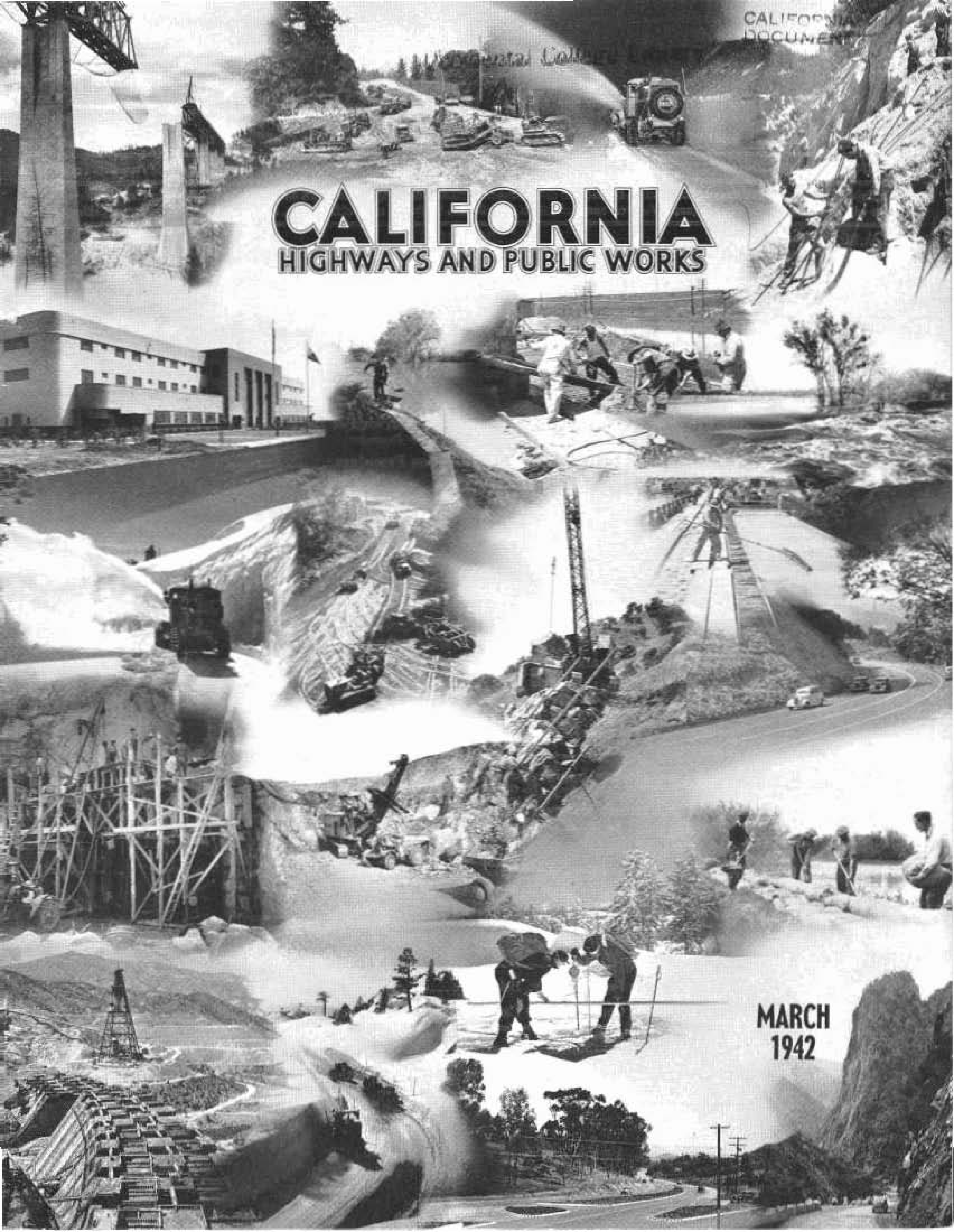
CALIFORNIA
HIGHWAYS AND PUBLIC WORKS



MARCH
1942

CALIFORNIA HIGHWAYS AND PUBLIC WORKS

Official Journal of the Division of Highways, Department of Public Works, State of California

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How Priorities Control System Affects Construction Activities of State Division of Highways

By J. G. MEYER, Assistant Office Engineer in Charge of Priorities

THE all out defense effort has dipped so deeply into the country's productive capacity there are not enough supplies to go around. Hence, in order to insure proper distribution of the available material, some system of control is necessary. "Priorities" is the control system selected by the Federal Government.

Some idea of the seriousness of the present scarcity may be gathered in connection with the Division of Highways' yearly steel requirements for all types of construction. This figure normally approximates 16,000 tons of all kinds of steel—a quantity insignificant in comparison with the Nation's yearly steel capacity of 85,000,000 tons—yet we are certain we shall not obtain even this 16,000 tons for California highways and bridges in 1942.

PRIORITY FUNDAMENTALS

Many people seem to think the "how" and "why" of priorities is a deep mystery. The complexity of the Nation's economic structure does require many forms and procedures. However the essentials for obtaining priority ratings and the application thereof in connection with roadwork is relatively simple.

A priority order gives one the right to obtain delivery of goods in the order of precedence such goods' usage bears to the Nation's war and essential civilian needs. Priority preference ratings range from AA, the highest rating in order of urgency, to A-1, A-2, etc., to A-10; then BB, B-1, B-2, etc.

The A-1 group is further subdivided into A-1-a, A-1-b, to A-1-j. In other words, if you have an A-1-e rating you should theoretically obtain earlier delivery than someone with an A-1-j or an A-2.

The priorities system is founded on the Congressional Act of June 28, 1940 as amended. Basically, it requires manufacturers and suppliers to accept priority rated orders. In other words, purchase orders accompanied by a certain priority rating must be fulfilled before delivery is made on lesser priority ratings or on nonpriority orders.

PRIORITY DEVELOPMENTS

Another basic requirement provides that the holder of a priority certificate must not use it to obtain delivery earlier than needed or in quantities greater than required to complete his project on schedule. Also a priority rating must not be used if delivery can be obtained without priority assistance.

Considerable change has been made in Federal personnel and procedure since priorities were established in June, 1941. At present this tremendous task is administered by the Division of Industry Operations, of the War Production Board (WPB), headed by Donald Nelson. Today the materials of construction are affected also by Federal price controls and rationing as well as by priorities.

The Office of Price Administration (OPA), headed by Leon Henderson, controls prices and rationing. Broadly speaking, the WPB, or Mr. Nelson, administers the war economy while Mr. Henderson, as dual head of the independent OPA and WPB's Civilian Supply Division, controls the civilian economy.

The need for specialized priority knowledge was immediately recognized by the California Division of Highways. Early in June, 1941, engineers were assigned under the direction of R. H. Wilson, Office Engineer, for this purpose. The division at the same time began to plan the adjustments required in normal policy in preparation for a defense economy.

Much credit must be given to the United States Public Roads Administration for its efforts in establishing, for all states, workable procedures for obtaining priority ratings for roadwork and the assignment of the ratings for this work.

This division's first efforts were made by telegram directly to the late Office of Production Management (OPM). Later, telegraphic requests were made through the Public Roads Administration which was able to assist materially because of its knowledge of the road problem and through its direct contact in Washington.

The next development was an OPM letter of August 30, 1941, indicating the priorities applicable to certain types of highway construction in accordance with Federal route classifications. The majority of priority rating orders received by the Division of Highways were obtained under the August 30, 1941, procedure.

DEFENSE CERTIFICATION REQUIRED

The present system for highway priorities requires certification that the project is essential to National Defense in order to obtain certain specified ratings. Such certification is also a requirement today for Federal financial participation in a project. Upon proper request, the local office of the Public Roads Administration initiates defense certification through contact with the Western Defense Command or the United States Engineers Office. Eventually the Secretary of War or Navy certifies the project.

After defense certification justifying expenditure of Federal funds, priority application is made. Where wholly State financed projects are involved, request for certification is made of the PRA in connection with the priority application. The workings of this procedure are indicated by chart on the following page.

When the project is certified and after application, a priority rating is assigned in accordance with the provisions of WPB Administrative Memorandum No. 12 effective December 19th. Such certified projects are termed "classified" projects, and the following ratings will be assigned by the WPB:

RATING CLASSIFICATIONS

(1) For access road projects *Certified* as essential to Defense:

Access roads to military, naval or defense manufacturing plants.	Priority corresponding to rating of establishment served except that highest rating will be A-1-e.

(2) *Certified* projects for correction of critical deficiencies of the Strategic Network of Highways and such other projects as are certified as essential to defense.

(a) All bridge tunnels, structures and approaches other than highway or railroad grade separations	A-2
(b) All other major construction including grading, surfacing and highway and railroad separation structures	A-4
(c) Minor construction projects including shoulder widening and minor drainage structures	A-10

All projects that are not certified are termed "unclassified" and the rating is determined by the WPB, based on the merits of the case in relation to National Defense and Civilian Welfare. Considering our experience to date on this latter type of project, it is assumed any rating granted would be A-7 to A-10 and then only where some connection with defense or civilian health and safety is clearly demonstrated.

LIMITS HIGHWAY PROJECTS

Thus it may be seen that priority ratings will only be granted to those road projects clearly necessary to National Defense, or essential to the public's health and safety for obtaining such critical materials that can not be eliminated by substitution.

This statement may be also used as a summary of policy governing highway, road or street construction where priority assistance is needed. The net effect is a limitation of major construction to the access roads and strategic network.

The following outline indicates in a general way the information required for priority application. The same data is also used to obtain the defense certification referred to above.

A. PRESENT NECESSITY OF PROPOSED WORK

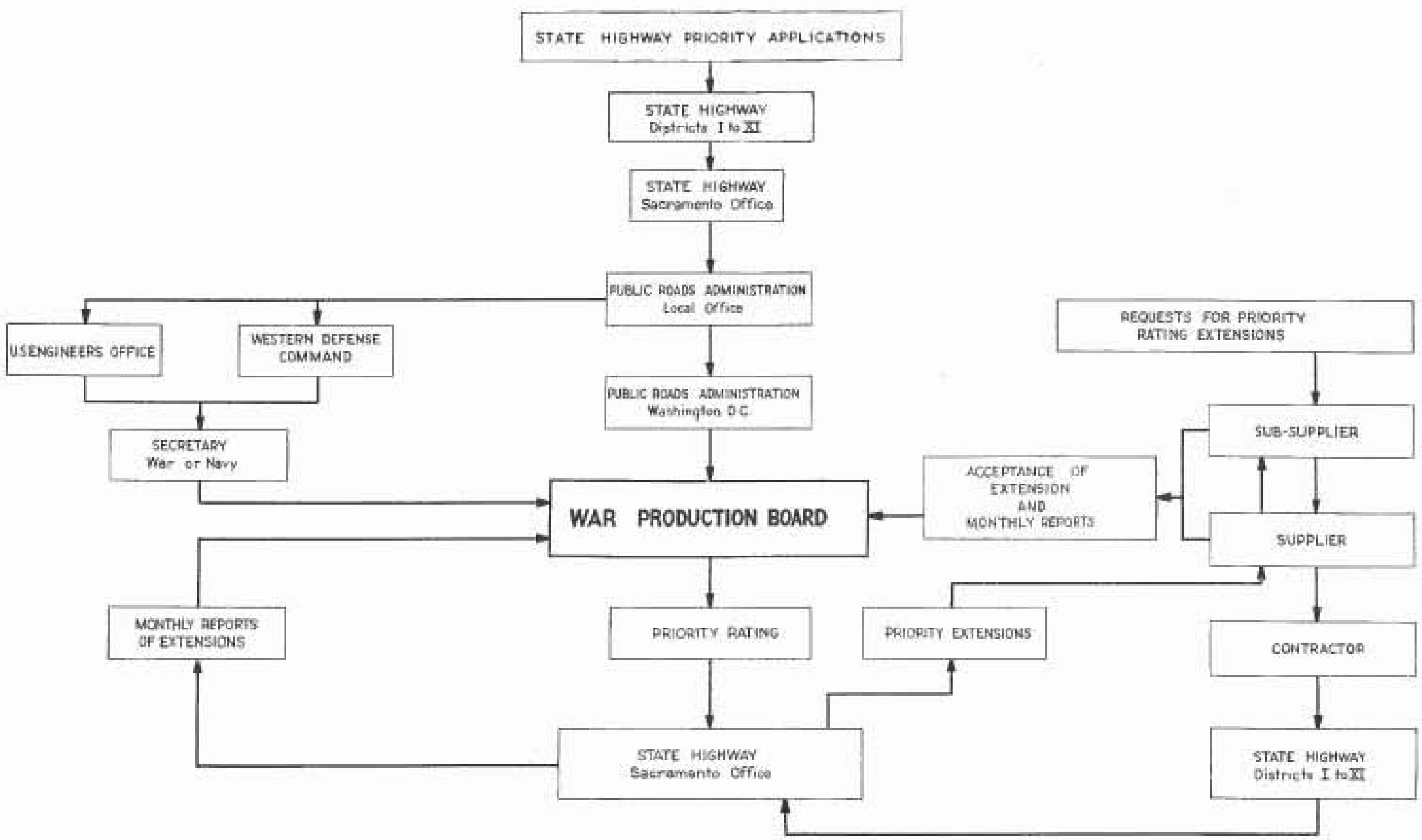
(1) Description of Work
Proposed type of work, costs and complete description of project.

