any group of two or more axles, whether part or all of a vehicle or combination, when the distance between first and last axle of the group is less than 18', shall not exceed that given by the formula,

W = 700 (L + 40)

Where, W = the gross load in pounds of the group of axles considered.

L = the distance in feet between the first and last axle of the group being considered.

2. Exceptions to these provisions have been made, applicable only to vehicles registered before January 1, 1942, and terminating January 1, 1952, applying only within the axle spacings given:

(a) The gross weight on a vehicle, in combination or otherwise, or on any combination of vehicles, when such vehicle or combination has a distance between its first and last axles of 25 feet or more, but not more than 45 feet, shall not exceed 68,000 pounds, *and* that given by the formula,

W = 850 (L + 40)

Where, W = the gross load in pounds on the vehicle or combination.

L = the distance in feet between the first and last axle of the vehicle or combination.

(b) The gross weight on any group of two or more axles, whether part or all of a vehicle or combination, when the distance between the first and last axle of the group considered is 14 feet or more, but is not more than 18 feet, shall not exceed that given by the formula,

W = 800 (L + 40)

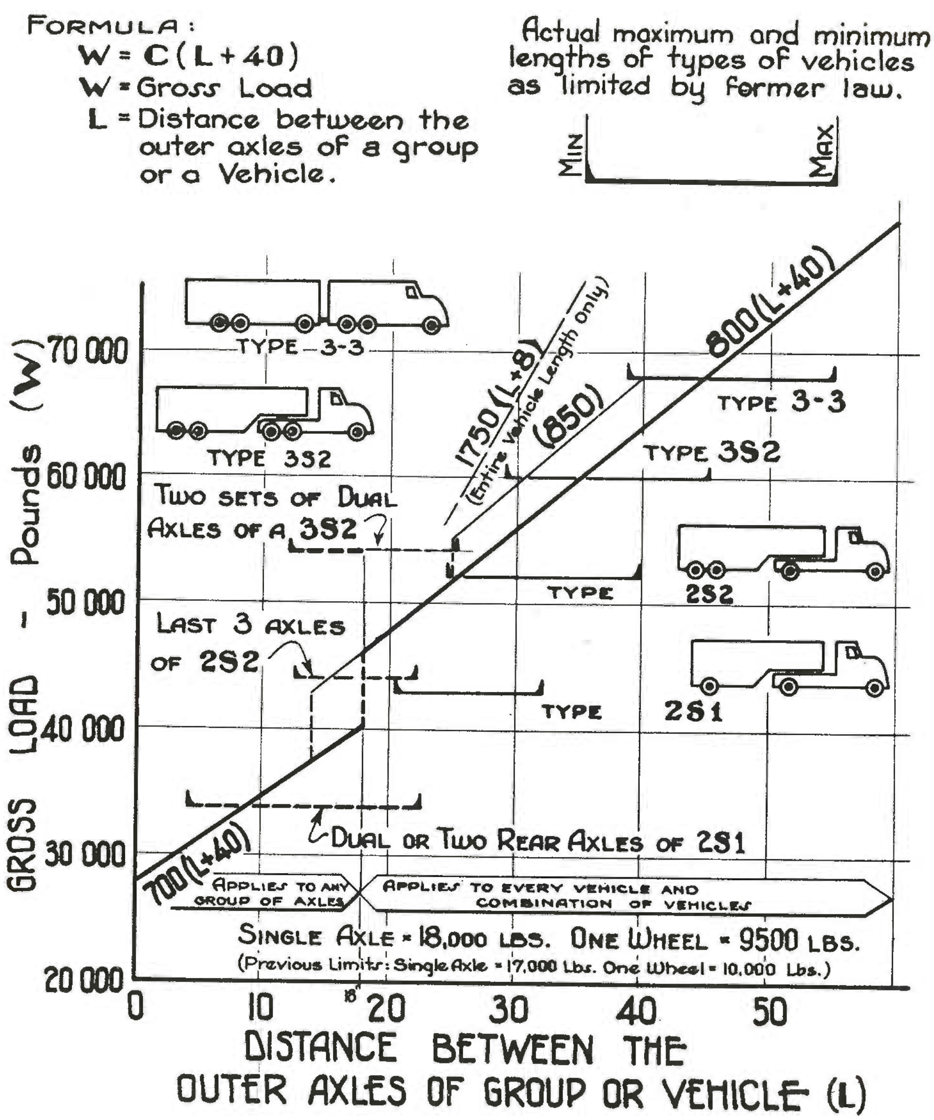
Where, W = the gross load in pounds of the groups of axles considered.

L = the distance in feet between the first and last axle of the group being considered.

It should be noted that all the provisions either of 1 or 2, and the maximum axle loads, are applied simultaneously to govern the gross weight.

The chart gives a graphical picture of the old and new load limits. The sloping lines obtained by plotting the formulas show that the gross load increases as the wheel spacing is lengthened. The horizontal lines show that the same load could be carried regardless of the axle concentrations under the old law. Vehicles with close-coupled axles represented by portions of the horizontal lines to the left of the sloping lines will have a lower maximum gross load or must lengthen their axle spacing.

ACTUAL GROSS VEHICLE LOADS PERMITTED BY THE NEW CALIFORNIA MOTOR VEHICLE CODE RESTRICTION COMPARED TO THE FORMER LIMITS



Total Revenues and Traffic of Bay Bridge During 5 Years

(Continued from page 1)

bonds to the underwriters, thereby reducing to $71,000,000 the total of outstanding bonds at that date and saving the interest on $1,500,000 of bonds to be redeemed, which was $60,000 per year.

TOTAL BOND RETIREMENTS

Since November 12, 1936, there have been retired Bay Bridge serial revenue bonds par value amounting to $1,110,000 and sinking fund bonds totaling $3,190,000. Other prior year retirements not made out of revenue funds included $300,000 of serial revenue bonds and $700,000 of sinking fund bonds retired out of Reconstruction Finance Corporation participation and $500,000 of serial revenue bonds retired out of construction funds.

Total bond retirements to February 28, 1941, were $1,910,000 of serial revenue bonds and $3,890,000 of sinking fund bonds.

The bonds outstanding as of February 28, 1941, were $31,090,000 serial revenue bonds and $36,110,000 sinking fund bonds.

Bonds originally issued were $33,000,000 serial revenue bonds and $40,000,000 sinking fund bonds, making a total of $73,000,000.

VEHICLES PAID $20,834,825

On February 28, the Bay Bridge had a balance of $4,790,382.01 representing cash on hand and investment in United States bonds.

Since November 12, 1936, a total of 47,950,012 vehicles have used the bridge. Vehicular toll revenues for that period amounted to $20,834,825. The bridge railway system carried 40,938,794 toll passengers with an accruing revenue to the bridge of $1,023,470.23, making the total of vehicular and railway revenues $21,858,295.23. Other revenues from rents, interest on reserve bank deposits and bank balances, etc., amounted to $195,683.88.

Toll traffic to the Exposition on Treasure Island and the revenue therefrom represented a total of 3,314,355 vehicles with a revenue of $1,337,500. Toll revenues exclusive of revenue from traffic to the Exposition ground was $20,520,795.

EARLIER TOLL-FREE DATE

On September 16, 1940, in answer to a wide-spread public demand, the State of California took over State ownership and operation of the Carquinez and Antioch bridges and immediately put into effect a 30-cent toll per automobile and passengers. This rate represented approximately a 50 per cent cut in tolls that had prevailed prior to State acquisition of the two spans.

So successful has been State operation of these bridges that Director Clark believes if the present traffic prevails, a further reduction in tolls may be possible. When Mr. Clark recommended the purchase of the Carquinez and Antioch bridges, he assured Governor Olson and the other members of the Toll Bridge Authority that tolls could immediately be cut in half and that the two spans would be toll-free at an earlier date than would be possible under private ownership. The franchises of the American Toll Bridge Company, which owned the bridges, would have expired in 1948.

Traffic gains on the Carquinez bridge already have justified Director Clark's prediction in this regard. His prediction has not only been justified, but it now appears that the bridges can be made not only toll-free on or before the date on which the American Toll Bridge Company franchises would have expired but in the meantime, according to Mr. Clark, the motoring public will probably have the benefit of further toll reductions.

TRUCK TOLLS REDUCED

The California Toll Bridge Authority, acting for the people, acquired the two bridges at a net cost of only $5,593,000.

Since the date of purchase, operation has been so profitable that average toll charges for trucks on both spans have been reduced approximately 12 per cent.

On May 6th, the California Toll Bridge Authority adopted a new schedule of toll charges for trucks which went into effect on May 16th. Prior to that time, the average truck toll on the Carquinez bridge was $1.54. The new average toll is $1.36. The previous average toll on the Antioch span was $1.24, the new toll is $1.10.

The toll revisions apply only to trucks and are so arranged that the greatest benefits will accrue to the operators of the lighter trucks up to about 14 tons gross weight. The Toll Bridge Authority considered a rate reduction in the lower weight brackets to be quite consistent and equitable inasmuch as prior reclassifications gave preference to the reduction of tolls on the heavier vehicles.

ANTIOCH BRIDGE DIFFERENTIAL

The revised truck rates for Antioch Bridge are slightly less than those for Carquinez Bridge. This is in recognition of the fact that the predominant truck traffic on the Antioch Bridge is agricultural and does not have the high value of the more generally commercial and industrial traffic of the Carquinez span.

The new toll schedule effects an average reduction in truck tolls of about 12 per cent below the former rates. The total decrease in toll income as a result of these reductions will not be over 3 per cent. The reductions were fully justified by the present financial condition of the Carquinez and Antioch bridges.

