77th Congress
1st Session } SENATE COMMITTEE PRINT

HIGHWAYS FOR THE NATIONAL DEFENSE

A REPORT

TO THE

ADMINISTRATOR, FEDERAL WORKS AGENCY,
MR. JOHN M. CARMODY

BY THE

PUBLIC ROADS ADMINISTRATION

FEBRUARY 1, 1941

Printed for the use of the Committee on Post Offices
and Post Roads

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1941

LETTER FROM THE PRESIDENT

THE WHITE HOUSE,
Washington, June 21, 1940.

Hon. JOHN M. CARMODY,
Administrator, Federal Works Agency, Washington, D. C.

MY DEAR MR. CARMODY: In order that we may be assured of the adequacy of our highway system to meet the needs of our national defense, I would like you, in collaboration with the Advisory Commission to the Council of National Defense and the War and Navy Departments, to have the Public Roads Administration of your Agency make a survey of our highway facilities from the viewpoint of national defense and advise me as to any steps that appear necessary.

I suggest that particular attention be paid to the strength of bridges, the width of strategic roads, adequacy of ingress to and egress from urban centers, and the servicing of existing and proposed Army, naval, and air bases.

I am sending a copy of this letter to the agencies enumerated above.

Yours sincerely,

FRANKLIN D. ROOSEVELT.

LETTER FROM THE NAVY DEPARTMENT

NAVY DEPARTMENT,
OFFICE OF THE SECRETARY,
Washington, January 15, 1941.

The ADMINISTRATOR:
Federal Works Agency, Washington, D. C.

SIR: The matter of access roads to the Military and Naval Establishments and certain private establishments engaged on national-defense production is assuming great importance. It is understood that a preliminary survey of the requirements for access roads to Naval Establishments has been made and that the complete project of providing adequate highways for the national-defense program may require a total expenditure approximating $230,000,000.

Informal inquiry of the Public Roads Administration indicates that a report is being prepared on this subject for submission to the President about February 1, 1941, and it is requested that early action be taken to accomplish at least the most urgent projects in the program.

Respectfully,

FRANK KNOX.

LETTERS FROM THE ADVISORY COMMISSION TO THE COUNCIL OF NATIONAL DEFENSE

THE ADVISORY COMMISSION TO THE
COUNCIL OF NATIONAL DEFENSE,
Washington, D. C., January 30, 1941.

Mr. JOHN M. CARMODY,
Administrator, Federal Works Agency, Washington, D. C.

DEAR MR. CARMODY: The matter of access roads to the Military and Naval Establishments and certain private establishments engaged on national defense production is assuming great importance.

Informal inquiry of the Public Roads Administration indicates that a report is being prepared on this subject for submission to the President about February 1, 1941, and it is requested that early action be taken to accomplish at least the most urgent projects in the program.

Yours sincerely,

RALPH BUDD,
Transportation Commissioner.

THE ADVISORY COMMISSION TO THE
COUNCIL OF NATIONAL DEFENSE,
FEDERAL RESERVE BUILDING,
Washington, D. C., December 10, 1940.

To: Mr. Ralph Budd.
From: William S. Knudsen.
Subject: Public Roads—Command Housing and Munitions Projects.

As the construction work progresses on command housing, munitions plants, etc., it is becoming increasingly clear that the highway and related traffic situation requires most careful consideration to insure reasonably satisfactory traffic conditions when these projects are in service. Present plans contemplate as many as 50,000 troops in several camps and ten to fifteen thousand employees in some of the munitions operations.

In many instances the camps are off the beaten path, so to speak, and existing road networks will doubtless have to be improved and supplemented.

Mr. Harrison has discussed this with Mr. Fischer from time to time and this note is simply to advise of our readiness to be of every possible service in this important matter.

WILLIAM S. KNUDSEN.

LETTER FROM THE FEDERAL WORKS AGENCY

The PRESIDENT,
The White House.

SIR: In the preparation of this report on highways for the national defense, the Secretary of War, the Secretary of the Navy and Mr. Ralph Budd, Transportation Commissioner of the Advisory Commission to the Council of National Defense, have cooperated through the Washington and field personnel of their respective organizations in the assembly and evaluation of the date which form the basis for the conclusions herein presented. The expressions of key officials in the defense program are quoted directly.