(2) DESCRIPTION OF EXISTING HIGHWAY OR STRUCTURE
Complete factual data on physical characteristics to indicate the specific hazard or deficiency to be eliminated.

(3) TRAFFIC SERVICE
A clear and complete presentation of traffic conditions for which existing facilities are inadequate. To include statistics on traffic accidents, etc.

B. NECESSITY FOR CRITICAL MATERIALS
To include an itemized list segregated into various classes with amounts of steel, non ferrous metals, and other materials which will require priority assistance. This statement must include a detailed statement of reasons why such materials are required and why substitutes can not be used.

Unless such data are completely and specifically presented, applications



are likely to receive little consideration. The application containing the above data is presented in letter form to the PRA for final submission to the WPB.

An important factor in obtaining priority consideration is that of proper design which eliminates critical materials such as steel, copper, rubber, etc. The unjustified use of critical materials will only result in unfavorable consideration of a priority application.

Present regulations prohibit the extension of priority ratings to obtain metal culvert pipe, burlap for concrete curing, metal guard rail or guard rail cable, metal signs or rubber joint material. In effect, the use of such materials is prohibited unless such materials can be obtained without priority ratings. It is expected this restriction will be extended to other nonessential critical materials.

The Division of Highways had anticipated this development and revised its designs accordingly. For example, mass concrete arch culverts without steel reinforcement were developed to supersede, to a large extent, reinforced concrete box culverts. The article by F. W. Panhorst, State Bridge Engineer, in the last issue of this magazine more fully discusses the highway design revisions required to fit the National Defense picture.

The suspension of automobile manufacturing and particularly the rubber scarcity has created a problem in providing and operating the cars needed for conducting highway business. At the present time there is no provision in the rationing program for tires for Division of Highway passenger cars. Likewise, under the rationing plan it will be difficult, if not impossible, to obtain tires for highway construction equipment.

The priorities issued for highway maintenance and construction equipment are largely A-3 to A-10 ratings. Such ratings are usually not sufficient to obtain delivery of construction equipment at any time. We are advised that entire factory productions of certain motor graders are turned over to Army and Navy needs. The obvious conclusion is that we will be forced to make even better use of our available equipment.

While there are many different types of priority orders for various usages, the priority preference ratings generally provided for highway and road work are of three kinds. First, there is the blanket project rating covering the material needs of an entire project that might consist of several contracts.

These priority orders are called P-19-e or P-19-a orders. P-19-e orders are issued for contract construction whereas the P-19-a orders are for strictly day labor projects. There is also the PD-1 or PD-1A certificate covering a specific order of material from a certain supplier. Another is the Maintenance and Repair Order P-100 providing an A-10 rating for maintenance and repair of publicly owned property and equipment.

The PD-1 and PD-1A forms are printed application forms which, when approved, are stamped directly thereon with the priority rating assigned. Our instructions are to use such a form of application for specific signal installations, grade crossing protection work, for publicly owned road equipment, and on construction projects involving only one or two critical materials. The PD-1 form is being superseded by the PD-1A form just issued.

The use of the PD-1A priority form simply involves transmission of the certificate received to the manufacturer of the article purchased.

Extension of the P-19-a or P-19-e certificates requires the contractor to supply copies of his purchase order to the State with the contractor's certification that such purchase order complies with the usual basic priority restrictions. After checking and certification of the contractor's certified purchase orders priority extension is made to the supplier involved. The supplier accepts such priority extension on the forms supplied and may in turn extend the rating to his subsuppliers. Chart No. 2 indicates the various steps in extending priority orders.

The Maintenance and Repair Order P-100 is particularly simple in application. When the purchase requiring priority assistance complies with the restrictions of the P-100 order the following rating statement is placed on the order and signed by the responsible official:

"Material for Maintenance, Repair or Operating Suppliers, under Preference Rating Order P-100 with the terms of which I am familiar."

With certain restrictions, the P-100 order in general provides for maintenance, upkeep and operation of a producer's property and equipment. As applied to roads and highway the "property" to be repaired and maintained comprises the highways, bridges and rights of way under highway administration and the equipment and building, owned by the department.

The P-100 may be used also by a contractor to repair and maintain equipment owned or leased by him. This order may not be used to obtain delivery of new equipment for replacement or as additions. Neither may the P-100 be used to obtain critical materials where substitutes are available such as metal culvert pipe, metal road signs, metal rope or cable for guard rail, metal plate guard rail, or reinforcing steel and under no circumstances to obtain rubber or burlap for highway use.

It may be seen then the trend in priorities is toward tightening of the loopholes in the system to prevent the unjustified use of needed war materials.

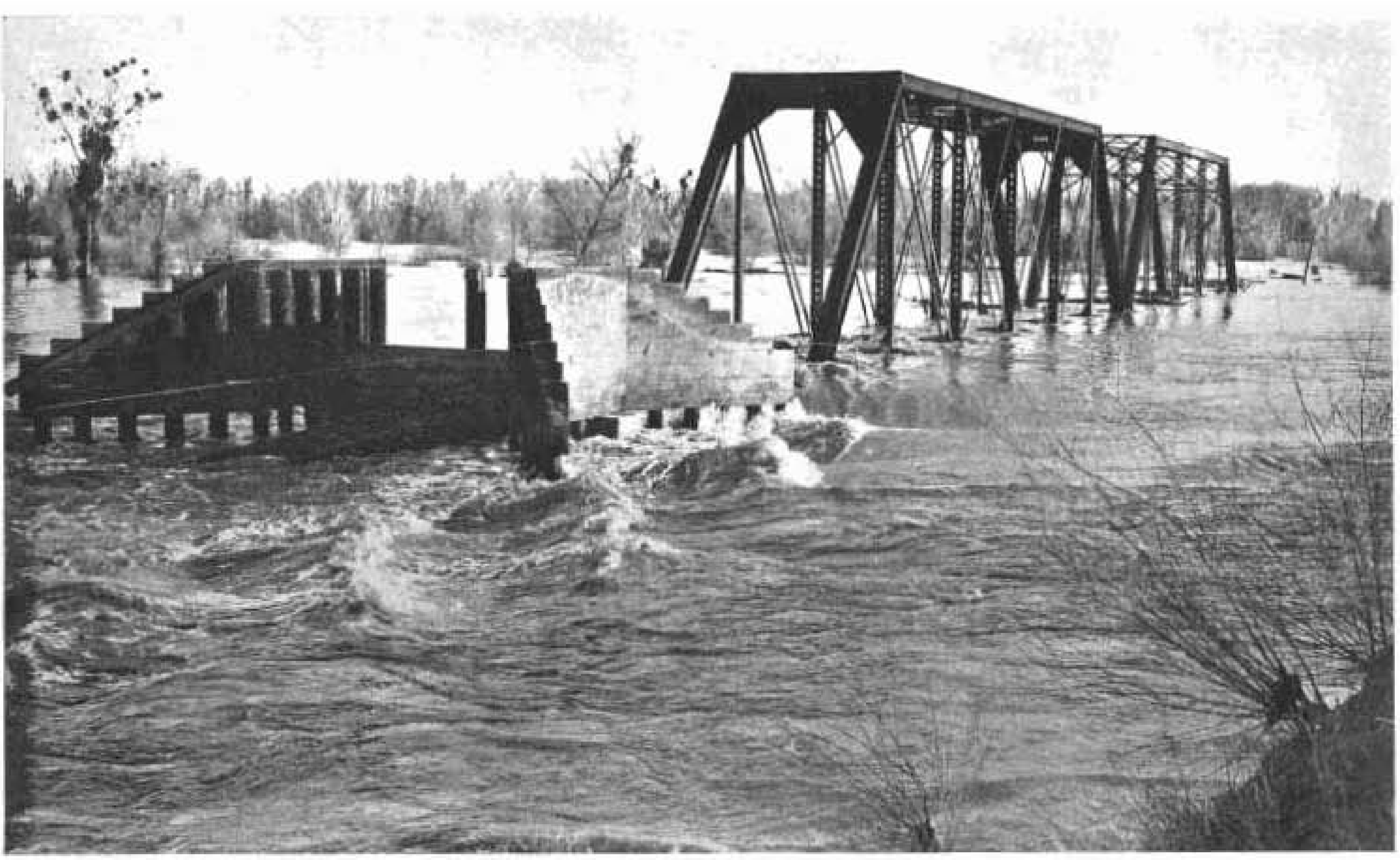
While priorities may be a continuous source of irritation to the constructor or designer, we must realize it or a similar system is necessary in order to provide for distribution to the greatest needs. As the war situation changes we may expect corresponding changes in priority regulations.

Bay Bridge will be Insured for $33,750,000

Reinsurance of the San Francisco-Oakland Bay Bridge, which was hampered by the European war, has been assured by a group of San Francisco and eastern brokers according to an announcement by Director of Public Works Frank W. Clark, who is Secretary of the California Toll Bridge Authority.

The bridge will be insured for $33,750,000 as soon as negotiations on the terminology of the insurance policy are completed. The coverage for damage will be the same as has been in effect under the original policies and will be in accordance with bond indenture requirements, Director Clark said.

A considerable portion of expiring insurance on the span was covered by London and European brokers.



Portion of railroad bridge span damaged by February break of Feather River levee in Reclamation District 803

Feather River Flood Did $2,086,000 Damage

FLOOD waters in the Sacramento Valley early in February caused peak flows in the Sacramento River which exceeded at some points the all-time high peak of record set during the February-March storm of 1940.

When the extent of the storm made it apparent that extremely high stages would be reached on the rivers in the valley, State Director of Public Works Frank W. Clark ordered that all possible measures be taken to protect the flood control works under State operation. In addition telegrams were sent to 31 reclamation districts in the flood path informing them of the dangerous stages of the rivers and requesting the districts to maintain patrols on all levees. Emergency patrol crews were placed in all portions of the Sacramento River Flood Control Project under the jurisdiction of the State and additional crews were ordered into the field to combat wave wash and strengthen those portions of the levees which appeared to be weakening.

In spite of the extremely high peaks reached along the Sacramento River, the Flood Control Project successfully carried these flows at all points where levees had been brought up to grade and standard. One serious break occurred near the junction of the Feather River flood channel and the Sutter By-pass in the north levee of the Feather River protecting Reclamation District 803 which had not been rebuilt to standards recommended by the United States Army Engineer Corps for that portion of the project.

DANGER FORESEEN

State Engineer Edward Hyatt, in a letter to Reclamation District 803 on January 9, 1942, pointed out that the levee was in a dangerous condition and advised the district that repairs should be made immediately.

A small amount of repair work was ordered by the district and a patrol maintained as the Feather River approached flood stage, but on the morning of February 8th a break occurred in the levee near the point where the Southern Pacific Railroad line from Knights Landing to Yuba City crossed the levee.

The break quickly widened to a breach 150 feet wide through which a large volume of water was pouring into Reclamation District 803. Emergency crews under the direction of the State Engineer were immediately put to work reinforcing the back levee of the district, not with any hope of stopping the flood waters, but to give farmers in adjoining Reclamation District 823 and Levee District No. 1, an opportunity to move out live stock and farm equipment before their places were inundated. The flood was held here for five hours.

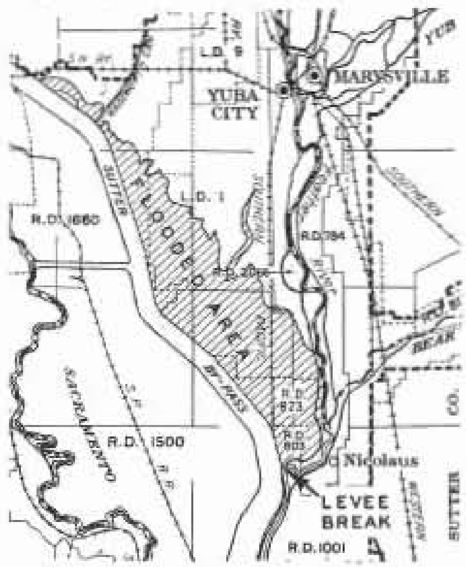
When the flood waters topped the low back levee of District 803, the emergency crews withdrew to the back levee of Reclamation District 823. Here again the waters were checked for an additional seven hours.