The rates for trucks are based on a sliding scale according to weight, with a general lower rate for larger ton loads and a larger reduction in several of the smaller ton weight classifications. Trucks and trailers, including any load up to 6,000 pounds gross weight will pay 20 cents per ton as compared with the former rates of 30 cents on Carquinez and 27 cents on Antioch for gross weights up to 4,000 pounds.

NEW RATE SCHEDULE

Additional gross weights from 6,000 to 12,000 pounds pay 20 and 17½ cents per ton compared with former rates of 25 cents and 22½ cents. Similar differentiations are made for varying increased weights throughout the list, with a minimum charge of 40 cents on both structures.

Following is the new schedule of tolls:

Class Vehicle	Rate Carquinez Bridge	Rate Antioch Bridge
1. Automobiles, ambulances, hearses, taxis	$ 0.30	$ 0.30
2. Trailers drawn by automobiles	.25	.25
3. Buses	1.00	.75
4. Motorcycles	.15	.15
5. Tricars	.20	.20
6. Commutation—for passenger automobiles only. Book to contain from 50 to 54 one-way trip tickets (depending on length of calendar month), good for the calendar month	10.75	10.75
In addition the book will contain twenty (20) provisional tickets, each good for a one-way trip upon presentation and payment of twenty-five cents (25c), provided all regular tickets have been used. Additional provisional tickets for the same calendar month will be issued upon surrender of the complete empty cover—front and back—of a $10.75 commutation book of the same month.		
7. Trucks and truck trailers, including any load. Tolls calculated to the nearest multiple of five cents, in accordance with the following rates:		
Gross weight up to 6,000 lb., per ton, at	.20	.20
Additional gross weight from 6,001 lb. to 12,000 lb., per ton, at	.20	.175
Additional gross weight from 12,001 lb. to 18,000 lb., per ton, at	.15	.125
Additional gross weight from 18,001 lb. to 24,000 lb., per ton, at	.10	.075
Additional gross weight from 24,001 lb. to 30,000 lb., per ton, at	.05	.025
Additional gross weight above 30,000 lb., per ton, at	.01	.01
Minimum charge	.40	.40
8. Vehicles requiring special permit—Gross weight, per ton	.20	.20
Minimum charge	1.00	1.00
Vehicles exceeding limits of special permit or which, through no fault of the Division of Highways, are not provided with a special permit, gross weight, per ton	.40	.40
Minimum charge	1.00	1.00
9. Vehicles not otherwise specified—Gross weight, per ton	.20	.20
Minimum charge	.40	.40

Student: Sir, are we supposed to do all the problems on the quiz?

Pro.: No, every other one is on there just to hold the paper together.

Counsel (to the police witness): "But if a man is on his hands and knees in the middle of the road, that does not prove he was drunk."

Policeman: "No, sir, it does not. But this one was trying to roll up the white line!"

George R. Winslow Retires After 29 Years in State Service

G. R. WINSLOW

AFTER twenty-nine years of service with the Division of Highways, George R. Winslow, Assistant Construction Engineer, retired on May 31st.

During all the years since he entered the field of engineering, Mr. Winslow has had only two idle weeks in a very busy life—one week in New York between jobs and one week spent in traveling from New York to California in 1912 to become associated with Austin B. Fletcher, who, in 1911, was chosen by Governor Hiram W. Johnson to head the first State Highway Department of California. Mr. Winslow's friends and colleagues feel that he has fully earned a long rest.

Executives of the Department of Public Works and the Division of Highways and fellow workers of Mr. Winslow tendered him a complimentary banquet at the Sutter Club in Sacramento on Saturday night, May 24th.

Old timers who attended the dinner included three men who were associates of Mr. Winslow in the early days of the formation of the Division of Highways. They are C. C. Carleton, first attorney for the Division and now chief attorney for the Department of Public Works; J. B. Woodson, who in 1912 was Division Engineer with headquarters in Fresno and who is now in headquarters of District IV, San Francisco, and F. G. Somner, retired, who in 1912 was Division Engineer with headquarters in Willits.

Missing was Thomas A. Bedford, retired, who was Division Engineer at Redding in those pioneer days. Mr. Bedford wrote from Rochester, Minnesota, that he was recuperating from a gall bladder operation and expressed his deep regret at being unable to attend the dinner.

Three engineers who entered the service of the Division of Highways shortly after Mr. Winslow were present. They are T. E. Stanton, Materials and Research Engineer; R. H. Stalnaker, Equipment Engineer, both of Sacramento, and L. H. Gibson, District Highway Engineer of District V, San Luis Obispo.

Born in Boston, Mass., on May 6, 1871, Mr. Winslow attended the Boston and Somerville public schools and then went to the Massachusetts Institute of Technology. One of his Pilgrim ancestors had charge of the roads at Martha's Vineyard Island. His first engineering work was as rodman on the Boston metropolitan sewer system. Later he worked in the office of McClintock & Woodfall doing general engineering work.

In 1898 he went to work for the Massachusetts Highway Commission and computed the earth quantities for the first contract let by the department. In 1906 he was employed by New York State when road construction under that State's first highway bond issue was launched.

Mr. Winslow and Mr. Fletcher had been friends in Massachusetts and when the latter became State Highway Engineer of California he sent for Mr. Winslow, appointing him Office Engineer of the Division of Highways here. The two men worked out the details of the organization of the department. Mr. Winslow was soon elevated to the post of Assistant Highway Engineer.

In 1920, Mr. Winslow was appointed District Engineer of District III, then in Sacramento, served in that capacity for four years and then was appointed Maintenance Engineer. In 1929 he became Assistant Construction Engineer, the office he held until his retirement.

Gradation of Mineral Aggregates in Dense Graded Bituminous Mixtures

By F. N. HVEEM*

THE use of mineral aggregates and soils in engineering works presents many problems due to variations in these materials. While physical and chemical differences are important, and have been much investigated, this paper will be confined to a discussion of particle size distribution of the granulometric composition and its effect on the design of mixtures.

The need for sieve analyses and grading studies is rather self-evident and the procedures involved are familiar to most engineers. However, it may be of interest to outline briefly some of the factors which lead to a study of aggregate gradations in California and to comment on some of the trends and relationships which came to light.

Mixtures of bitumen and mineral aggregate have been used since ancient times and bituminous pavements are by no means new. However, from time to time the same old combinations of asphalt and mineral aggregate have a rebirth under a new name usually with a real or implied modification in some element or proportion. When the first oil mix road in California was built in 1926 it was generally regarded as something new and distinctly different from earlier types of bituminous pavements and attracted considerable attention because it appeared at a time when the need for low cost road surfacing was becoming acute. Today this type of surface covers many miles of rural highways.

MANY DETAILED STUDIES

Wide-spread use of the oil mix type of surfacing has not been free from trouble and our present knowledge of the process has resulted from a great deal of study and research on the part of numerous highway departments. In common with other States, California is more or less continually investigating and attempting to improve design methods and testing procedures in order to assure satisfactory construction.

Since the first report by McKesson and Frickstad in 1927, detailed studies have been under way including among other things, an investigation of the possible influence of aggregate gradation. In 1929 there were a number of oil mix sections already in use ranging from good to poor. The main idea at that time was to find out why certain sections were behaving well and why others were showing considerable distress despite the fact that they had been constructed under the same specifications and apparently under the same conditions. We were well equipped for the study with a full quota of preconceived opinions and ingrained notions among which was the belief that the principles of aggregate gradation had been well expounded and we were more or less prepared to find that many of the troubles on oil mix roads could be accounted for by improper grading of the aggregate. However, when a series of samples taken from good and bad sections were analyzed, it was a little disturbing to discover that some of the most unconventional and irregular grading curves were identified with the most successful roads, while in several failures, the gradings complied very nicely with orthodox ideas as represented by Fuller's curve.

DISCOVERY UPSETS THEORIES

This discovery was something of a shock and tended to destroy faith in "well known principles." We could not escape the conclusion that a satisfactory bituminous surface could be constructed almost without regard to aggregate gradations if the bitumen content was adjusted for the particular aggregate and gradation. It was evident that this optimum bitumen content had no consistent relationship to the void volume except that it was always less than the amount required to fill the voids. Against this conclusion was the fact that virtually all construction men are concerned with "good grading" and with "poor grading" and even though it was evident that the "principles of grading" must be quite elastic, the possibility still existed that there might be an "ideal grading." Therefore, the first step was to compare gradings of various mixtures for the purpose of discovering any common properties or similarities which might exist.

In order to cover as broad a field as possible, portland cement concrete gradings were included in the study as well as gradings of bituminous mixtures. As these gradings covered a wide range of sizes, it was necessary to prepare grading charts which would permit comparison on a relative scale. This brought up the question as to the type of chart and the scales to be used.

FULLER'S CURVE

Figure No. 1 shows a simple linear scale on which Fuller's curve has been drawn. Fuller's curve as you know, has the form of an ellipse on the finer portion of the curve and has been projected either as a curve or straight line from the vertical axis of the ellipse to the upper right hand corner of the chart. The linear scale for the sieve sizes is not very satisfactory because the lines in the sand sizes are too crowded for definition. A better type of chart is the semilogarithmic type shown on Figure No. 2. The abscissa value or the screen sizes on the logarithmic chart give good definition throughout the entire range. Fuller's curve is shown transferred to the semilogarithmic chart.

The following figures, No. 3 to 9, will show the results obtained by platting the grading curves of previously existing construction which for the most part, represents gradings that resulted from long study or experimentation on the part of several individuals responsible.