The State highway departments have contributed generously the essential services of their organizations in the making of needed surveys and plans and have included a large number of important projects in current construction programs. These existing, well-organized highway organizations, cooperative in spirit, are in a position to furnish an irreplaceable and immediate contribution to quick action in the phases of the defense program dependent upon highway transport.

The various units of the Federal Works Agency, including the headquarters staff, the Public Roads Administration and the Work Projects Administration, are pushing forward all projects it is possible to finance with existing funds under the legal requirements which must be met, and to develop the program of most needed road projects.

Finally, we have received assurances of complete cooperation from the equipment manufacturers, the material producers and the highway contractors through their organized associations, in carrying forward the programs of construction in line with the best traditions of service to meet the country's requirements which are a product of this critical period.

The recommendations in this report involve both authorizations for appropriations and legislation which you may consider desirable to place before the Congress for appropriate action.

Respectfully submitted.

JOHN M. CARMODY,
Administrator, Federal Works Agency

LETTER FROM COMMISSIONER OF PUBLIC ROADS

FEBRUARY 1, 1941.

MR. JOHN M. CARMODY,
Administrator, Federal Works Agency.

SIR: This report presents the essential requirements and priorities of operations necessary to provide roads and streets reasonably adequate for the national defense. Two general construction programs are necessary, the providing of access roads, and the development of the strategic network to eliminate known weak and inadequate sections. There is no padding of the needs with theoretical conceptions or community desires unconnected behind defense requirements. Our highways and streets are inadequate for the national defense in definite particulars. These deficiencies can be remedied promptly and progressively [i. e., in order of their importance] only if adequate programs including the necessary funds are provided, to be carried out through the established State and Federal highway organizations.

France built the Maginot line of defense fortifications, a conception based upon tradition and the historical pattern of previous wars with Germany. Holland relied upon her neutrality and perhaps her below-sea-level possibilities of flooding the land. These and other similar considerations may have influenced the planning of the German military machine. The relatively small number of motor vehicles and production capacity in the countries of Europe, so totally unlike the conditions in the United States, provided a rare opportunity to the German General Staff. At the very moment England was imposing limitations upon the motortruck, Germany was subsidizing its use and, as a major national policy, engaging on a magnificent scale in the construction of a national system of superhighways. The mileage actually completed before Germany's war machine went into action could not have met more than a limited utility, but the whole scheme was symbolic of Germany's conception of the new technique of warfare based upon fast and coordinated movement of mechanized power units over the land, upon the sea, and in the air.

In each of these fields of operation the defense program of the United States is generating large amounts and varieties of highway traffic which demand new roads and new bridges. Indicative of the universal service of highway transport, many of the most pressing new highways or bridges are to serve essential requirements of the shore establishments of the Navy.

The effort of the Public Roads Administration in this report is to present the necessary highway program as determined in detail by the three major defense agencies. The suggested division of costs is based upon the principle of major use. The access roads, as to the traffic to be served or as to their priority, are in the main requirements of the defense program. The development of the strategic network is very largely required by civil traffic, but the potential defense needs will advance the priority of many projects.

Every effort is being made to utilize funds heretofore made available for the normal Federal-aid highway program and the work-relief program for the defense-road projects. Many of these are under way. The recommendations for additional financing in this report provide for the immediately apparent projects which cannot otherwise be provided or which can only be partially financed.

Many of the access roads consist of groups of projects in vitally important areas, such as the Norfolk area, and will require at best a substantial time period to complete. Early consideration of this report and provision for carrying the recommendations into effect will contribute greatly to the elimination of serious traffic congestion now handicapping the defense operations in these areas.

Respectfully submitted.

THOS. H. MACDONALD,
Commissioner of Public Roads.

HIGHWAYS FOR THE NATIONAL DEFENSE

A REPORT TO THE ADMINISTRATOR, FEDERAL WORKS AGENCY, MR. JOHN M. CARMODY, BY THE PUBLIC ROADS ADMINISTRATION

Defense roads and highways, as classified in this report, have been designated as such by one of the three major defense agencies—the Army, the Navy, and the Advisory Commission to the Council of National Defense. All highways which serve the business of the public have a corresponding degree of utility in the national defense, but the intensive specialized operations characteristic of the present concentration upon training men, producing ships, planes, equipment, ordnance of all kinds and munitions, and the building of defense bases, generate localized highway traffic of large and growing magnitudes. These are new or greatly expanded highway transport services that must be provided for first and quickly.