By reason of this delaying action on the part of the emergency crews, virtually all of the 6,000 head of live stock in the area were saved, and in addition to moving farm equipment out ahead of the flood waters, many farmers moved their household furniture as well.

Approximately 1,500 persons were evacuated from the area without loss of life.

Before the flood waters abated some 32,000 acres of highly developed and comparatively densely settled farm lands in Sutter County were inundated. At the request of the State Engineer Sutter County officials made a preliminary survey of the flooded area and estimated the possible property and crop damage at $2,086,000.

County estimates were: Farm improvements, $300,000; farm equipment (largely dehydrators, and other heavy equipment that could not be moved), $50,000; railroads, $104,000; highways, $32,000; possible peach



Sketch map of flooded area

crop damage, $1,260,000; other tree crops, $240,000; miscellaneous crops and forage, $100,000.

In addition various portions of the Sacramento River Flood Control Project works sustained damages estimated at $250,000.

As soon as the extent of the flood was determined the State Engineer conferred with Colonel W. T. Hannum, Colonel R. C. Hunter and Henry Rich of the U. S. Engineer Corps to lay plans for closing the breach and draining the inundated area. Ten days after the break occurred equipment was being moved in to begin closing the break. J. R. Morton, of the Marysville office of the U. S. Army Engineer Corps, is in charge of the work.

Less than a week later two-thirds of the break, which had widened to 350 feet, was temporarily closed. The remainder was left open for draining the area, but will be closed immediately if a second storm should cause a rise in the Feather River or Sutter By-pass.

Both No. 1 and No. 2 pumping plants, which are operated by the State for drainage in the area, were in the path of the flood and put out of commission. By March 1st, however, the water had drained from the area to a point where Pumping Plant No. 2 could be operated again.

(Continued on page 16)

Break in Feather River levee of Reclamation District 803, Sutter County, that flooded 32,000 acres of farm lands

Designing Foundation Courses For Highway Pavements and Surfaces

By FRED J. GRUMM, Engineer of Surveys and Plans

The following article is a summary of the principal features of an article bearing the same title which appeared in the November, 1941, issue of this magazine, with additional information intended to supply the answer to many requests for more detail.

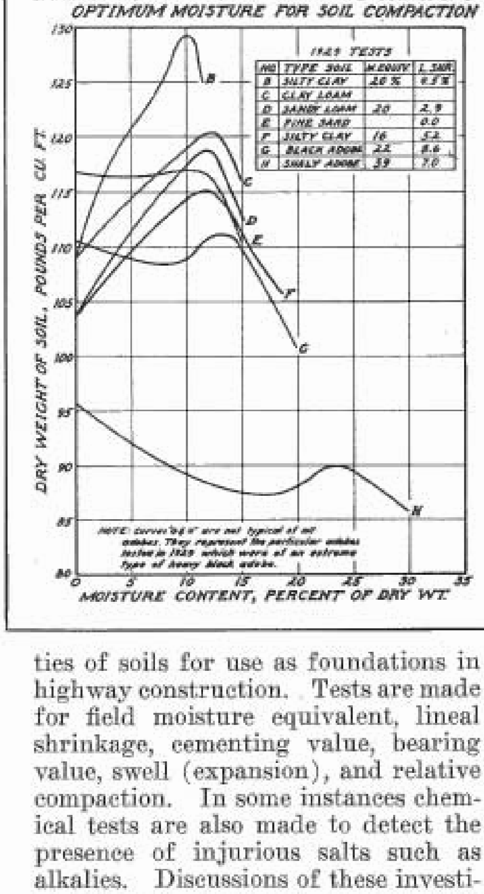
INTENSIVE investigations have been undertaken by many universities, State highway departments, and other engineering agencies to determine the properties of various soils and soil and gravel combinations as support for pavements of various types in order to provide a rational basis for economical highway design.

Choice of a pavement must rest largely on two important factors: the number and magnitude of loads to which it will be subjected and the quality of materials economically available for its support. If foundation materials are poor, and moderate to heavy loads are indicated, the pavement itself may be of a type having considerable structural or "beam" strength, thus reducing the unit stresses transmitted to the subgrade within the limits prescribed for that material. On the other hand, if the surface required is for light to moderate loads and materials with high supporting qualities are available for the foundation, it will probably be found that the most economical design consists of a flexible type surfacing. This latter type has no beam strength and little, if any, greater load spreading characteristics that an equal thickness of well graded crushed rock or gravel and should, therefore, be supported by a "ballast" or base course of sufficient thickness and high enough bearing value to withstand the unit stresses to which it will be subjected.

SOIL INVESTIGATIONS

The Materials and Research Department of the California Division of Highways, under the direction of T. E. Stanton, Materials and Research Engineer, has for many years studied the problem of determining the qualities of soils for use as foundations in highway construction. Tests are made for field moisture equivalent, lineal shrinkage, cementing value, bearing value, swell (expansion), and relative compaction. In some instances chemical tests are also made to detect the presence of injurious salts such as alkalies. Discussions of these investigations may be found in an article "Highway Soil Studies" by Mr. Stanton, which appeared in the June, 1938, issue of this magazine, and a paper by O. J. Porter, Senior Engineer in the Materials and Research Department, who is largely responsible for the development of our bearing value tests, titled "The Preparation of Subgrades," which appeared in the Proceedings of the Eighteenth Annual Meeting of the Highway Research Board, Part II, December, 1938.

FIG 2
CURVES SHOWING TEST RESULTS USING CALIF. DIV. OF HWY. METHOD FOR DETERMINING OPTIMUM MOISTURE FOR SOIL COMPACTION



Experience and observation have shown that the bearing value and expansion tests are of primary significance in determining the qualities of a soil proposed for use in a pavement foundation. These tests are related, and, while modified from time to time, are performed in general as follows:

The sample received from the field is scalped to retain only the material passing a sieve with ¾-inch square openings. A test sample consisting of about 5,000 grams of well graded material or about 4,000 grams of fine material, such as sand, is prepared by separating into three sizes: 1. Material passing a No. 4 sieve; 2. Material passing a ⅜-inch sieve and retained on a No. 4 sieve; and 3. Material passing a ¾-inch sieve and retained on a ⅜-inch sieve. Whenever possible the material is tested with the grading exactly as received from the field. When oversize particles prevent testing by this method, the representative grading is maintained by compensating for the amount of material retained on the ¾-inch sieve by increasing the amounts of the two sizes retained on a No. 4 sieve in about equal proportions, keeping the amount of material passing a No. 4 sieve constant. This method in practically all cases represents the poorest condition to be encountered in the field, as the presence of larger particles would increase the bearing value.

MAXIMUM COMPACTION

The prepared test sample is mixed with sufficient water to obtain maximum compaction. This involves several trials with varying moisture content to establish a curve, as shown in Figure 2. When many tests are being made, an experienced operator can determine the proper amount of moisture for satisfactory results without taking the time for numerous trials.

The test sample is then placed in a cylindrical bronze mold, 8 inches in height and 6 inches in diameter, equipped with a base plate of the same material which can be fastened on either end of the mold by friction lugs, and consolidated by applying a load of 2,000 pounds per square inch with a hydraulic jack illustrated by type "A" in Figure 1.

After consolidation, the height of the compacted material is measured, and then a piston with a cross-sectional area of three square inches, in the hydraulic jack illustrated by type "B" in Figure 1, is set on top of the compacted specimen, the Ames dial is set at 0.0 inches, and a load applied to produce a penetration of 0.05 inches per minute. The loads required to cause succeeding penetrations of 0.1 inch, 0.2 inch, 0.3 inch, 0.4 inch and 0.5 inch are recorded. When this is finished, the top inch or two of the material is disturbed, and the base plate is placed on the opposite end of the mold with filter paper placed between base plate and mold. The material is then recompacted with a load of 2,000 pounds per square inch, and the height measured. A filter paper is then placed on top of the specimen and a perforated bronze plate about ¼-inch in thickness and about 5¾-inches in diameter is placed over this. The distance from the top of the mold to the perforated plate is measured with a depth gauge graduated to 0.01-inch intervals. The specimen is then placed in a tank of water to soak, with a bronze weight of 10 pounds placed on top of the perforated plate. The height of the material is measured every day up to a maximum of four days, and when the swell ceases the sample is again placed in the hydraulic jack and tested for bearing value.

The hydraulic jacks described above are for use in making tests in the various districts. Final results, especially on critical materials, such as selected base and imported borrow materials, are based on tests made with a specially designed bearing value machine, making the same type of test with greater refinement, in the Headquarters Laboratory in Sacramento. Tests in District VII are made in a similar machine in Los Angeles.

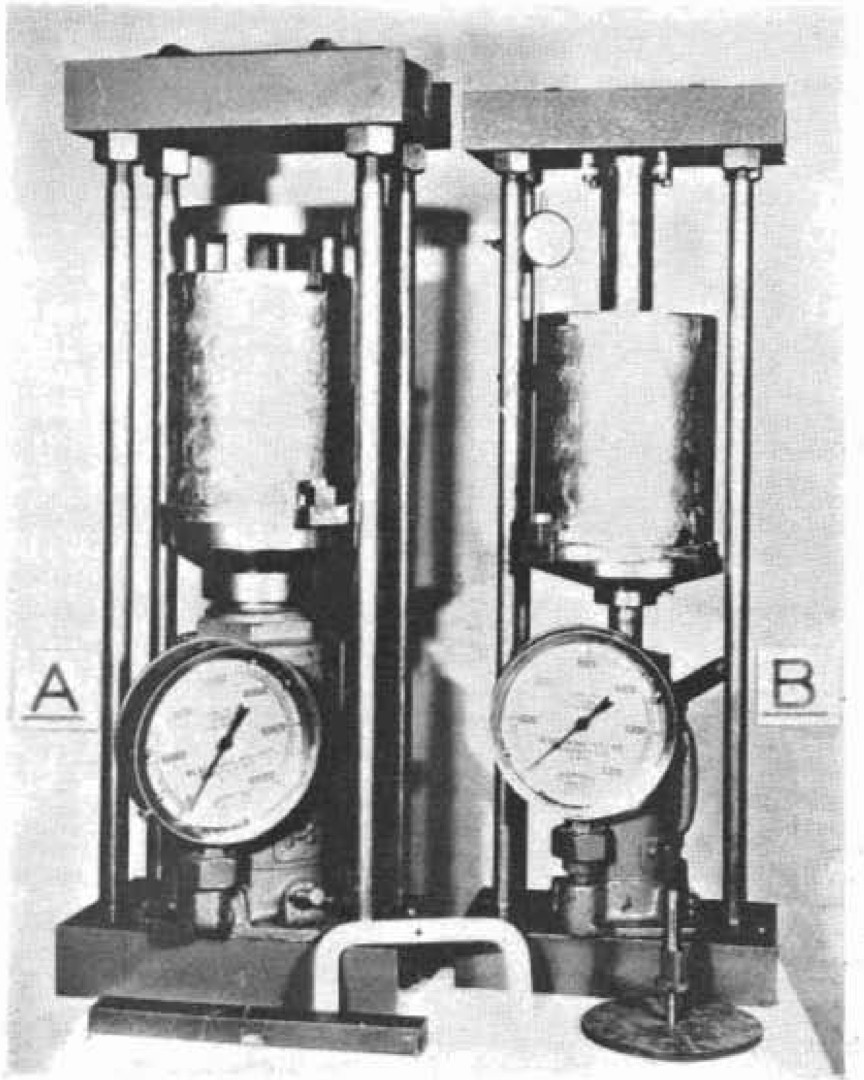


Figure 1—Hydraulic jacks compression testing assemblies. A—For consolidating soil sample. B—For bearing test

BEARING VALUES

The bearing values are listed in percent of a standard load which has been determined from our experience. The standard loads are as follows:

	Loads in pounds per square inch	
Penetration	Soaked	Unsoaked
0.1 inch	2,000	1,000
0.2 inch	2,800	1,500
0.3 inch	3,400	1,900
0.4 inch	3,800	2,300
0.5 inch	4,300	2,600

We have found that the bearing value at 0.1-inch penetration, compacted and soaked, is probably the most reliable indication of the quality of the soil. This must not be taken to mean, however, that careful study should not be made of all the characteristics of the soil sample, including the bearing values at all penetrations, both soaked and unsoaked, in order to make a proper evaluation of the qualities of the material. On the basis of bearing values at 0.1-inch penetration, compacted and soaked, we have prepared a chart of desirable total thickness of base and surfacing over soils of various bearing values, shown in Figure 3.

FACTORS IN DESIGN

At the present time we are striving to attain the following standards in subgrade construction:

Portland cement concrete pavement: subgrade consisting of a minimum depth of one foot of material with a minimum bearing value of 20 per cent at 0.1-inch penetration, compacted and soaked, and swell less than 3 per cent.