* *Senior Physical Testing Engineer, Materials and Research Department, California Division of Highways.*

Fig. 1

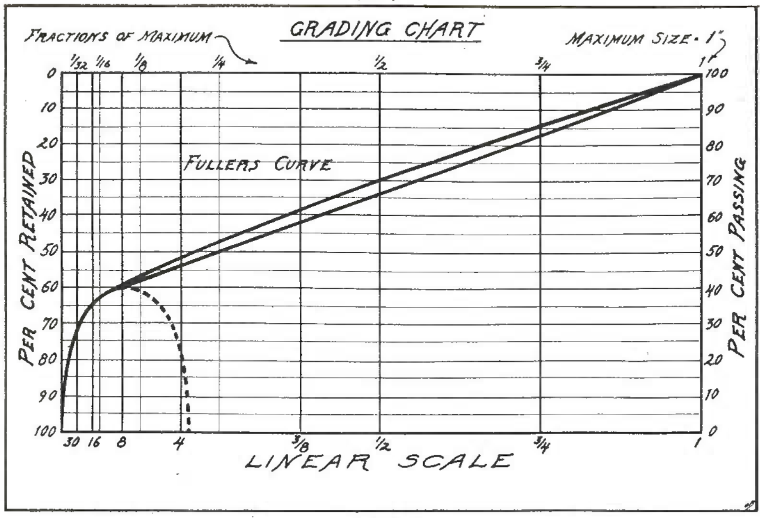


Fig. 2

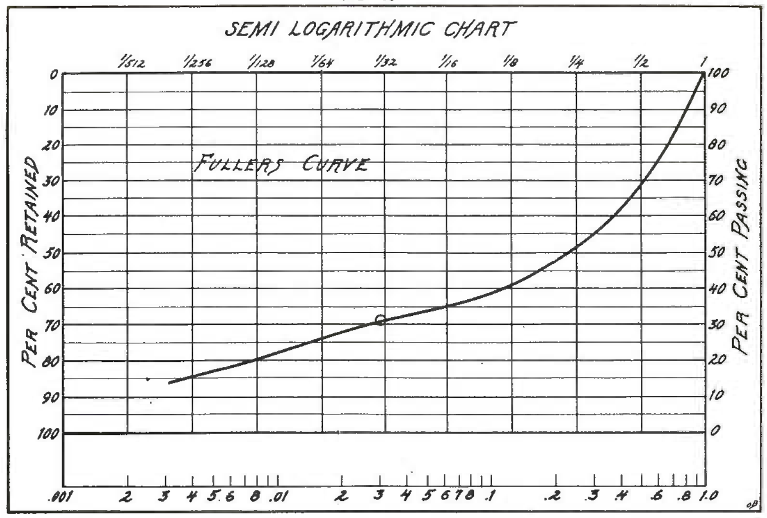


Fig. 3

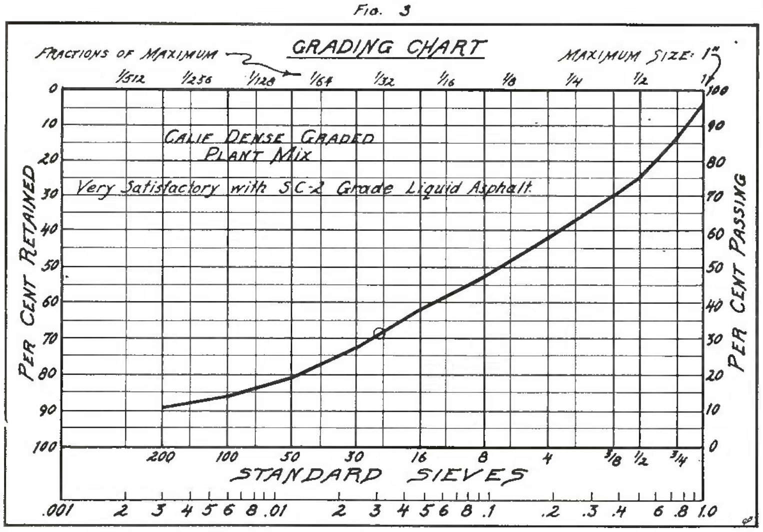


Fig. 4

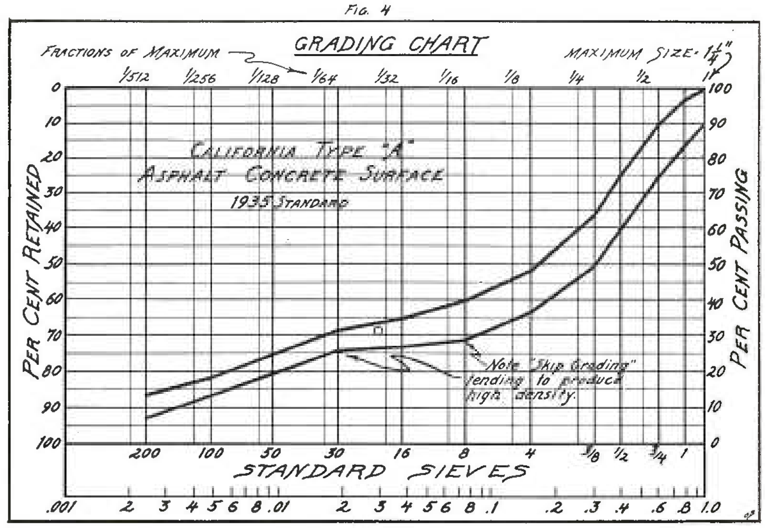


Fig. 5

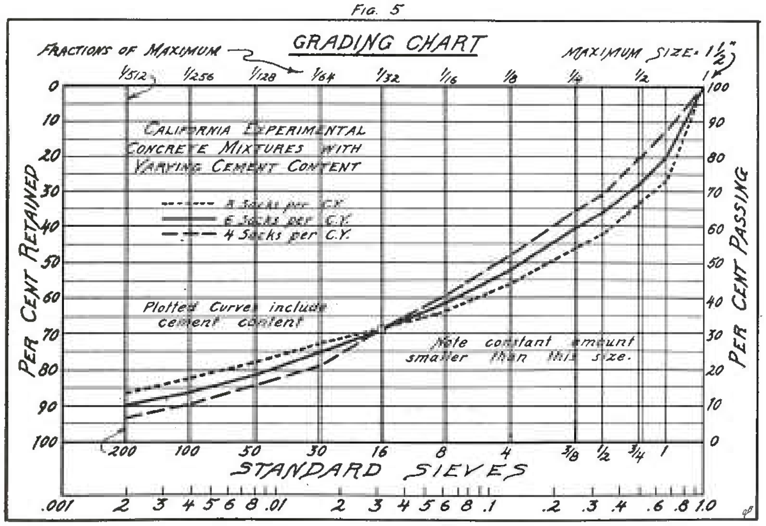


Fig. 6

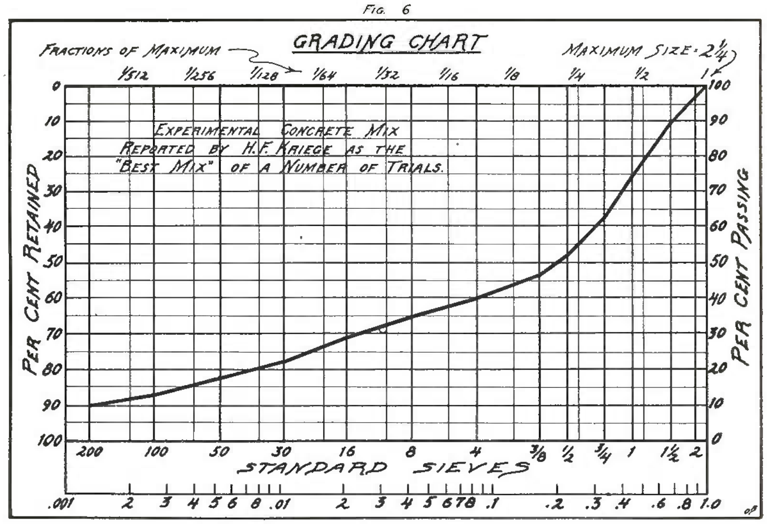


Figure No. 3 shows the grading of a plant mix surfacing in California from one of the most satisfactory jobs constructed prior to 1930. All material is smaller than 1 inch.

Figure No. 4 is Type "A" Asphaltic Concrete surface used in California for a number of years past. Material passes 1¼ inches.

Figure No. 5 is a series of three gradations of portland cement concrete using aggregate below ½ inch, with three percentages of cement. The three mixes were part of a laboratory experiment aimed at securing similar workability and water cement ratios with the varying cement contents. It should be noted that for comparison portland cement concrete mixtures are platted with the cement content included with the aggregate. You will note that the three gradations developed experimentally tend to intersect at a point represented by 31 per cent of the vertical scale and at a size equal to .031 on the abscissa scale. This point will be referred to later.

Figure No. 6 represents a grading of portland cement concrete developed by Professor H. F. Kriege and reported in Rock Products. All aggregate was smaller than $2\frac{1}{4}$ inches maximum.

Figure No. 7 is the "best grading" developed in our own laboratory for Portland cement concrete with a certain type of crushed rock at $2\frac{1}{2}$ inches maximum.

Figure No. 8 is paving concrete with $3\frac{1}{2}$ inches maximum stone and Figure No. 9 is paving concrete using 4 inches maximum stone.

DIFFERENT EXPERIMENTS

I would again like to repeat that all of these gradations were developed by different individuals working independently and separated by considerable distance and time, and each one represents the most ideal combination which was developed after a great many trials and consideration of other combinations. These figures by no means represent all of the material studied. Each is somewhat typical of the particular size group. **In passing I might call attention to the fact that regardless of individual variations in coarse and fine aggregate all of these most satisfactory gradings tend to pass close to the point represented by the co-ordinates, 31 per cent of the material passing a size equal to .031 of the particular maximum size of the gradation.** This prevailing common type or pattern of grading seems to be too consistent to be accidental and has been used to establish grading charts which have been made the basis for the design of bituminous paving mixtures. These charts shown herewith, indicate tolerance limits which are, in effect, a rationalization of data similar to that just shown.