This report recognizes the continuing, serious highway problems generated by 32,000,000 motor vehicles now in use. The first important trend of the defense program has been to concentrate large numbers of these vehicles in relatively small areas, many removed from well developed local and main roads, without materially diminishing the volume of traffic already existing on the improved rural roads and city streets. Next should future conflicts conceivably result in building up a degree even of the present volume of highway use, the highways of the Nation in the immediate future, including the speeding up of defense operations, is geared to the motor vehicle for local, [illegible] transportation. Considering the utility of the highways and streets as a whole, exclusive of those specifically designated as defense highways, the normal maintenance operations and a program of replacement of worn-out and inadequate surfaces, perhaps below a normal construction program but none the less an irreducible minimum, are essential.

DEFENSE ROAD PROGRAMS DEFINED

Comprehensive studies of the major objectives to be served determine that two general programs are necessary to provide needed highway facilities and to improve inadequate sections where these exist:

First. The road program primarily required for defense operations.

Second. The road program required to improve inadequate sections of the strategic network.

THE ROAD PROGRAM REQUIRED FOR DEFENSE OPERATIONS

The program for defense operations is made up of essential improvements of the following classes of roads, all of an emergency character:

Reservation roads.—These are the company streets and other roads within the Federal reservation areas of Army cantonments, depots, and bases, and the various shore establishments of the Navy. Their total usage is for defense purposes.

Access roads.—These include numerous roads, each of short mileage, that are required to give local access from main highways, railroads and waterways to Army and Navy reservations and industrial plants engaged in the defense-production program. Also included are certain roads and streets that connect with rail terminals and airports and that may be used to a considerable extent by traffic generated directly by the defense program. In many cases the usage of this class of roads by [illegible] traffic is small and the necessary improvements are required [illegible] by defense usage.

Tactical roads.—These include certain small [illegible] of roads which give access to [illegible] isolated points of strategic importance [illegible] of the country. They include [illegible] mileage located near military reservations and in areas [illegible] as the theater of tactical maneuvers. By reason of [illegible], they are likely to be used often for the practice training of [illegible] motorized and mechanized Army. Many of the roads of this class are little used for traffic of any kind, [illegible] with surfaces [illegible] with [illegible] usage. To prevent or repair damage by military movements in maneuvers and war games, substantial improvements will be needed and must be charged almost wholly to defense. On other roads of the same category, which are more heavily used by civil traffic, the regular and frequent addition of military movements will necessitate improvement beyond the needs of the civil traffic. Such improvements also must be charged almost entirely to the defense program.

THE PROGRAM FOR IMPROVEMENT OF THE STRATEGIC NETWORK

The strategic network, shown in plate I,[1] is a connected system of highway routes which have been designated by the War and Navy Departments as the routes of principal importance from the standpoint of national defense. Broadly viewed, the network consists of a system of main trunk routes totaling approximately 74,600 miles, and auxiliary roads approximately paralleling the main lines on each side, with cross connections at frequent intervals.

The network includes routes joining all important centers of defense industry and all military and naval concentration points. Its main lines include the interregional highway system recommended by the Public Roads Administration in the report, Toll Roads and Free Roads; and with few exceptions these main lines are included in the Federal-aid highway system. The auxiliary lines are made up in considerable part of State and local roads not included in the Federal-aid system.

[1] Not printed.

Since, in its main lines at least, the strategic network is heavily used by civil traffic, and since purely military traffic imposes few if any highway requirements superior to those required for the adequate accommodation of civil traffic, it follows that almost any improvement that may be made to facilitate movement of traffic will be serviceable to an important civil-traffic stream as well as to military movements and defense traffic.

Development of the strategic network to complete adequacy for both civil and defense traffic can only be regarded as a long-time operation, and a practically continuous undertaking. In some of its sections, however, it provides necessary access to reservations and defense industries. Other sections are likely to be used frequently in tactical maneuvers. The improvement of these sections and the elimination of a certain number of the more serious weaknesses, particularly the strengthening of a considerable number of substandard bridges, should be provided for as urgent necessities. Otherwise the improvement of the strategic network is not stamped with the defense urgency that distinguishes reservation and access roads and some tactical roads.