Cement treated base: subgrade consisting of a minimum depth of one foot of material with a minimum bearing value of 20 per cent at all penetrations, compacted and soaked, and swell less than 3 per cent.

Asphalt concrete: subgrade consisting of a minimum depth of one foot of material with a minimum bearing value of 30 per cent (preferably 50 per cent) at 0.1-inch penetration, compacted and soaked, and swell less than 3 per cent.

Bituminous surfacings: subgrade to be from 6 inches to 24 inches in depth, dependent on underlying soils, climate and traffic, the top 6 inches to be composed of material with a minimum bearing value of 80 per cent at 0.1-inch penetration, compacted and soaked, with swell less than 3 per cent. Approximate depths of succeeding blankets of lower quality materials may be secured from the chart.

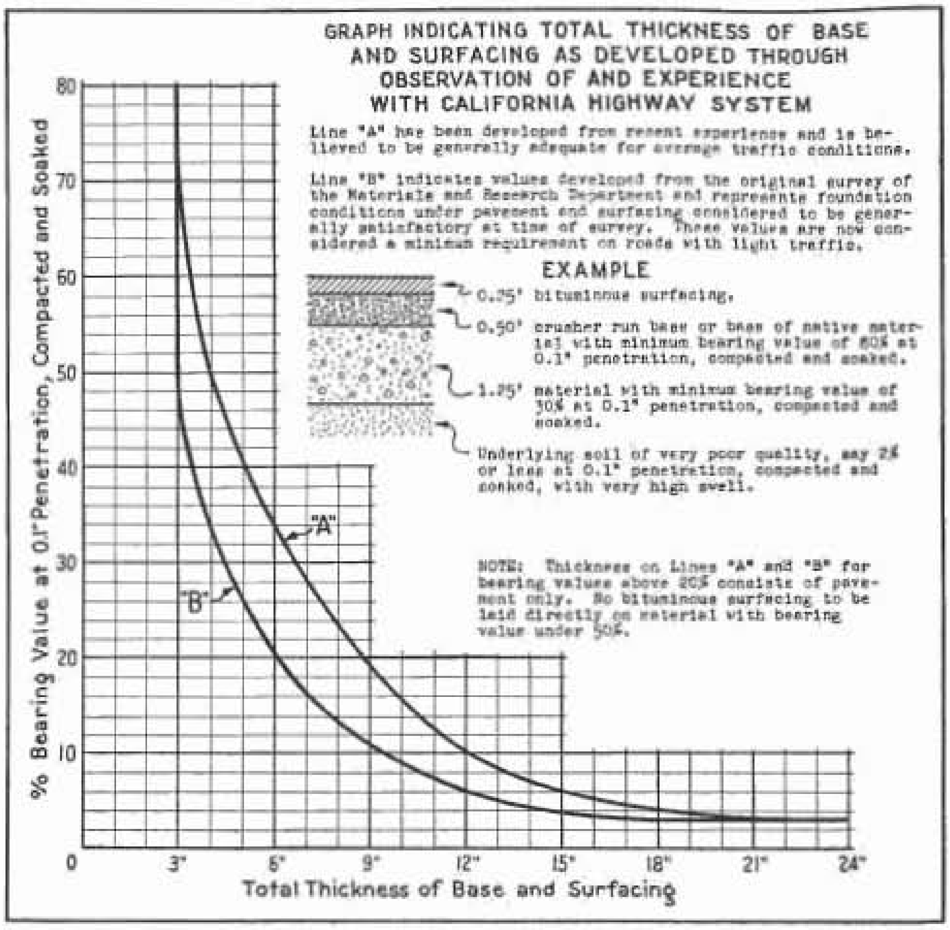


Figure 3—Showing relation between subgrade bearing value and total thickness of base and surfacing

LOAD DATA

The other very important factor in design is the determination of the number and magnitude of loads to which the pavement will be subjected. To use this information intelligently, we must equate the loads to a chosen standard. For example, we have all seen roads which have given many years of service under large volumes of light traffic fail almost instantaneously when, for some reason, continuous heavy truck traffic is routed over them.

Our adoption of a standard wheel load and "weighted" figures to apply to other loads in order to secure the total number of equivalent repetitions of the standard load is based on studies of the behavior of portland cement concrete pavement under load stress; studies of the work of Dean H. M. Westergaard, who is responsible for developing the first rationalized analytical theory of stress calculation for portland cement concrete pavement, and a later book, "Reinforced Concrete Pavements," by Royall D. Bradbury, of the Wire Reinforcement Institute, published in 1938. A table on page 60 of the latter book, based largely on investigations of the Illinois Division of Highways, is referred to later in our methods of determining equivalent load repetitions.

The basis of all practical data, is, of course, the actual counting and weighing of vehicles on the highway. These data have been accumulated by our Highway Planning Survey conducted in cooperation with the Public Roads Administration.

With these traffic data in hand, various highway surfacings have been observed and studied in the field and their behavior and condition correlated with the data. Credit for much of the study and information secured therefrom is due to A. M. Nash, until recently Assistant Engineer of Surveys and Plans, and now Assistant District Engineer of District IV in San Francisco.

Probably the best explanation of the method of computation used is an example, which is shown in Figure 4.

Table 1 shows the method of compiling and computing traffic data and equivalent wheel load repetitions.

Table 2 is copied from a page of the traffic data tabulation prepared by our Highway Planning Survey, and shows *average daily traffic* both from the standpoint of *total traffic* as well as *truck* or *commercial traffic*. These data are developed each year from our annual State-wide 16-hour (6 a.m. to 10 p.m.) traffic counts taken for two days in each July (a Sunday and a Monday). These annual traffic counts are analyzed and proper equating factors applied to convert them to 24-hour *daily average traffic*, which is the figure shown in the tabulation. The proper factors for each section have been developed from data accumulated at automatic recorder stations, continuous count stations, special count stations, etc. These are constantly being verified and extended.

Table 3 represents a page from the tabulation prepared by the Highway Planning Survey of the results of its State-wide study of the type, character and weight, and relative distribution, of the commercial increment of traffic using the State highways. Some 106 stations were established at strategic locations throughout the State, at each of which a representative cross-section of commercial traffic was sampled to form the basis of the data shown in Table 4. The data

(Continued on page 20)

FIGURE 4

ROAD VI-KER-4-E

Loadometer Station L-52

Limits: South of Famoso____

Average daily traffic (1940)________________ 6629 }
Average daily commercial traffic 1940_________ 1442 } Average=2163
Est. average daily commercial traffic 1950____ 2884 }

2163 x 365 x 10 x 2.88=22,737,456 axle loads in 10 years

Wheel Load Groups

1. 4500-5500 _____ 10.71%=2,435,182 x 1= 2,435,182 }
2. 5500-6500 _____ 9.61%=2,185,076 x 2= 4,370,140 }
3. 6500-7500 _____ 11.96%=2,719,400 x 4=10,877,600 } Estimated equivalent 5000 pound wheel loads in 10 years
4. 7500-8500 _____ 6.02%=1,368,795 x 8=10,950,360 }
5. 8500-9500 _____ 3.40%= 773,074 x 16=12,369,184 }
6. 9500 and over_ 0.91%= 206,911 x 32= 6,621,152 }

Total estimated equivalent 5000# wheel loads in 10 years___ 47,623,618
Design repetitions (traffic in one direction)______________ 23,811,809
REMARKS: Loadometer station at Junction of Routes 4 and 33 at Famoso.

TABLE 1

RURAL STATE HIGHWAY SYSTEM TOTAL AVERAGE DAILY TRAFFIC AND AVERAGE DAILY TRUCK TRAFFIC 1940

Roads are arranged in order by County, Route and Section

County	*Route*	*Section*	*Total average daily traffic*	*Average daily truck traffic*	*Trucks, percent of average daily traffic*
INY	128	A	73	13	18
KER	4	A	6123	1131	18
		B	6110	1222	20
		C	8553	1913	22
		D	7886	1517	19
		E	6629	1442	22 ←
		F	5975	1418	24
		G	8272	1701	21
KER	23	A	1658	322	19
		B	826	157	19
		C	747	155	21

TABLE 2

GROSS WEIGHT DISTRIBUTION OF COMMERCIAL OUTFITS

Loadometer Station No. 52

Location, Famoso-Junction Routes 4 and 33

Direction and route	*North on 4*		*South on 4*		*West on 33*	
Gross weight of outfit in pounds	*Number*	*Per cent Cumulative*	*Number*	*Per cent Cumulative*	*Number*	*Per cent Cumulative*
Under 10,000____	232	37.5	178	30.1	141	48.3
" 20,000____	365	59.0	324	54.8	204	69.9
" 30,000____	460	74.3	426	72.1	238	81.5
" 40,000____	519	83.4	478	80.9	258	88.4
" 50,900____	556	89.8	529	89.5	267	91.4
" 60,000____	580	93.7	546	92.4	272	93.4
" 68,000____	599	96.8	560	94.8	279	95.5
" 80,000____	616	99.5	582	98.5	291	99.7
" 90,000____	619	100.0	591	100.0	292	100.0
Average gross weight __________	21,350		23,566		17,890	
Average axle weight __________	7,138		8,179		6,133	
Ratio $\frac{\text{Aver. gross wt.}}{\text{Aver. axle wt.}}$ ____________	2.99		2.88 ←		2.92	

TABLE 3

ANALYSIS BASED ON SPRING-SUMMER STRESSES

Induced stress (lb. per sq. in.) (1)	*Equivalent wheel load in pounds* (2)	*Equivalent repetitions divided by actual repetitions* (3)	*Multiplier of previous figure* (4)	*California adopted factors* (5)
396	5,000	$\frac{600}{600} = 1$		1
			2.667	
416	6,000	$\frac{1467}{550} = 2.667$		2
			2.454	
435	7,000	$\frac{3273}{500} = 6.546$		4
			2.391	
454	8,000	$\frac{7044}{450} = 15.653$		8
			2.091	
472	9,000	$\frac{13091}{400} = 32.728$		16
			2.200	
489	10,000	$\frac{25200}{350} = 72.000$		32

TABLE 6

DISTRIBUTION OF AXLE WEIGHTS AT LOADOMETER STATIONS

Station No. 52. Location, Famoso
Direction, S. on Rt. 4. Total Outfits, 490

Axle weight, lbs.	Axle designation A	B	C	D	E	F	G	Total	Per cent
Less than 1,000									
1,000- 1,999	43	16	3	1				63	4.12
2,000- 2,999	78	32	14	9	4	2		139	9.09
3,000- 3,999	138	37	10	10	7	3		205	13.40
4,000- 4,999	70	26	17	9	4	3		129	8.43
5,000- 5,999	51	33	11	9	6	3		113	7.39
6,000- 6,999	29	22	19	8	2	1		81	5.29
7,000- 7,999	23	36	10	5	2	1		77	5.03
8,000- 8,999	24	23	11	10	2	1		71	4.64
9,000- 9,999	19	27	21	9	1	3	1	81	5.29
10,000-10,999	13	25	24	16	4	1		83	5.42
11,000-11,999	2	16	15	18	5	6		62	4.05
12,000-12,999		25	30	19	6	5		85	5.56
13,000-13,999		30	19	24	7	4		84	5.49
14,000-14,999		44	22	17	11	5		99	6.47
15,000-15,999		31	5	13	5	3		57	3.73
16,000-16,999		17	6	8	3	1		35	2.29
17,000-17,999		20	5	2	2			29	1.90
18,000-18,999		18	2	1	2			23	1.50
19,000-19,999		6	1			1		8	.52
20,000 and over		6						6	.39
Totals	490	490	245	188	73	43	1	1,530	100.00
Accum. axle wt. in 100 lbs.	22,059	48,111	23,500	19,481	7,524	4,380	90	125,145	
Avg.axle wt.in 100 lbs.	45	98	96	104	103	102	90	8,179	

TABLE 4

	Induced stress (lb. per sq. in.)	*Per cent of mod. of rup. strength*	*Repetitions required to cause rupture*	*Actual repetitions per year*	*Equivalent repetitions per year based on stress of 396 lb. per sq. in.*	
Spring-Summer	396	52.8	360,000	600		600
	416	55.5	135,000	550	$550 \times \frac{360,000}{135,000} =$	1,467
	435	58.0	55,000	500	$500 \times \frac{360,000}{55,000} =$	3,273
	454	60.6	23,000	450	$450 \times \frac{360,000}{23,000} =$	7,044
	472	63.0	11,000	400	$400 \times \frac{360,000}{11,000} =$	13,091
	489	65.2	5,000	350	$350 \times \frac{360,000}{5,000} =$	25,200
Fall-Winter	313	41.3	Infinite	600		0
	333	44.4	Infinite	550		0
	352	47.0	Infinite	500		0
	371	49.5	Infinite	450		0
	389	51.9	520,000	400	$400 \times \frac{360,000}{520,000} =$	277
	406	54.2	220,000	350	$350 \times \frac{360,000}{220,000} =$	573
					Total=	51,525

$$\text{Crack expectancy} = \frac{360,000}{51,525} = 7 \text{ years}$$

The above table is copied from page 60 of "REINFORCED CONCRETE PAVEMENTS," by Royall D. Bradbury, published by the WIRE REINFORCEMENT INSTITUTE in 1938.