Figure No. 10 is a so-called general grading chart showing the slope of the curve from maximum to minimum with the abscissa values drawn as relative sizes only.

Figure No. 11 is the same type of curve on which the abscissa values represent actual sieves as they would appear for a grading ranging from 1 inch to dust. Having thus arrived at smooth attractive looking curves, through the simple expedient of ignoring those cases which did not conform, it may be well to offer some explanation which would help to show why this uniform type of grading will often be more satisfactory than other curves.

MAXIMUM DENSITY

Figure No. 12 is a collection of aggregate gradings which have been proposed, tried, or, in some cases, used with considerable success. I would like to point out the heavy shaded line which, from Professor Kriege's report may be taken as the ultimate in maximum density. Professor Kriege stated that if 50 per cent of the coarsest size was combined with 50 per cent of the finest material, the **resulting density would be greater than that of any other combination of sizes within the maximum and minimum limits.** It appears then, that any virtue in the type of grading shown on Figure No. 11, is due to the avoidance of certain difficulties more or less inherent in other patterns of gradation. These liabilities or hazards are set forth on the figure in the form of brief notes indicating possible or probable results should the grading curve go beyond the tolerance limits in the area of the chart covered by the notation. However, these notations are an over simplification. For example, on Figure No. 13 the hypothetical grading shown is deficient in fine sand. A grading of this type will ordinarily be porous and may or may not be undesirable depending on local conditions.

Figure No. 14 shows a distinctly different type of grading which is caused by an excessive amount of sand between the 30 and 100 mesh size. This type of curve is typical of a mixture containing wind blown sand. Our experience has shown that such mixtures are usually low in stability and are often permeable as well.

IDEAL GRADING

As a result of this study it was possible to assign a few reasons why a grading curve should have some particular or pecular characteristics. It appears that there are a number of factors which may be affected by the gradation and also several **which are not.** It is necessary for the designer to distinguish and isolate the separate individual items and properties which are needed to accomplish the purposes of a particular project. It is also **necessary to know which of the essential properties depend on and are affected by the aggregate gradation.** With this information and knowledge, it is possible to develop an ideal grading for a specific purpose and from that to determine how nearly the ideal grading can be achieved with the aggregate available. Thus, the basic requirements and conditions can be stated rather briefly but it is not always a simple matter to arrive at a practical solution because in practice, the best grading that can be secured is usually a compromise.

As the word "compromise" implies recognition and allowance for the demands of several diverse elements, it is now necessary to describe some of the factors which may affect the choice of gradings. One of the first and desirable properties of mixtures are the qualities of plasticity and mobility which are usually grouped under the heading of workability. Hydraulic concrete, bituminous mixtures, and stabilized soils all must be workable; the degree required **depends on the conditions of use and type of equipment.**

WORKABILITY IMPORTANT

Workability is usually of greater importance in portland cement concrete than in bituminous mixtures, nevertheless, it is one common requirement which is affected by gradation.

Another property influenced by grading is permeability. The importance of this property depends almost entirely on the type of structure. (A distinction should be made between permeability and density. The terms are not synonymous.) In paving mixtures it may be important that they be tight and relatively impermeable under conditions where it is necessary that a vulnerable subgrade be protected from the entrance of surface water through the pavement. It is often true, however, that the greatest danger of subgrade saturation comes from capillary moisture and a tight paving surface which restricts evaporation will frequently promote failure through an accumulation of moisture in a plastic subgrade. It has been demonstrated that a surface mixture with the proper degree of porosity will permit the subgrade to main-

Fig. 7

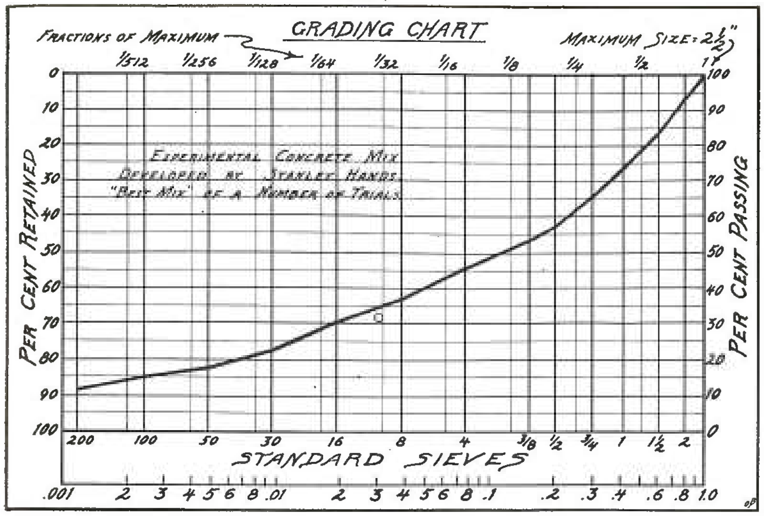


Fig. 8

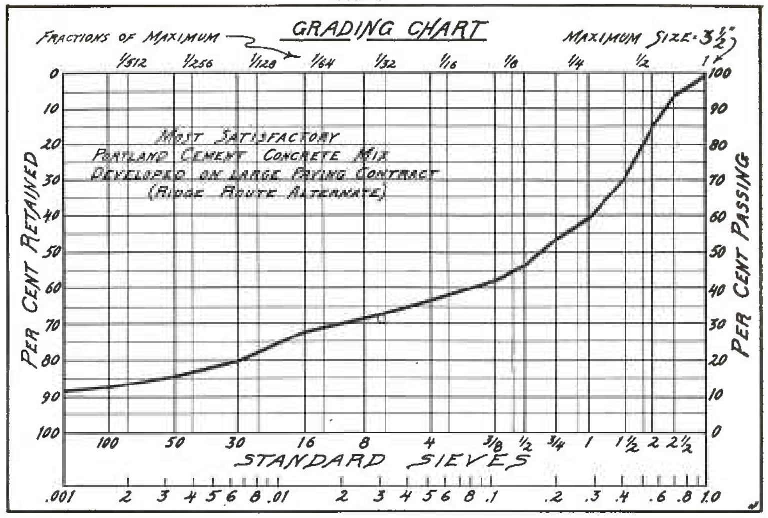


Fig. 9

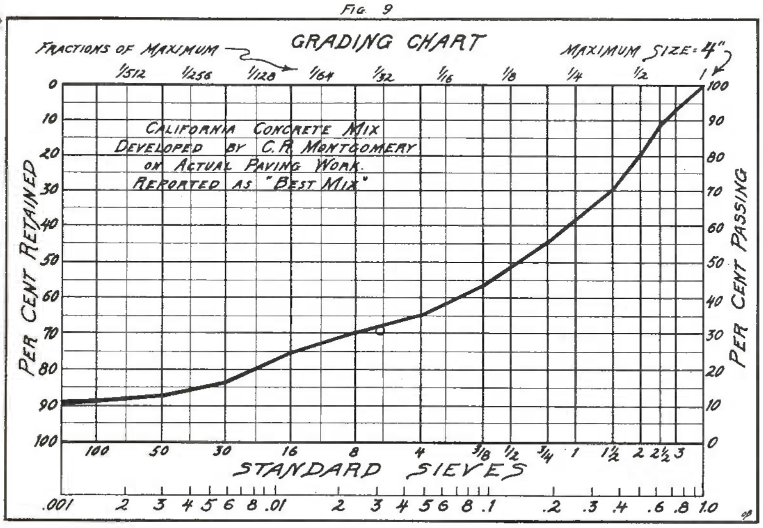


Fig. 10

STATE OF CALIFORNIA DIVISION OF HIGHWAYS MATERIALS & RESEARCH DEPT.

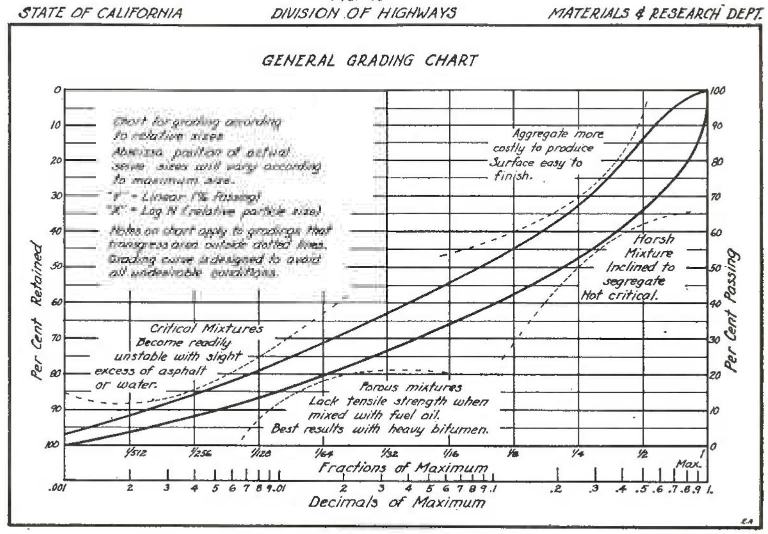


Fig. 11

STATE OF CALIFORNIA DIVISION OF HIGHWAYS MATERIALS & RESEARCH DEPT.

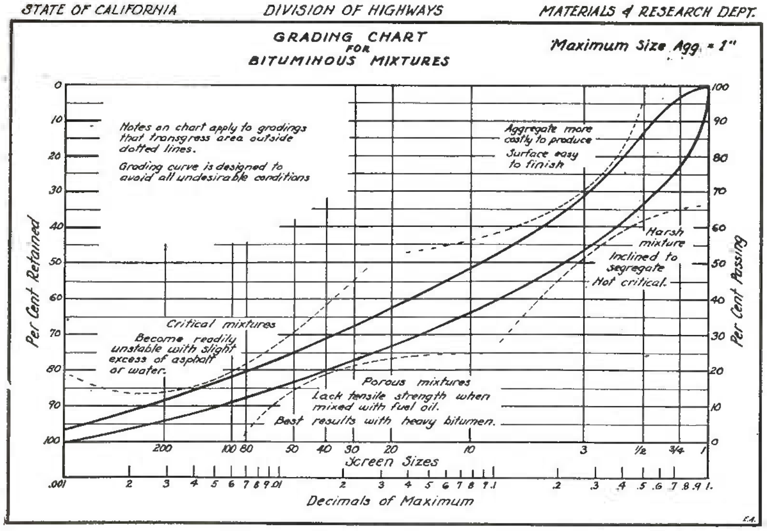
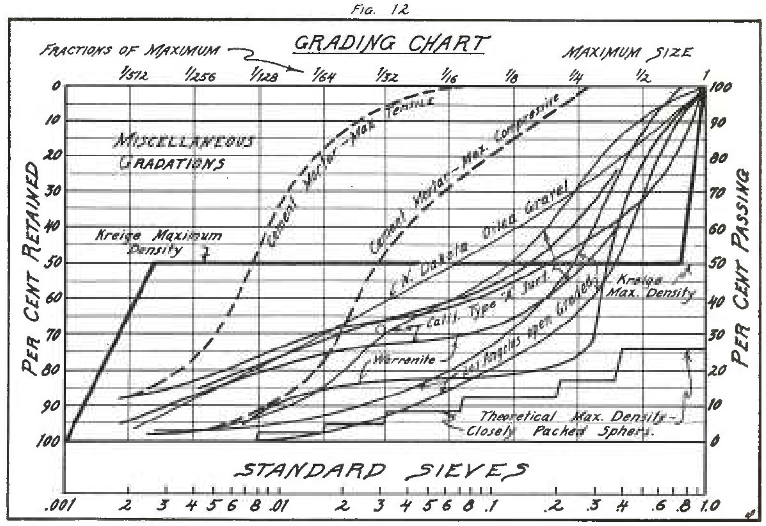


Fig. 12



tain a stable equilibrium by allowing moisture to evaporate rapidly enough to prevent excessive concentration. So far as is known, the design of paving mixtures has not often been deliberately adjusted to provide the necessary permeability. It is hereby suggested that it is a possibility well worth consideration.

Economy is a factor which may at times influence the choice of gradings but its importance varies with the particular conditions. Durability is important for virtually all structures but is not usually affected by the gradation of aggregate. Surface texture is a property peculiarly important to pavement construction and the present widespread interest in traffic safety makes skidding resistance an essential property, and the texture is inevitably influenced by the grading of the aggregate. Important properties which are only slightly or indirectly effected by aggregate gradation are the **compressive strength** of portland cement concrete and the **stability** of bituminous mixtures.

A great deal of discussion has appeared in technical literature concerning the significance of the voids ratio. So far as the writer has been able to determine, there is little evidence to show that the voids ratio can be dependably utilized in the design of mixtures. Neither the amount of binder required nor the important properties can be confidently predicted from a knowledge of the void volume alone. As stated by someone, while a packing box full of baseballs and one filled with peas will have virtually the same void volume, the number of points of contact and the superficial area will vary inversely with the particle diameters.

DESIGN OF ALL MIXTURES

In conclusion it may be pointed out, that mineral aggregates are possessed of one inherent property which affects the design of all mixtures regardless of the type of binder used. This property is described as internal friction of the granular mass implying that all solid particles offer resistance to sliding depending on their surface texture and pressure with which they are held in contact.

The equilibrium characteristics of the mass depend on the conditions which pertain at the points of contact between the discrete particles. A void has little if any character and particles do not transmit their influence across void spaces—only at points of contact. The stability of bituminous mixtures is largely dependent on maintaining a high value of internal friction, while on the other hand, the strength of portland cement concrete depends on the water cement ratio. This ratio can be maintained at its lowest value when the internal friction of the aggregate is inherently low, therefore the design of portland cement concrete tends to encourage the use of finer sands and smooth particles which in combination with water, promote mobility. In bituminous mixtures, the tendency should be towards the use of rough stone and a reduction of fine mobile material to the lowest amount possible in order to maintain high internal friction. However, as the stability of bituminous mixtures is also influenced by the cohesion any reduction in the amount of fines tends to reduce the cohesion values as well as to increase the permeability, thus we are around the circle and back to the need for compromise.

BEST GRADING

The best grading for any particular mixture can only be that which utilizes the available aggregates to give as many of the desired properties as may be possible. For this reason standardization of aggregate gradings can easily be carried too far and as utilization of aggregates is primarily a local problem due care should be exercised in the adoption of national standards for materials which are strictly speaking, not manufactured and which vary throughout the country. Commercial aggregates are not often shipped long distances and there seems to be no good reason for requiring that crushed stone, sand, or gravel, in one region should meet gradations found satisfactory for materials at some distant point.

As an example of the manner in which gradings can be slightly modified to secure less critical mixtures, figure No. 15 shows for comparison the asphaltic concrete grading used in California for a number of years past and the dotted line shows the modification which will be used in the future. The two gradings have virtually the same amount of sand finer than 10-mesh, however, the gradation of both fine and coarse material has been altered. This change in grading tends to reduce the density of the combination and will provide a mixture which is less critical.

STABILOMETER VALUES

Figure No. 16 shows comparative stabilometer values of the old and new type of grading. You will note that with a bitumen content of 5.6 stabilometer values are virtually identical. However, with a slight increase in asphalt, the older more dense mixture tends to lose stability rapidly whereas the modified gradation will show satisfactory stability up to about 6 per cent of asphalt and in no case falls as low as the older type.

The lower chart shows variations in density with the two types. With 5.9 per cent of asphalt, the new gradation has nearly 2 per cent greater void volume and in this connection a large number of studies have indicated that when the relative specific gravity is higher than 97 per cent, virtually all asphaltic mixtures tend to lose stability. Sufficient void space must be provided for the necessary amount of

In Memoriam

Samuel A. Cobb

Samuel A. Cobb, Associate Highway Engineer in the Department of Public Works, Division of Highways, District V, San Luis Obispo, California, succumbed to a heart attack May 27, 1941, while on official duty at Salinas.

Mr. Cobb was born near Tyler, Texas, January 2, 1879, and was a graduate of Texas A & M College.

His earlier activities covered engineering work for railroad and public services in the Texas Panhandle district and Oregon. From 1919 to 1925 Mr. Cobb served the State of Washington as Highway Locating Engineer.

He entered State service for California in March, 1928, as locating engineer in District VI at Fresno. In December, 1931 he transferred to District V at San Luis Obispo and for several succeeding years had the distinguished duties of resident engineer on the southern section of the Carmel-San Simeon Highway, a portion of the Roosevelt highway. During the past two years he was Safety Engineer for District V and succumbed while making traffic studies in the vicinity of Salinas.

His varied career, character and timely advice won him a host of friends throughout the west.

He is survived by his wife, brother and four daughters.

His fellow workers feel deeply his untimely passing and share sympathy with his bereaved family for the loss of a man who was held in high esteem by all who knew him.