TABLE 5

Before pictures of danger points on highway that called for widening, realignment or replacement

Santa Barbara Improvemer

By L. H. GIBSC

THE completion of two major projects on the Coast Highway marks another milestone in the progressive improvement of this road in Santa Barbara County. The two projects are located along the ocean shore between Tecolote Creek and Las Varas Creek and between Orella and 1 mile west of Canada del Refugio.

This reconstruction consisted of three separate contracts and was started in August, 1940, when a contract was awarded to Basich Brothers of Torrance for grading and surfacing the section between Tecolote Creek and Las Varas Creek, a length of 3.4 miles.

In September, 1940, a contract was awarded to Carl Hallin for the construction of a new reinforced concrete girder bridge across Dos Pueblos Creek within the limits of the road contract. A third contract was awarded in October, 1940, to Basich Brothers for the grading and surfacing between Orella and 1 mile west of Canada del Refugio, a length of 2 miles.

Traffic using this route has varied from an average of 2,000 cars per day in the winter months to 6,000 in the summer, with particularly heavy concentrations on Sundays and holidays as recreationists sought the beach areas. For this volume of traffic the alignment, grade and surface on both of these sections were considerably substandard.

The designs for the new sections were made to eliminate these obsolete features. Comparative tabulation between the old and new sections of highways clearly indicates the improvements effected by the reconstruction.

	Tecolote Creek to Las Varas Creek		Orella to One Mile West Canada del Refugio	
	Old	New	Old	New
Total number of curves	8	4	10	4
Total curvature	146°	63°	210°	211°
Minimum Radius	358 ft.	5000 ft.	700 ft.	1000 ft.
Maximum Grade	6.5%	3.1%	6.8%	3.9%
Minimum vertical sight distance	320 ft.	1400 ft.	320 ft.	875 ft.
Minimum horizontal sight distance	240 ft.	900 ft.	360 ft.	475 ft.

County
ts Completed

N, District Engineer

In the design of the section between Tecolote Creek and Las Varas Creek the new standards of construction are those for a high type of two-lane thoroughfare. On the Orella portion of the route, however, the road at Canada del Refugio was restricted between the location of the railroad on the ocean side and the rapidly rising hills on the north.

4-LANE MOVE EXPEDIENT

The cost of the necessary heavy grading for construction to similar standards of curvature required for modern two-lane highway was such that it was found more expedient to somewhat reduce the standards of alignment and construct the road as a four-lane divided highway.

Soil conditions throughout both of these sections are poor and a one-foot blanket of imported borrow was placed over the full width of the roadbed to insure a suitable foundation. A base course six inches in thickness was constructed of cement treated aggregate.

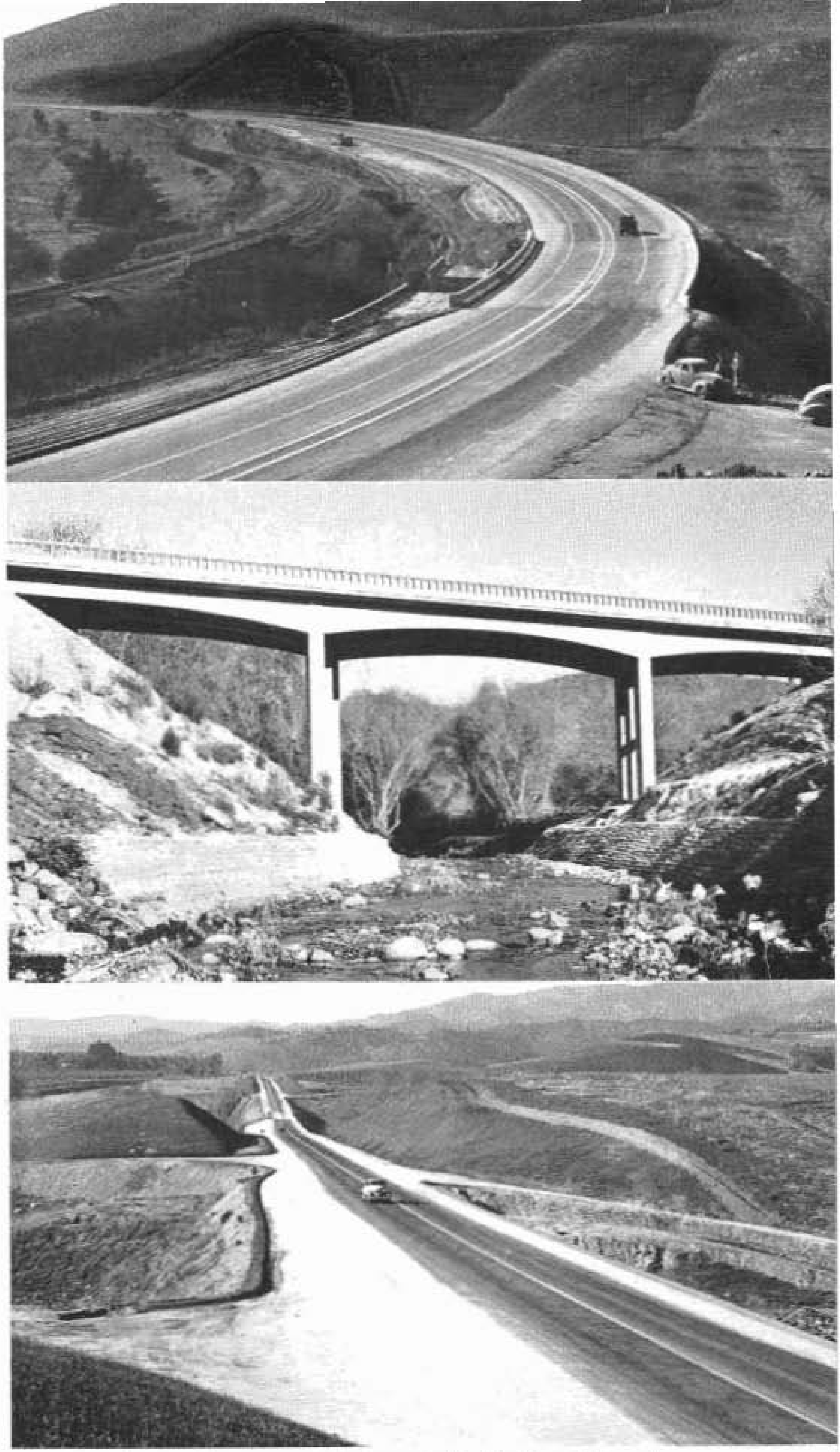
The surface placed on top of this base consists of a plant-mixed surfacing three inches in thickness. On the two-lane sections the roadbed was graded to a width of 36 feet with a cement treated base being 24 feet in width and the surfacing 22 feet in width.

On the four-lane portions the roadbed was graded 64 feet in width and the cement treated base was constructed 50 feet in width, with the surfacing 50 feet in width. The shoulders and gutter or dike were surfaced with plant-mix surfacing on both projects.

DRAINAGE STRUCTURES INSTALLED

The work in the construction of the section between Tecolote Creek and Las Varas Creek involved 381,000 cubic yards of roadway excavation, 35,000 cubic yards of imported borrow, 13,000 tons of cement treated

(Continued on page 16)



After pictures of improvements that remedied bad traffic conditions shown on adjoining page

Problems Of Highway Maintenance Arising Out Of The War Emergency

By W. A. SMITH, Assistant Maintenance Engineer

PROBLEMS faced by the Division of Highways organization in maintenance of the State highways during the war were discussed by the Maintenance Engineers from all districts in the State at Sacramento on February 24th and 25th.

Mr. Franz R. Sachse, Assistant Director of Public Works, Mr. G. T. McCoy, Assistant State Highway Engineer and Mr. Robert E. Reed, Attorney of the Division of Contracts and Rights of Way, presented the general view of these problems. In addition to maintenance work, matters relating to personnel, accounting, equipment and safety and traffic were taken up and discussed at length with the heads of the respective departments. The meeting was conducted by Mr. T. H. Dennis, Maintenance Engineer.

The effect of the rationing of tires and automobiles on California's income from the gasoline tax was discussed and it was pointed out that the Division of Highways is going to have less money with which to carry on normal work and the Maintenance Department is going to feel the impact from reduced revenues. It is certain as time goes on, the engineers were told, you will find an increased problem in maintaining roads originally built for light normal traffic which now are required to carry heavy military traffic.

The effect of curtailment of traffic on highway revenues will become apparent beginning with the April collections. This is due to the lag of two months between levy and collection. It is impossible to make a firm estimate as to probable decrease in revenue.

Several factors affecting the highway maintenance work were brought out during the conference. The more serious of these matters are as follows:

1. Accelerated damage to highway surfaces due to general increase in hauling is already apparent.

2. A further increase in bus and truck traffic must be anticipated along with the decline in passenger car traffic as the war effort intensifies. This is the portion of the traffic which most seriously damages the road surfaces.

3. Limiting of reconstruction of highway surfaces; first, by reduction in revenue available for the purpose; and, second, effect of Federal regulations limiting priorities for securing materials and equipment to projects which are either on access highways or on the strategic network.

4. Evidence that damage to the surfaces on nonstrategic highways is as great as on the strategic highways. This is especially serious as the military and defense work forces will necessarily use these roads without regard to their condition and without considering the fact that funds for construction will be limited or not available. Estimates of damage to highway surfaces by defense hauling in recent months shows a total of over $1,600,000 is required for adequate restoration. Of this amount some 64 per cent is required on nonstrategic highways.

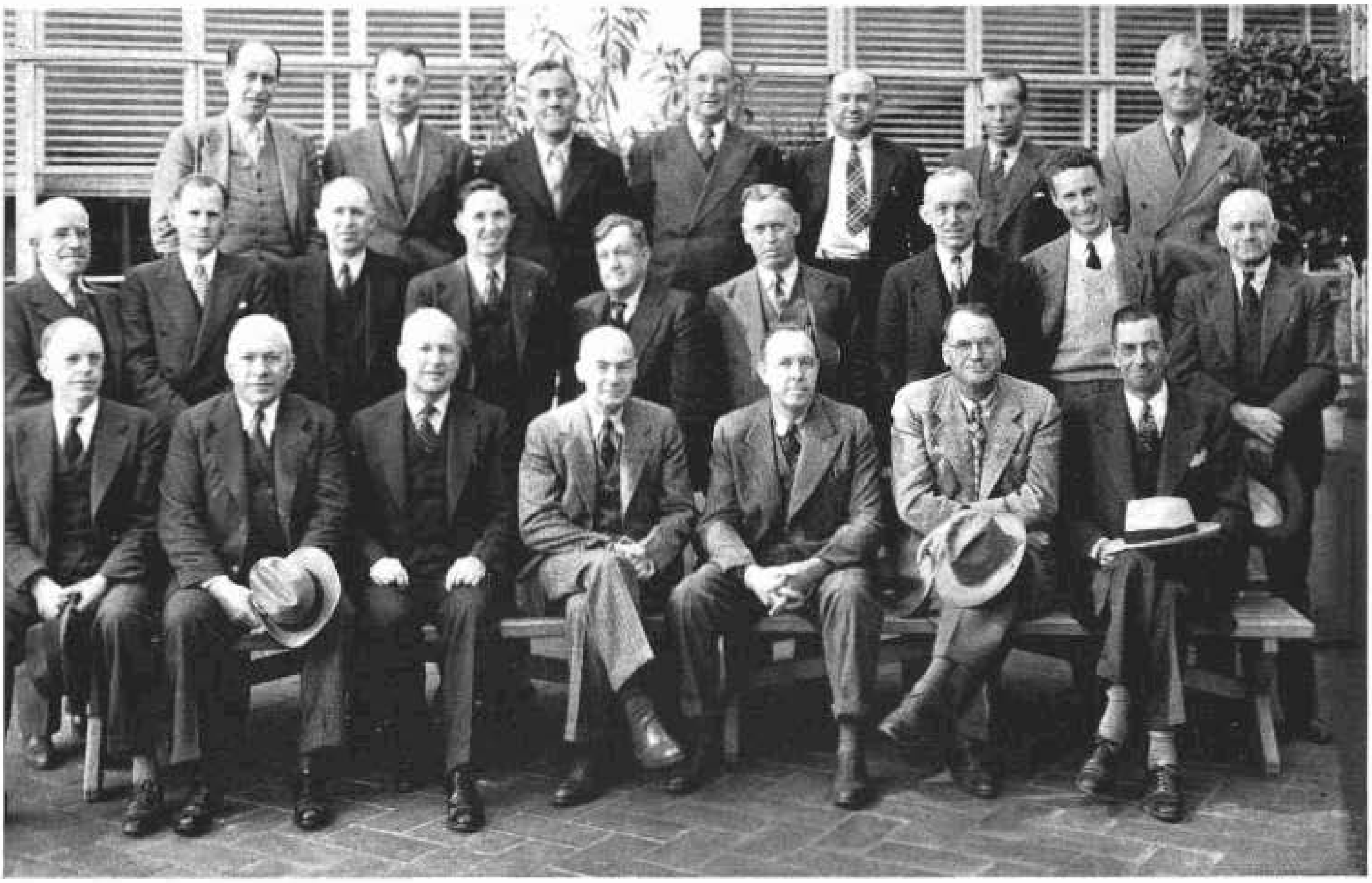
5. Difficulties in securing materials and in connection with keeping up equipment and the organization are foreseen. Maintenance of highways involves considerable quantities of materials. Securing these materials in the face of military needs for surfacing airports and for other defense projects is increasingly difficult. This same situation applies in regard to equipment. In the past the division has rented privately owned trucks, power shovels, tractors and similar heavy equipment in considerable amounts each year to work on slide removals and surface repair work. This equipment is now working full time on defense projects and there is no assurance it will be available as in the past. The maintenance forces must therefore rely on use of State-owned equipment. Replacement of worn out equipment is uncertain and even the securing of replacement parts will involve delays.