Fig. 13

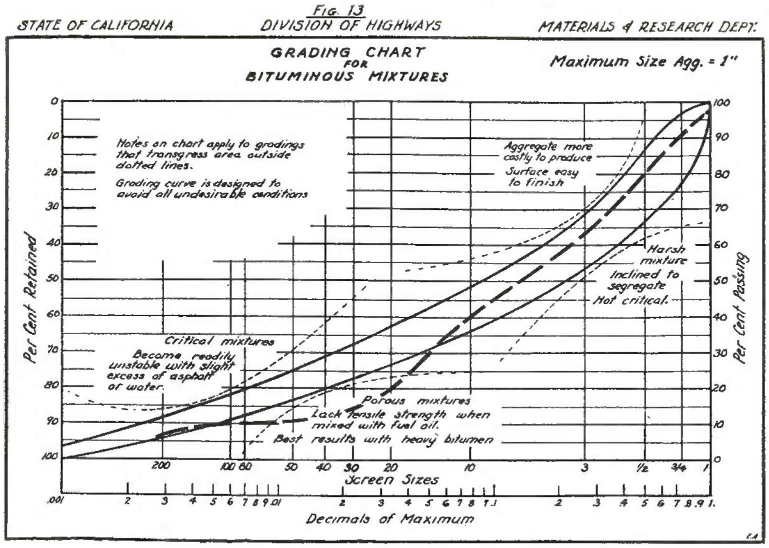


Fig. 14

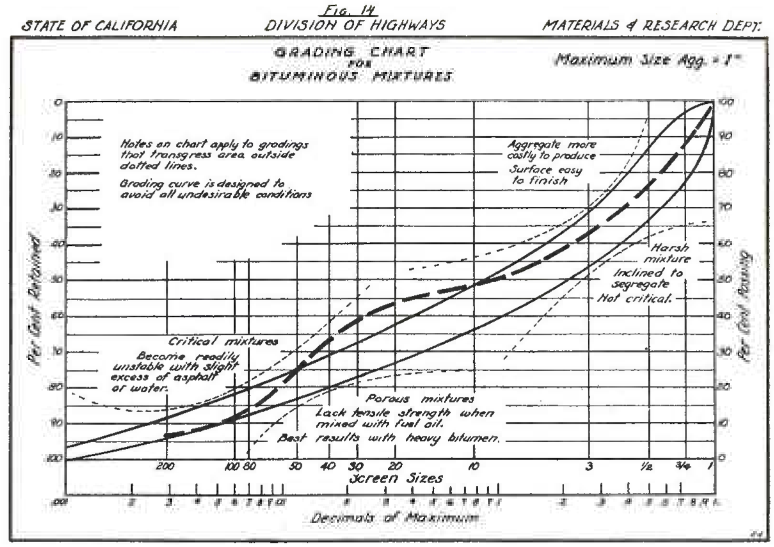


Fig. 15

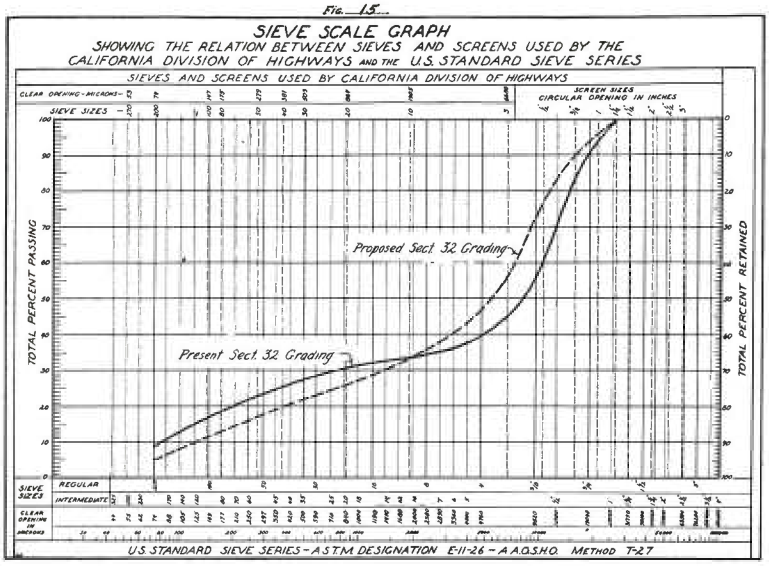
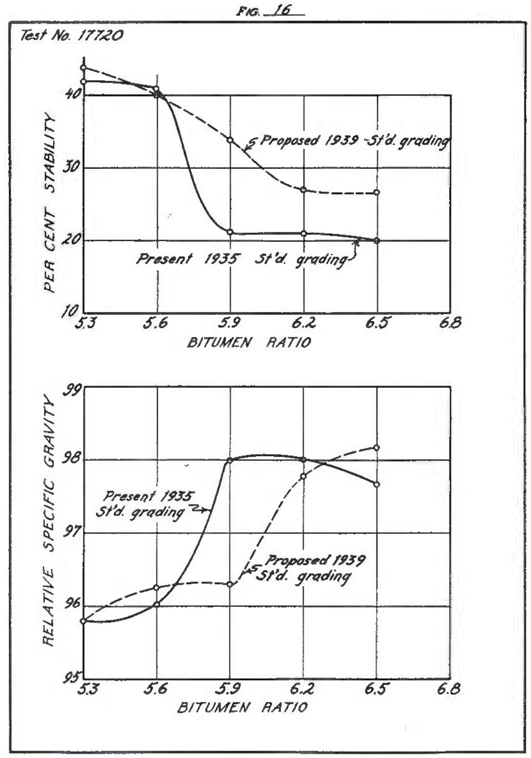


Fig. 16



asphalt and the new type of grading has been found to be more accommodating and less critical than the older type.

In conclusion, it can be repeated that the best gradation is that which best suits the particular purpose and material available and, to borrow a phrase from Mr. T. C. Powers, **"A wide variety of gradings can be used but we can not tolerate much variation."**

Madera-Friant Project

(Continued from page 4)

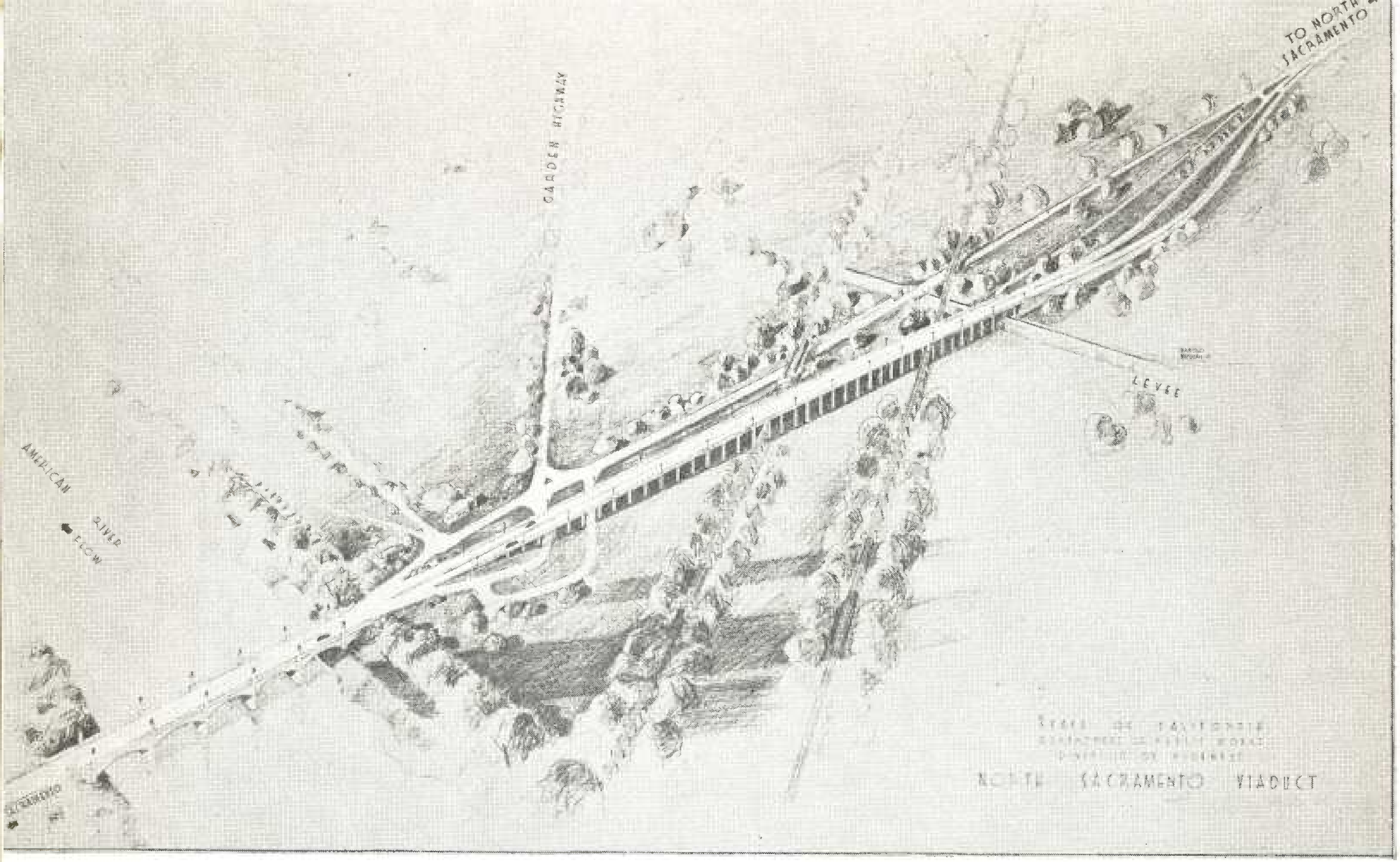
tractors, motor graders, carryalls and other equipment, the rental value of which was nearly $12,000.

Grading equipment varied from wheelbarrows to eight cubic yard carryalls. When the haul (or push) was too great for the wheelbarrows in some instances, strings of dump wagons, five in a row, hooked together by a long chain, were loaded by hand, and were hauled out to dump by a small tractor, while another string of five was being loaded.

Another similar means of hand excavation and loading was employed to comply with WPA regulation. A truck equipped with a special hoist was used to pick up, haul, dump and return six 2-cubic-yard dump boxes. The boxes were spotted where desired and loaded by hand. It kept the hoist truck busy supplying empty boxes for the workmen.

The dump wagon and 2-cubic-yard-box method of excavation proved much more interesting to the hand shovelers than did the wheelbarrows and the output was increased considerably. The men worked unusually hard to get the wagons or boxes loaded before the tractor or truck got back with the empties. In turn, the tractor operator and truck driver hurried to get the empties back.

A little over a year has been required to complete the project as originally planned. The result has been the construction of over six miles of wide roadbed with a 22-foot oil treated surface and a fine 142-foot reinforced concrete bridge.



Artist's sketch of proposed viaduct over American River overflow area on U. S. 99 between Sacramento and North Sacramento

Viaduct to North Sacramento

By R. W. HUTCHINSON, Associate Bridge Engineer

BIDS WERE scheduled for opening on June 18th for the construction of the North Sacramento Viaduct across the American River overflow area between Sacramento and North Sacramento. If an acceptable bid is received, work should start on the project about July 1st.

Approximately one year will be required to complete the structure and approach work. This will be welcome news to the people of the Sacramento area for whom the past wet winter and the activities at the Sacramento Air Depot have emphasized the necessity for a dependable route across the overflow channel.

The proposed project will make a true all year highway north on Route U. S. 99 and east on Route U. S. 40, as well as between the two cities which it will connect. The existing road has been intermittently closed by high water during the winter for an average of eight days per season for the past five years. On these days traffic must be detoured over narrow levee roads which add three miles and at least one-half hour to the trip between the two cities. The inconvenience has to be endured by the 20,000 to 25,000 cars which daily use this highway.

This stretch of road has been no less a tribulation to the highway maintenance forces than to the traveling public. Each period of high water meant a long vigil with sand bags to keep the road open as long as possible, patroling of detour roads and finally the cleaning up of mud and debris after the waters had subsided.

The new structure will start about 300 feet north of the American River bridge and will rise on easy vertical curves at a maximum rate of 6.2 per cent to a height of more than 50 feet above ground. It will clear the railroad trestles by 28 feet to provide for future raising of the tracks which are now below the extreme flood plane established by the State Reclamation Board Engineers.