Most of the men in the organization are experienced along engineering, mechanical or operating lines. When not called into the armed forces many of them are tempted to consider employment either with contractors or defense plants. The State service can not compete with private industry in rates of pay or the opportunity for making extra money by overtime work. In some cases there is a feeling, also, that it is more patriotic to engage in such work but proper maintenance of the State highways is essential work both from the public and military viewpoint.

6. Reconstruction of surfaces on State highways has not kept pace with traffic demands or normal deterioration. The demands on State highway funds have been great especially since 1933 when the mileage in the system was practically doubled without extra allowance for financing. Restoration of surfacing has not kept pace with the deterioration resulting from use and weathering nor with obsolescence.

Reports of actual failures at many points and signs of impending failures at other locations were cited as evidence of this situation. Discussion emphasized that a program of restoration and strengthening the surface on at least 300 miles of the system should be undertaken this year in order to adequately serve traffic during and for a period immediately following the emergency. The financing of such a program is outside the scope of maintenance.

7. Possibilities of reduction in highway maintenance work: The conference devoted considerable time to discussion of this subject. Reduction in expenditures may be brought about either by elimination of certain functions or by lowering the standard of work. These measures may be applied either to a portion of the



Group of Maintenance Department executives of the eleven highway districts who attended Sacramento meeting to consider economy measures necessitated by war situation—Front row: H. B. La Forge, H. S. Comly, C. E. Bovey, T. H. Dennis, W. A. Smith, G. F. Hellesoe, J. E. Stanton. Second row: Thos. Eastman, H. L. Cooper, E. E. Evers, C. F. Woodin, R. H. Stalnaker, W. L. Fahey, F. L. Meyer, E. S. Whitaker, E. M. Cameron. Third row: R. B. Millard, N. R. Bangert, R. D. Kinsey, J. M. Hodges, J. C. Womack, C. E. Thompson, P. L. Fite.

highway system or uniformly to the system as a whole. As an offset against any savings which might thus be made, it was pointed out that there are increased expenditures inherent in the war emergency.

For example over $100,000 of the funds allocated for maintenance purposes have been expended since December 7, 1941, to pay wages of guards at important bridges, at stations where valuable equipment is stored and at powder magazines. This expenditure has been necessary to reduce the possibility of damage or destruction through sabotage which might close an important highway.

Delays in delivery of material, lost time in waiting on repair of equipment and changes in the personnel are all matters which can not be avoided and yet cause added expense in a time of emergency.

Work which can best be eliminated would, at first glance, include items of improved service such as reduction in traffic striping, highway lighting, weed eradication, spraying and burning roadside vegetation to reduce fire hazard, care of trees and shrubbery, snow removal, sanding icy pavement and placing nonskid surfacing.

Items of this kind represent some 12 per cent of the total amount budgeted for maintenance purposes. The work is of unquestionable public benefit but only a small part is essential to preservation of the highways.

Major expenditures in the improved service class include traffic striping and snow removal. The program for traffic striping is being reviewed with the thought of reducing the width of stripe, limiting the work to only the most important routes and lowering requirements as to visibility of the stripe. It is estimated annual expenditures for the work might be reduced $100,000 by applying such measures.

The program for snow removal may be reduced by eliminating work on strictly recreational routes and spring work on roads which are closed during the winter.

Consideration will be given to elimination of the program of spraying and burning roadside vegetation in selected areas next season. This latter program, while of no direct benefit to the highways, is important in reduction of fire hazard on adjoining property and has received general support from agricultural and lumbering interests in the past.

It should be kept in mind that programs such as traffic striping and highway lighting were undertaken solely to reduce hazard. Elimination of service at one point or in favor of retention of some other service must answer the test of necessity.

The care of roadsides normally requires over 30 per cent of the funds used for highway maintenance. For the 1940-41 season $3,158,800 was expended. Of this total $2,528,800 or 80 per cent was required for slide removal and storm damage repair. Such

(Continued on page 17)

Grading Completed For Widening Grapevine Grade From 3 to 4 Lane Highway

By E. T. SCOTT, District Engineer

THE first step in the elimination of one of the State's most hazardous stretches of highway has been completed. Griffith Company of Los Angeles have finished grading operations for the widening of Grapevine Grade on U. S. 99 from a three-lane to a four-lane divided highway.

Work just completed was along a portion of the Ridge Route in Kern County from Old Fort Tejon northerly and down hill on a continuous 6 per cent grade. The widening connects with the southerly end of a 19-mile stretch of four-lane divided highway extending north toward Bakersfield.

This important transportation route which connects Los Angeles with the San Joaquin Valley has a daily traffic average of nearly 6,000 vehicles, of which about 20 per cent are trucks and trailers.

Because of the 6 per cent grade on the Grapevine Grade, trucks travel at a very slow rate of speed, while traveling in either direction. Not being hindered by the grade, passenger vehicles traveling at a high rate of speed overtake the slow moving trucks.

If the truck is observed soon enough and if the center lane of the three-lane pavement is not occupied by vehicles moving in the opposite direction, nothing happens. Unfortunately conditions have not always been right, and the result has been that this 6-mile stretch of continuous 6 per cent grade down the hill has taken an annual toll for the past few years of from 10 to 14 killed and many more injured.

While the work just completed provides a wider roadway, the improvement of traffic conditions will have to await the widening of the pavement under a new contract which will be under way in a few weeks.

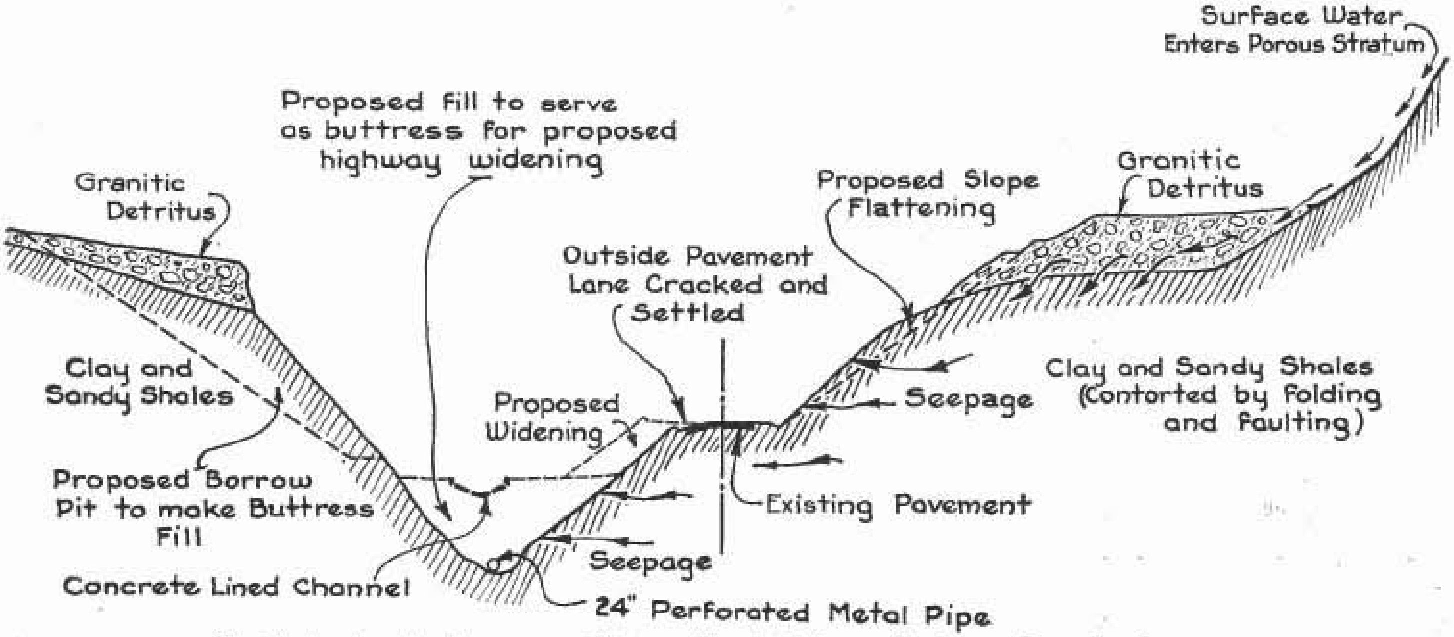
SLIDE STABILIZED

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

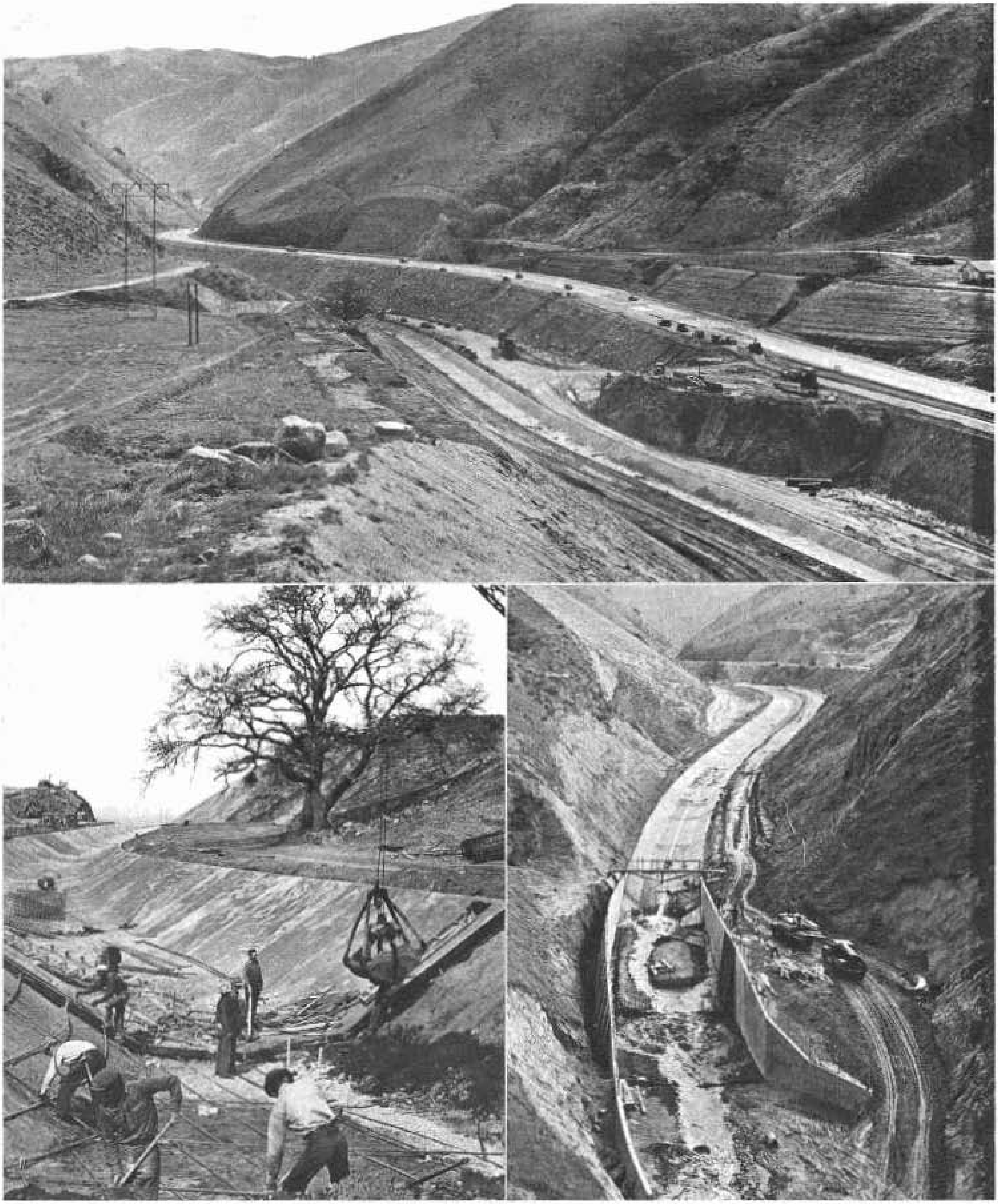
At various places along the hillside numerous holes were drilled by hydraugers. Starting at a point two or three feet above the highway gutter grade, the holes were drilled from two or three degrees above horizontal to 20 degrees above horizontal in order that any water encountered would flow freely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

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

The highway embankment was buttressed by filling the canyon below the roadway for a distance of nearly 2,000



Sketch showing plan for proposed buttress fill and highway widening on Grapevine Canyon



Top picture shows completed portion of flume, paralleling Grapevine Grade highway, for carrying creek waters past slide area. Lower pictures show work on reinforced concrete lining of flume and the special spillway construction at its lower end feet and to a depth of about 40 feet. To prevent the possibility of the creek cutting out this buttress fill, a concrete lined channel with special spillway at the lower end was constructed. Some 3,800 cubic yards of reinforced concrete were used and provided a channel capable of handling 3,000 second-feet of water. It has been said by persons dwelling on the hill above the highway, that since the buttress has been completed, ground vibrations previously felt when heavy trucks pass on the highway, have ceased.