Connections will be made at the end of the American River bridge and at the south limits of North Sacramento. An off-ramp connection will be made to the Garden Highway and bottom lands passing under the structure so that cars will not have to cross opposing traffic.

At the south end of the structure where construction will interfere with traffic on the existing highway, a detour will be provided which will ultimately be used as a permanent connection to the bottom land roads.

The viaduct will provide four traffic lanes on two 25-foot roadways separated by a four-foot dividing strip and in addition, two sidewalks each four feet wide. An open type steel railing will permit an unobstructed view from the deck and will harmonize with the structural features of the viaduct. The deck will be lighted by 20 incandescent luminairs.

The viaduct will be of reinforced concrete with the exception of the steel railing and expansion details. It will be 1,496 feet long consisting of 36 spans each 41 feet long with 10-foot cantilever spans at each end of the bridge. The bridge deck will have an overall width of 65 feet consisting of a six and one-half inch slab supported on 11 shallow girders each one foot wide.

The depth of the superstructure will be only 3 feet 8 inches, which was an important consideration in clearing the railroads with a minimum rise. The deck will be supported on bents consisting of a cap four feet wide and two columns each three feet square. The underside of the girders and cap will be kept on a plane to improve the appearance of the structure from the access roads which pass beneath it.

The use of two column bents proved economical for the the unusual height required in this type of construction and will permit the railroad tracks to enter through one span, pass diagonally between the bent columns and emerge through the adjacent span. This will eliminate the necessity of expensive skewed construction at the railroad crossings. Except at the railroad structures, where special footings are required to avoid interference, the bent columns will be carried on shallow footings just below ground level. Each column footing will be supported by nine concrete piles.

Expansion and contraction is provided for at eight joints. At the deck a sliding steel plate covers the required open joint. Structural loads are carried across the joint by a steel hanger rocking on steel pins to permit longitudinal motion. These joints are located at maximum intervals of five spans, or 205 feet, so as to keep at a low value the bending stresses due to temperature and thus permit more efficient use of the columns in carrying other stresses. The expansion joints are located seven feet from the bents so as to maintain continuous spans throughout.

Special attention was given the architecture of the structure because of the prominence which it will have when raised high above the flat river bottom. The dimensions of the deck and supporting columns were chosen so as to reduce the apparent bulk as much as possible.

An effort was made in design to procure similarity of details throughout the structure so as to obtain economy and speed in construction through the multiple use of forms and equipment. The repetition of details will enable the contractor to carry on the work in the most efficient order without the risk that portions of the work may be delayed by special materials not at hand.

Plans for approach roads were prepared by District III under the direction of C. H. Whitmore, District Engineer, and plans for the structure were prepared by the Bridge Department under the direction of F. W. Panhorst, Bridge Engineer.

DIFFICULT MATTER TO JUDGE EXACT SPEED

To ascertain the reliability of eye-witnesses' estimates of the speed of a motor car, the Royal Automobile Club of Sweden carried out carefully some 21,000 tests made with people of all descriptions, including persons who claimed to be experts. Not more than 18 per cent of those tested were able to place the speed of a passing motor vehicle within 5 per cent of the correct figure. More than half were as much as 20 per cent and more out in their estimates.

People who, because of special experience, might be expected to gauge fairly accurately were no better than others, and in some cases even worse. The tests were held under varied conditions. Trials were made in town and country, in daytime and at night; the cars were driven past in different gears, and attempts were made to produce all the conditions which might be present at accidents and collisions.

Orleans Bridge Wins First Prize in National Design Competition

(Continued from page 2)

The bridge has a reinforced concrete slab floor on longitudinal steel stringers. The floor beams are framed into a 30-inch, 108-pound wide flanged stiffening girder. These girders were fabricated as chords of the dead load camber curve and were fully spliced at 36-foot lengths.

Splices were placed about three feet from a floor beam or suspender connection to facilitate erection. Stiffening girders were completely assembled in the shop to their dead load camber position and all splices were reamed for rivets in this position. The splices were not riveted until the concrete slab had been poured and the bridge had taken its dead load deflection.

The steel towers contribute a great deal to the appearance of the structure and consist of two columns braced by elliptically shaped cross braces forming an arch over the roadway. The hinges at the tower bases rest on welded structural steel shoes.

Construction began in November, 1939, and was completed in September, 1940. The bridge was designed by the State of California and built under contract. C. H. Purcell is State Highway Engineer and F. W. Panhorst Bridge Engineer. C. W. Caletti and Company, San Rafael, was the general contractor, H. H. Gilbert the designer, and C. C. Winter the Resident Engineer for the State.

Replacement Program

Our present improved roads will not remain so without constant maintenance and replacement when they get beyond the condition of economical maintenance, or so obsolete that they are a menace to safe highway transport. The highway system very rapidly would decrease in adequately improved mileage if construction should stop. On the basis of road life studies made in connection with the state-wide planning surveys, if we were to eliminate future construction and reconstruction, by 1960 there would be only 27,000 miles of surfaced roads remaining from approximately 209,800 surfaced miles now in the Federal-aid system.

—*Highway Facts*

New Highway to Link Santa Ana and Coast at Corona Del Mar

By H. J. FALLAI, Assistant District Office Engineer

IT WAS the year 1769. A strange cavalcade, two brown-frocked padres and 61 soldiers of Spain with lances flashing in the sun, waited on the east bank of the Santa Ana River while axmen slashed a trail through the thick woods. After two hours of this work, a bearded officer ordered camp made for the night. It was Gaspar de Portola and his weary band cutting California's first trail.

It is the year 1941. Old trails have become old roads and old roads have become modern highways, in whose irregular network Los Angeles is linked to Portola's camp ground near Olive in Orange County and Olive is connected with Santa Ana and the sea. A new thread is being added to this network by the award of a contract on January 13, 1941, to Mittry Brothers Construction Company, of Los Angeles, for the extension of South Main Street, Santa Ana, at an estimated cost of $208,853.93.

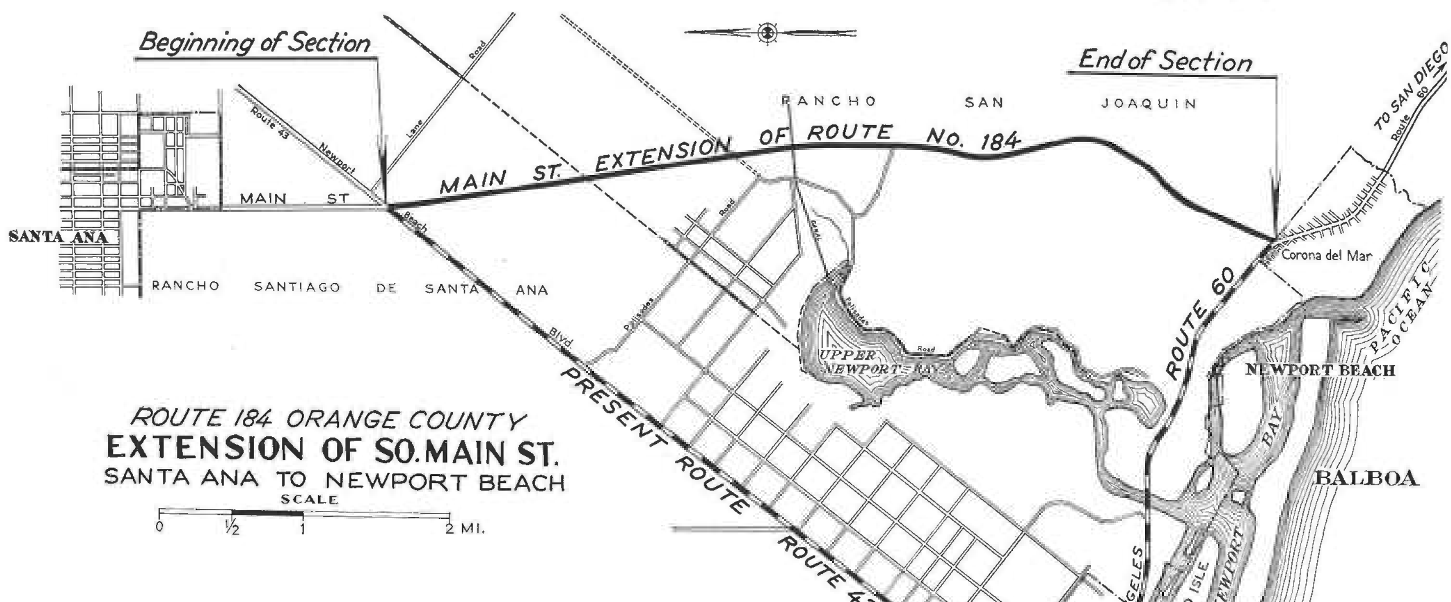
The construction, now under way, is 6.33 miles in length, and strikes due south to the sea from the intersection of Main Street and Newport Beach Boulevard at Santa Ana to Corona Del Mar. Heretofore, traffic flowing from the interior via Santa Ana to beach communities along the South Orange County coast has had to follow Newport Beach Boulevard. The new route offers a saving to the traveling public of 3.3 miles, or approximately half the length of the new improvement.

With the constantly increasing volume of traffic in the metropolitan area adjacent to Los Angeles, the planning of important new highways has necessitated the adoption of freeway design. In anticipation of a substantial volume of traffic that may utilize the new route, this improvement has been designed as a freeway, with rights of egress and ingress to abutting property restricted and future cross-overs limited to certain definite locations.

The absence of intersecting roads and the directness of the alignment will contribute to free and unobstructed travel. In order to reduce hazards the project has been designed for two lanes of pavement on each side of a median strip separating opposing traffic streams. The southerly 2.2 miles, where hilly terrain prevails, include a 6-foot dividing strip on a roadbed 66 feet wide. The northerly 4 miles lie mostly in flat country and provision is made for a future 20-foot center strip, with a roadbed 80 feet wide.