HEAVY CURBING CONSTRUCTED

As a part of the contract, 3,000 lineal feet of heavy curb with a 15-inch vertical face was constructed on what will be the outside edge of a 10-foot shoulder on the down hill traffic lane. The curb is located near the top of the grade along a stretch of highway where in the past several trucks have gone out of control and have sought guard rail and other obstacles to rub up against to retard their speed. The curb as constructed more or less as an experiment, it is believed will be very effective in aiding runaway vehicles.

Grading operations, which involved over half a million cubic yards of earth and rock and the importing of about 60,000 cubic yards of borrow material, were carried on with practically no interference with traffic.

Work was carried on under the supervision of Resident Engineer Don Evans with W. E. Bertken acting as Resident Engineer on the job.

New Traffic Problem Study

A new study of traffic problems entitled "Traffic Accidents and Congestion" by Maxwell Halsey, Associate Director, Bureau of Street Traffic Research, Yale University, has recently been published. Setting forth the principles which underlie the scientific methods currently being developed to reduce traffic accidents and congestion, this volume approaches traffic problems from the engineering point of view and is intended not only for traffic students but for those professionally engaged in traffic and highway engineering.

"Believe me, if my wife scolds me for coming home late, I'm going to tell her a thing or two."

"Don't do it! Tell her one thing and stick to it."

Improvements Completed in Santa Barbara County

(Continued from page 11)

base and 15,000 tons of plant-mixed surfacing. In addition to these items, drainage structures consist of a reinforced concrete arch culvert which was constructed at the crossing of Eagle Creek and pipe culverts varying in size from 18 inches to 36 inches in diameter which were placed throughout the project.

The work on the section between Orella and 1 mile west of Canada del Refugio involved 164,000 cubic yards of roadway excavation, 33,000 cubic yards of imported borrow, 14,000 tons of cement treated base and 11,500 tons of plant-mixed surfacing.

In addition to the above items, drainage structures were placed throughout the project. A reinforced concrete girder bridge was constructed across Refugio Creek, consisting of two 36-foot spans, two 40-foot spans and two 9-foot cantilevers, all on concrete bents with timber pile foundations. This bridge, which is located in a four-lane section of highway, provides for a 56-foot roadway.

The bridge across Dos Pueblos Creek was built under a separate contract and was completed on March 28, 1941. This reinforced concrete structure consists of one 60-foot and two 50-foot spans on concrete piers and abutments. The bridge provides for a 27-foot clear roadway.

LOCAL BORROW DEPOSITS

The base material for the cement treated base and the mineral aggregate for the plant-mixed surfacing, as well as a portion of the material for the imported borrow was secured from a local deposit in the Arroyo Quemado, located 4 miles from the westerly end of the Orella Project and 10 miles from the westerly end of the Tecolote Creek Project. The contractor set up his plant in this location and supplied the materials for both contracts.

The project between Tecolote Creek and Las Varas Creek will cost approximately $260,000. The construction of the bridge over Dos Pueblos Creek cost approximately $21,200. The contract between Orella and 1 mile west of Canada del Refugio cost approximately $200,000 including the bridge over Refugio Creek.

J. C. Adams has been the Resident Engineer for the State on the road construction and E. C. Bissell was the Resident Engineer on bridges.

Feather River Flood Did $2,086,000 Damage

(Continued from page 5)

Use of this pump, in addition to natural drainage is hastening the dewatering process.

In addition to the damage caused by the flood in Sutter County, other portions of the Sacramento River Flood Control Project were weakened by wave wash, slips and erosion.

The Division of Water Resources prepared a report on the extent of the flood for presentation to the Congress in support of U. S. Engineer Corps recommendations for improvements to the Sacramento River Flood Control Project. The report declares:

FEDERAL AID IMPERATIVE

"It is imperative that appropriations in the amount of $4,000,000 be made by the Congress for expenditure between July 1, 1942, and June 30, 1943, in order to assure continued essential agricultural production and to afford adequate protection from floods to two transcontinental railroads, two main line railroads to the Pacific Northwest and many highways of great importance in connection with war production activities."

Fifteen sections of Sacramento River Flood Control Project levees which are in need of heightening and enlarging are listed in the report by the division. In addition funds are required for bank protection, revetment, levee setbacks and dredging.

The automotive industry annually uses 380,000,000 pounds of cotton, 16,640,000 pounds of wool, 2,800,000 bushels of corn or its equivalent, 590,000 bushels of flax, 12,500,000 gallons of molasses, 2,000,000 pounds of castor oil, 1,500,000 gallons of soybean oil and 800,000 gallons of tung oil.—*The Trail*, December, 1941.

A shady business never yields a sunny life.

Problems of Highway Maintenance Arising Out of the War

(Continued from page 13)

work as clearing or cleaning of culverts, ditches and gutters, mowing grass, spraying and burning weeds, removal or trimming of trees and brush and maintenance of drinking fountains and parking areas is also included.

The only item in the list which can apparently be definitely discontinued is the mowing of grass. The work on other items may be reduced in certain areas and in degree of performance at other points.

The care of roadside trees and shrubbery, to mention a relatively small item, requires about 2 per cent of the maintenance funds. These plantings are intended primarily to improve the appearance of the roadsides, but they also serve to protect cut and fill slopes from erosion. While a certain amount may be saved if maintenance is less intensive, the major part of the annual expenditure must be continued if the investment is to be perserved.

Over a period of 20 years and more a generally high standard of maintenance has been established for the entire State Highway System. The public generally has come to expect that, barring acts beyond the control of man, the highways will be in safe usable condition at all times. It is generally accepted that failure of the organization to meet such expectation may involve claims for damages in event an accident occurs not only against the State, but against individuals in the organization.

There is certain to be a reduction in revenue available for State highway purposes. It is unlikely, however, that the corresponding reduction in traffic volume or weight will occur in like degree on the State highway. In fact if the war effort is to be successful, it may be expected that heavier traffic will occur. In any event the through routes must be kept in condition for emergency moves of the military forces at any time.

In the face of the standard of work carried on in the past, the effect of continued heavy use by defense traffic on obsolete surfacing, and the needs of strictly military traffic, there is little prospect of radical reduction in demands for highway maintenance.

In Memoriam

LESTER C. MEDER

The California Division of Highways and particularly the Materials and Research Department suffered a severe loss when Assistant Physical Testing Engineer Lester C. Meder passed away from a heart ailment on Saturday, February 7, 1942.

Mr. Meder was born in Carson City, Nevada, October 8, 1901, and received his early education in the Carson City schools. He graduated from the University of California in 1931, receiving the degree of B.S. in the College of Chemistry. Prior and subsequent to his college work he was connected with the National Bureau of Standards both at Denver and San Francisco, being engaged primarily in cement testing and investigational work.

In September, 1933, Mr. Meder accepted a position with the Materials and Research Department of the California Division of Highways with which department he remained until his untimely death cut short a career in which he was rapidly establishing a reputation as a portland cement research specialist.

While with the department he was the recipient in 1938 of the Wason Medal for notable research from the American Concrete Institute for joint authorship with Thos. E. Stanton of the paper on "Resistance of Cements to Attack by Sea Water and Alkali Soils."

He was the author of a series of articles published in the April, May, and June, 1940, issues of California Highways and Public Works, dealing with the development of cement through centuries of experiment dating back to early Assyrian, Egyptian, Grecian and Roman periods and progressing to the present day portland cement.

He played a prominent part in the studies conducted by the department during recent years which led to discovery of the cause of the failure of concrete in many concrete pavements and other concrete structures in some areas of the State as described in an article on the "Expansion of Concrete Through Reaction Between Cement and Aggregate" published in the December, 1940, and September, 1941, Proceedings of the American Society of Civil Engineers and was one of the contributors to a series of papers on the same subject just published in the January, 1942, Journal of the American Concrete Institute.

The State has lost a valuable employee, one who will be exceedingly difficult to replace.

Bids and Awards for February, 1942

KINGS COUNTY—About two miles southeast of Corcoran, a timber bridge across Sweet Canal to be constructed. District VI, Route 135, Section B. F. Fredenburg, So. San Francisco, $7,577; Geo. Von KleinSmid, Bakersfield, $8,289; E. G. Perham, Los Angeles, $9,189; Kiss Crane Service, Berkeley, $9,282; Geo. E. France, Visalia, $9,645; Trewhitt-Shields, Fisher, Fresno, $10,398; Dan Caputo, San Jose, $10,759. Contract awarded to M. E. Whitney, Bakersfield, $7,194.

LOS ANGELES COUNTY—Traffic signal system furnished and installed on East Third Street, between Indiana Street and Bonnie Beach Place, District VII, Route 172, Section A. Econolite Corp., Los Angeles, $8,590. Contract awarded to Pacific Union Marbelite Co., Los Angeles, $8,345.

LOS ANGELES COUNTY—Traffic signal system furnished and installed on East Third Street, between Bonnie Beach Place and Atlantic Blvd., District VII, Route 172, Section A. Pacific Union Marbelite Co., Los Angeles, $8,995. Contract awarded to Econolite Corp., Los Angeles, $8,780.

RIVERSIDE COUNTY—At the Keen Camp Maintenance Station, about 22 miles east of Hemet, a water supply well to be drilled and cased. District VIII, Route 64, Section N. Contract awarded to Coe Machine Works, San Bernardino, $2,391.

SANTA CLARA COUNTY—Between Bascom Avenue and Race St., about 1.2 miles in length, storm sewers to be constructed. District IV, Route 5, Sections B, SJ's. John Pestana, Oakland, $26,872; Dan Caputo, San Jose, $27,788; A. J. Raisch, San Jose, $27,858; Edwin J. Tobin, Oakland, $29,818; McGuire & Hester, Oakland, $29,856. Contract awarded to Earl W. Heple, San Jose, $24,589.

SANTA CRUZ COUNTY—At Wilder Creek, Little Baldwin Creek and Coja Creek, a total length of about 1.3 miles, to be graded and surfaced with road mixed surfacing. District IV, Route 56, Section B. Parish Bros., Sacramento, $103,872; R. L. Oakley, Pasadena, $145,584. Contract awarded to Granite Construction Co., Watsonville, $91,749.

"Keep 'Em Rolling" a Slogan for Motorists

America's wartime slogan to motorists—"Keep 'Em Rolling"—has a new significance when the absolute need of automobile transportation in some sections of the nation is studied, it is pointed out by the Automobile Club of Southern California.

In the United States, a total of 2,320 cities and towns with a combined population of 12½ million, are without any form of local mass transportation, and are entirely dependent for passenger transportation upon the automobile. Another 872 cities which do have transportation are served only by buses.

The best way to save daylight is to use it.