This project was initiated in 1935 by Orange County as a relief project. The county's share of the work consisted of the construction of a graded roadbed and the installation of the necessary culverts for the southerly 4 miles of the route.

Work under the present contract was started on February 5, 1941, and includes completion of the grading and culverts, the construction of a bridge and placing the pavement. While it provides for a four-lane divided roadway for the southerly 2.2 miles, the northerly 4.1 miles, where flat topography offers no re-



strictions to sight distance, will be the conventional two-lane road. This, however, is stage construction and, as soon as funds are available, the four-lane divided highway will be realized for the full length of the job.

On this improvement, the question of type of pavement or surfacing was the occasion of considerable study. Inasmuch as limited funds did not permit the placing of the conventional type of heavy pavement, some cheaper type had to be developed. Laboratory investigation indicated that within the project area suitable soil was available for cement stabilization.

As a result of these studies, a typical roadway section was evolved, consisting of a blanket of selected material ranging from 7 to 10 inches compacted depth, topped by 8 inches of cement treated soil base, and 3 inches of plant-mixed surfacing. This type of construction promises a surface that will withstand a substantial volume of traffic at a cost less than that of the usual types of heavy pavement.

Construction of the cement treated base will consist of scarifying and thoroughly cultivating the uppermost 8 inches of selected soil, followed by the addition of Portland cement in a uniform application varying from 6 to 8 per cent by weight of dry soil. The soil and cement will be thoroughly mixed and the necessary water added until a uniform mixture results. The mixture will then be shaped and rolled to yield a compacted base 8 inches in thickness as the subgrade for the plant-mixed surfacing.

A forecast of future traffic which may utilize the new extension was estimated from traffic counts taken at various intersections in the vicinity of the new improvement. From analysis of this data it was concluded that the minimum traffic expectancy approximated 1,510 vehicles for a 16-hour week-day, while the maximum expectancy totaled some 3,340 vehicles per day.

It is probable that the estimate of 3,340 vehicles does not indicate the full extent of travel which may be expected. In the light of past experience in this area, there is reasonable assurance that highway improvements such as this develop more traffic than is indicated by traffic movement observations taken prior to the completion of the work.

(Continued on page 24)

Construction Scenes on Santa Ana-Corona del Mar Highway Link. Top—Culvert Construction near Santa Ana. Center—Graded route at Corona del Mar end. Bottom—Junction point with Coast Highway

Bids and Awards for May, 1941

CALAVERAS COUNTY—Between San Andreas and Angels Camp, about 3.4 miles to be graded and surfaced with plant-mixed surfacing on a base of untreated rock surfacing. District X, Route 65, Sections A,B,Ang. Hemstreet & Bell, Marysville, $154,728. Contract awarded to Claude C. Wood, Lodi, $128,084.

LASSEN COUNTY—Between Constantia and Route 21, about 12.1 miles to be surfaced with plant-mixed surfacing. District II, Route 29, Section E. A. Teichert & Son, Inc., Sacramento, $57,680; Hemstreet & Bell, Marysville, $57,860; Piazza & Huntley, San Jose, $65,600; Isbell Construction Co., Reno, Nev., $68,920; J. A. Casson, Hayward, $70,840; Marshall S. Hanrahan, Redwood City, $81,700. Contract awarded to Fredericksen & Westbrook, Sacramento, $56,120.

LASSEN COUNTY—Between Viewland and Madeline, about 18.1 miles to be surfaced with road-mixed surfacing and shoulders to be constructed. District II, Route 73, Sections B,E,F. Fredericksen & Westbrook, Sacramento, $53,166; J. C. Compton, McMinnville, Ore., $58,584; Lee J. Immel, Berkeley, $58,684; Oranges Bros. Construction Dept., Stockton, $62,151. Contract awarded to Harms Bros.-Powers & Patterson, Sacramento, $44,199.

MARIN COUNTY—Between Myrtle Avenue in San Rafael and San Quentin Wye, about 1.3 miles in length, Portland cement concrete pavement, curbs, gutters and sidewalks to be constructed. Plant-mixed surfacing to be constructed on crusher run base, and penetration treatment to be applied to shoulders. District IV, Route 1, Sections S,Rf. Lee J. Immel, Berkeley, $20,387; Chas. L. Harney, San Francisco, $21,529. Contract awarded to A. G. Raisch, San Francisco, $19,743.

MENDOCINO COUNTY—Across the South Fork of Eel River, about 65 miles north of Willits, a bridge to be redecked. District I, Route 1, Section K. Louis Biasotti & Son, Stockton, $14,692; A. Soda & Son, Oakland, $13,220; C. C. Gildersleeve, Berkeley, $11,996; Mercer Fraser Co., Eureka, $12,151; E. E. Smith, El Cerrito, $14,938. Contract awarded to A. O. Lightford, Upper Lake, $8,790.

ORANGE COUNTY—A bridge across the Santa Ana River, about four miles south of Yorba Linda, to be repaired. District VII, Route 175, Section B. J. S. Metzger & Son, Los Angeles, $23,298; The Contracting Engineers Co., Los Angeles, $24,335; J. E. Haddock, Ltd., Pasadena, $25,543. Contract awarded to J. E. Burrell & Sons, Long Beach, $19,155.

PLUMAS COUNTY—Between North Fork and Keddie, about 19.9 miles to be surfaced with plant-mixed surfacing on imported borrow on a portion of the project and over existing pavement on the remainder of the project. District II, Route 21, Sections B,C. A. Teichert & Son, Inc., Sacramento, $153,412. Contract awarded to Hemstreet & Bell, Marysville, $143,442.

PLUMAS COUNTY—Between Beckwourth and Edes Ranch, about 9.3 miles to be surfaced with plant-mixed surfacing and shoulders to be constructed. District II, Route 21, Section G. J. A. Casson, Hayward, $47,000; Fredericksen & Westbrook, Sacramento, $47,990; A. Teichert & Son, Inc., Sacramento, $50,690; Isbell Construction Co., Reno, Nev., $55,175; Jones & King, Hayward, $55,830; Piazza & Huntley, San Jose, $56,145; Hemstreet & Bell, Marysville, $56,315; Claude C. Wood, Lodi, $58,672. Contract awarded to Poulos & McEwen, Sacramento, $44,147.

SANTA CLARA COUNTY—Area at El Camino Read Underpass in Palo Alto to be landscaped and an irrigation system to be installed. District IV, Route 2, Sections A.P.A. West Coast Nursery Co., Palo Alto, $8,732. Contract awarded to Leonard Coates Nurseries, Inc., San Jose, $8,227.

SAN LUIS OBISPO-SANTA BARBARA COUNTIES—At points between 40 and 67 miles east of Santa Maria, a bridge across Carrizo Canyon to be constructed and two bridges across Cuyama River to be redecked. District V, Route 57, Sections B,C,D. The Contracting Engineers Co., Los Angeles, $52,390. Contract awarded to T. C. Tunsen, Modesto, $39,998.

Boy Scouts Do Good Deed On Flooded Road

Four members of Boy Scout Troop 16 of Fellows, California, had an opportunity to do their good deed for the day on March 3d when they assisted maintenance men of the Division of Highways in Kern County to handle traffic on a debris-clogged road. The Scouts—Eugene Colfax, Milton Scott, Bill Beard and Ray Wright—were commended for their work in the following letter sent to each of them by District Highway Engineer E. T. Scott of Fresno:

> It was with sincere appreciation that this office received the information from our Maintenance Superintendent, Mr. M. L. Cardwell of Taft, that during and following the storm of March 3, 1941, particularly between the hours of 8.00 p.m. and 9.00 p.m. you, in company with three other members of Boy Scout Troop 16 of Fellows, voluntarily removed debris consisting of lumber and limbs washed on to the traveled way of the State Highway and flagged traffic operators with a lantern, warning them of dangerous conditions ahead.
>
> Please accept the thanks and commendation of this Department of the State for this action on your part which displayed a spirit admired by everyone.
>
> A copy of this letter is being forwarded to our Central Office.
>
> Yours very truly,
>
> E. T. SCOTT,
> District Engineer.

New Highway to Link Santa Ana and Coast

(Continued from page 23)

It is certain that some of the traffic which normally flows along the inland route between Santa Ana and San Clemente will be attracted to the new route. No attempt has been made to forecast the peak traffic that may be expected on Sundays and holidays, when large numbers of people are attracted from the interior to beach communities along the Orange County coast. It is possible this peak may reach 10,000 vehicles per day.

It is not often that a project affords a saving in distance of approximately half the length of the improvement. Just as important is the money saved to the traveling public by such shortening. This is a major consideration in evaluating the economic justification of a project.

In this connection it is possible to evaluate the saving in distance. Adopting as a conservative base the minimum traffic expectancy of 1,510 vehicles per day, traffic may be expanded into a yearly count of 622,000 vehicles. With a saving in distance of 3.3 miles and a conservative operation cost per vehicle of 3 cents per mile, the yearly saving in operating costs by the public will total approximately $62,000. This means that an automobile traveling the new route once a day for one year would net a saving to the individual driver of a little over $10 per year.

Progress of the work was retarded by the unprecedented winter rains but, as this article goes to press, the contract is approximately 10 per cent complete, and work promises to be in full swing within a very short time.

By March, 1942, a new road from Santa Ana to Corona del Mar will invite an eager quota of 622,000 vehicles and each vehicle will reap a substantial saving in operating costs.

Experience is not what happens to a man. It is what a man does with what happens to him.

Judge—Have you a lawyer, Sambo?

Sambo—Naw, suh, Jedge. We done decided to tell de troof.

State of California
CULBERT L. OLSON, Governor

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

FRANK W. CLARK, Director of Public Works

FRANZ R. SACHSE, Assistant Director

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