Scene at a San Diego intersection where a single automatic signal keeps four streams of traffic rolling

Automatic Signal Controls 3,000 Cars An Hour At Four-Way Intersection

By R. B. LUCKENBACH, District Traffic Engineer

THE installation of full traffic actuated signals, at the junction of Pacific Highway (U. S. 101) and Rosecrans Street in the City of San Diego, approximately one year ago, has provided a service which is efficiently handling peak hour traffic exceeding 3,500 vehicles an hour. This installation has caused much favorable comment from the traveling public and traffic officers, as it controls the traffic with a minimum of friction and a high degree of safety.

The topography of San Diego makes it difficult to provide sufficient main traffic arteries, consequently the principal intersections carry large volumes. Improvement of the Pacific Highway, the main route to Los Angeles, in 1938 and later the Mission Valley Road connection to the Pacific Highway on the east with a subsequent improvement of a westerly connection at the same intersection, resulted in serious congestion and several accidents.

DESIGNED BY STATE ENGINEERS

Traffic data were secured and designs for the signal system and channelization were made by the Division of Highways in the Fall of 1939, which resulted in the installation being completed by a local contractor January 1, 1941.

Peak hour counts of traffic entering this intersection from all directions have been taken as follows:

	Cars
Sunday, November 5, 1939	1,837
Monday, November 6, 1939	850
Saturday, June 15, 1940	1,011
Sunday, January 19, 1941	3,683
Sunday, February 2, 1941	3,710
Sunday, March 9, 1941	3,433
Thursday, April 17, 1941	3,122
Sunday, September 14, 1941	3,470

During this time numerous 15-minute counts have also been taken on Sundays, showing volumes of 950 to 1,086 vehicles. At the present time, 30-minute volumes occasionally exceed 2,000 vehicles and would be larger except that an adjacent intersection restricts the flow.

The intersection is complicated by heavy turning movements between the northerly, southerly, and easterly legs of the intersection. There are relatively few turns to and from the westerly leg. Congress Street, which is the fifth leg of the intersection, is a dirt road which had a very low volume, seldom exceeding 50 vehicles per day, and no provision was made in the original installation for controlling it, although the system can be extended to provide control later.

Considering the four heavy legs of the intersection, there are normally 12 entering movements of traffic to provide for. After eliminating the four right turns, the remaining eight were studied and it immediately became evident that three separate time intervals would be necessary to eliminate the major conflicts.

After careful study of the approach angles, a three-phase sequence was adopted which provided a minimum of conflict and still permitted almost continuous use of the intersection area. Also an additional lane was added to each approach with a separate left turn lane for the southbound left turn movement. The sequence is indicated on the intersection diagram as phases A, B, and C.

The use of a merging left turn with the heavy through traffic, as shown on phase "B," is one of the unusual features which has proved very successful.

To our knowledge, no similar installation was in operation, at that time, in the western United States.

The controller assigns right of way in accordance with the constantly varying demands of traffic which are registered by the detectors. This constant adjustment of time interval tends to produce maximum intersectional efficiency at all times, including hours of lighter volume, as it permits continuous use without idle time, and will go from any interval to either of the other two if no demand is on the intervening phase.

TRAFFIC DEMAND GOVERNS

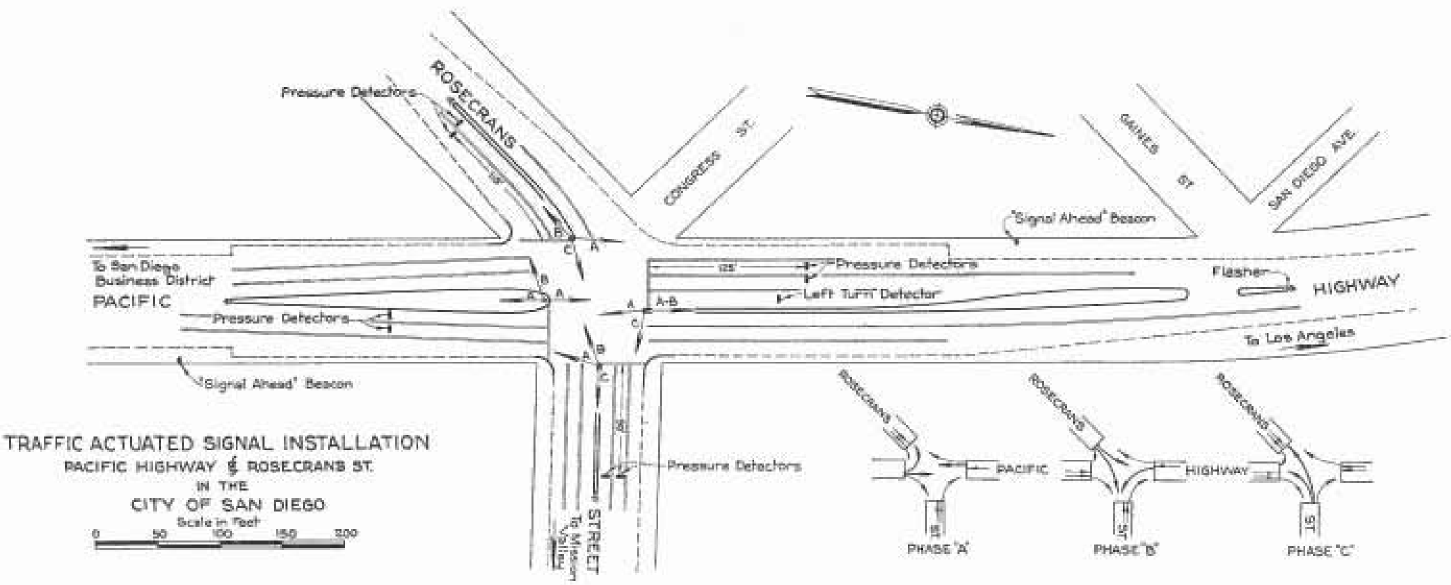
Right of way is not given to any street, without traffic demand thereon, and in the complete absence of traffic, the go signal will remain where it was last assigned unless otherwise adjusted for preference to a particular street.

which operates from each detector impulse. After the initial interval has expired, each impulse cancels the time in effect and starts a new time period.

MAXIMUM INTERVAL 25 SECONDS

This feature causes the traffic to yield the right of way when the vehicle spacing exceeds a predetermined time. The controller is at present adjusted for nine to 10 seconds minimum and 25 seconds maximum for each of the three phases which after adding the amber light time gives a total cycle of 35 to 85 seconds.

Under reasonably uniform traffic distribution, the system will handle 3,000 vehicles per hour on a cycle of 50 to 55 seconds with a smaller cycle for lower volumes. As compared to usual three-phase systems, this is a very high efficiency and is largely attributable to the full actuated principle of operation which on that particular location probably increases the intersection's capacity 50 per cent over other available types of control.



Sketch showing locations of advance traffic detectors and channelization islands that efficiently control movement at busy intersection

THREE-PHASE SYSTEM

A full traffic actuated three-phase dispatching system was selected as being the best available to give the desired results. The high degree of efficiency for all traffic volumes and the very favorable public reaction to full actuated control indicates the additional expense of such an installation was justified.

The system consists essentially of three parts, namely the detectors, which register the vehicles entering the intersection; the controller, which is the brain of the system; and the lighting units, which indicate the right of way to the motorist.

Demand on one street when the right of way is on the other causes right of way to be transferred only after a minimum adjustable interval has elapsed and after proper clearance interval as follows:

Immediately, providing there has been no demand on the other streets.

After an adjustable maximum interval despite continued demand on the other street.

The timing mechanism operates on the static principle without motor or clock and provides for an adjustable initial interval sufficient to clear stopped cars plus a vehicle interval

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A traveler at a small hotel ordered two boiled eggs for breakfast.

The waiter who served him brought three.

"Here," said the traveler, "why have you brought me three eggs? I only ordered two."

"Yes, sir," said the waiter, smiling, "but one of them might fail you."

Pet—"Don't you think, darling, that your new overcoat is a bit loud?"

Darling—"Never mind, pet. I'll wear a muffler with it."—Smith's Weekly.

Designing Foundation Courses for Highway Pavements and Surfaces

(Continued from page 5)

furnished by Table 3 consist of the *average gross weight* per sampled vehicle, the *average axle weight* and the *average number of axles* per vehicle. The first two are not used in determination of design requirements, being informative only. The third or last figure is used in determining the number of commercial vehicle axles during any particular period; in this case a 10-year period.

Table 4 represents a page from the tabulation, which supplements the data shown in Table 3, showing the axle weights by 1,000 pound increments and the percentage for each weight group of the commercial traffic actually sampled at each of the loadometer stations. In other words, it represents a cross-section of the commercial traffic passing through the particular loadometer station and is considered as typical of the probable weight distributions actually using that section of highway.

The axle classifications A, B, etc., are standard classifications which have been adopted to indicate whether the sampled vehicle is a truck, truck and trailer, truck and semitrailer or any of the various other combinations of commercial vehicles in common use.

"WEIGHTED" FACTORS

Table 5 is copied from page 60 of "Reinforced Concrete Pavements" by Royall D. Bradbury as discussed above.

Table 6 shows: (1) the induced stress from Table 5; (2) the equivalent wheel load, which conforms to the group adopted for the form for computation of equivalent repetitions; (3) the numbers representing the equivalent repetitions divided by the actual repetitions as secured from Bradbury's tabulation; (4) the multipliers of each preceding figure; and (5) the factors adopted for use in the form for computation of equivalent repetitions.

A uniform multiplier of *twice* the preceding factor has been adopted. This results in a considerably lower total than would be secured if Bradbury's figures for portland cement concrete pavement were followed exactly. The factors are, of course, arbitrary, but have been adopted only after several years of observation and correlation of all types of surfacings and pavements subjected to known volumes and weights of traffic, and, in our opinion, represent a reasonable compromise applying to all types of surfacing. Indeed, in view of the assumptions which must necessarily be made to arrive at definite figures, we believe the factors chosen are proving thoroughly practical as a basis for design of highways in this State. Moreover, it must be realized that Bradbury's figures refer to the number of repetitions of a given load required to induce the *first crack*, while from the practical standpoint, we are concerned with evaluating the more severe condition of definite slab failure.

DESIGN STANDARDS

On the basis of these computations, we have tentatively adopted the following highway design standards, based on total estimated number of wheel load repetitions over a 10-year period:

1. HEAVY INDUSTRIAL TYPE

(10,000,000 equivalent wheel loads or over): Outside traveling lanes to consist of 0.92 foot-0.67 foot-0.92 foot portland cement concrete pavement; or 0.75 foot-0.50 foot-0.75 foot lower cement content portland cement concrete base surfaced with asphalt concrete 0.25 foot thick. Inside or passing lanes to consist of 0.75 foot-0.58 foot-0.75 foot portland cement concrete pavement; or 0.58 foot-0.42 foot-0.58 foot lower cement content portland cement concrete base surfaced with asphalt concrete 0.25 foot thick.

2. MEDIUM INDUSTRIAL TYPE

(2,500,000 to 10,000,000 equivalent wheel loads): All lanes to consist of 0.75 foot-0.58 foot-0.75 foot portland cement concrete pavement; or 0.58 foot-0.42 foot-0.58 foot lower cement content portland cement concrete base; or cement treated base varying in thickness from 0.50 foot to 0.75 foot in accordance with number of wheel loads and other conditions, with bituminous surfacing 0.25 foot thick; or asphalt concrete pavement of adequate strength where subgrade is suitable and wheel load repetitions are under 5,000,000.

3. LIGHT INDUSTRIAL TYPE

(less than 2,500,000 equivalent wheel loads): Pavement to consist of 0.75 foot-0.60 foot-0.75 foot asphalt concrete or some combination of local base materials surfaced with bituminous mixtures as the equivalent repetitions decrease below the top limit designated above, the design necessarily being subject to various local conditions of traffic and materials.

(Note.—Figures 0.75 foot-0.58 foot-0.75 foot indicate pavement slab 0.58-foot thick, increasing to a thickness of 0.75 foot in a distance of two feet at each edge of each lane.)

Naturally, our weighted "fatigue factors" and other instruments of design will be subject to modification in other States, inasmuch as they are affected by the average flexural strengths secured in concrete pavement as well as the severity of the climate and other factors which induce large stress increments to add to the direct load stress.

It is particularly gratifying to record that in the actual application of this method of evaluating the probable destructive elements of traffic, the computed measure of service in terms of wheel load repetitions is proved with astonishing accuracy by the condition of the existing facility, especially if the design has been less than the standards now considered adequate.

We feel confident that, as far as California conditions are concerned, the methods outlined above constitute valuable tools, rough though they may be, to help determine more accurately the conditions for which we must design.

California Has Low Auto Tax Rate

California motorists are reported to be enjoying the lowest per-vehicle special tax cost in the Nation. The average cost per vehicle for fuel tax and registration fees in California last year was $22.99, while Florida tops the list of States with $67.70.

"Well, I think I'll put the motion before the house," said the chorus girl as she danced out onto the stage.

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