ROAD IMPROVEMENTS REQUIRED

Studies of the Public Roads Administration and the State highway departments and numerous conferences that have been held in which these agencies have participated with representatives of the War and Navy Departments and the Work Projects Administration, and local officials concerned, have determined the more important improvement needs of the various classes of defense roads thus far developed by the expanding defense program.

These needs are described briefly in the following sections relating to each class of roads:

Reservation roads.—At most Army and Navy reservations, rapid preparations are in progress for the housing, provisioning, equipping, and training of greatly enlarged military and naval forces. This involves the construction of barracks, storehouses, equipment and ammunition depots, garages, airdromes, shops and powerhouses, drill and aviation landing fields, rifle ranges, and facilities of many other kinds. For proper internal access to all these varied facilities, the construction and improvement of many miles of reservation roads and streets is an immediate and absolute necessity. As the schedules set up by the War and Navy Departments call for occupation of the reservations by fully expanded forces at a very early date, the building and improvement of these reservation roads must be regarded as the most urgent of all defense road construction.

Reconnaissance surveys by the Public Roads Administration, made after consultation with the post commanders at military and naval reservations, indicate that there is need for the improvement or outright construction of 1,500 miles of road lying entirely within these Federal reservations.

Provision is being made for many of these improvements in the contracts awarded by the War and Navy Departments for general construction within the reservations. These provisions are being supplemented by aid rendered by the Work Projects Administration

through Work Projects Administration projects sponsored by the post commanders, and in a few instances the Federal highway funds, administered by the Public Roads Administration, are available to effect required improvements.

It is assumed that any further provision that may be necessary to effect required improvements of roads of this class will be reported by the War and Navy Departments, which have exclusive jurisdiction. Therefore, no recommendations in this regard are made in this report.

Access roads.— The required program of access road improvement is highly dynamic. Indicated needs are growing from day to day as the general defense program matures.

Some of the military and naval reservations and defense industries are being newly established on land previously occupied by very small populations. Many are being substantially enlarged. Practically all are being greatly expanded in population and in motor transport and mechanized equipment facilities.

In the creation of new areas and the expansion of old ones, reservation limits are being extended in many cases over existing roads and occasionally over important highways. Since it is usually desirable or necessary to exclude the public from the reservation areas, the intercepted roads must generally be closed at the reservation limits. One of the first and, to the civil authorities of the States and their subdivisions, one of the most urgent highway problems created by these reservation extensions, and similar industrial developments, is that of constructing new links around the reserved areas. Thus far no general provision has been made for payment of the cost of such essential restorations by the Federal Government. This, in the view of State and local governments, is an omission that leaves an unfair burden to be borne by them.

From the standpoint of the national-defense effort, the objective in access road construction is to provide adequate highway connections for the reservations and industrial areas with nearby main highways and railroads or other transportation services, and from neighboring towns and cities. From the standpoint of highway traffic, the developments planned at nearly all of the reservations and new industrial sites will be equivalent in their generation of highway traffic to the creation of a considerable number of new cities of very substantial size. The resident population at many of the Army camps will range between 2,000 and 78,000. At the Glenn L. Martin Co. plant near Baltimore, Md., to name a single industrial example, the number of workers engaged in the production of airplanes is expected to increase in a short time to 38,000 from the present employment of 13,000, which represents in turn an increase from 1,750 in 1930.

The reconnaissance surveys and conferences completed to date indicate a present need for the improvement of 2,830 miles of access roads to serve the 192 reservations thus far designated, at an estimated cost of $220,000,000.

These determined needs of reservation access-road improvement and additional road changes and improvements of as yet indeterminate extent and cost, required to serve vital defense industries, constitute, after the reservation roads, the most urgent of defense road requirements.

Required improvements range from the resurfacing and widening of two-lane roads to the construction of multiple-lane highways and large bridges, all of which should be completed in 1 year or less, if possible.

Tactical roads.—To a limited extent a considerable part of the highway mileage of the country, especially that part included in the strategic network, will be employed by the Army from time to time in tactical maneuvers to test and practice the use of its vast new motorized and mechanized equipment. In designing improvements for this "tactical" mileage, it will be necessary to take greater account of the probability of use by the maneuvering Army forces than in road designs generally. Tactical roads include: (1) A relatively small mileage of roads connecting with more or less isolated strategical points. Traffic on these roads will be almost exclusively military; (2) other roads in the immediate vicinity of military reservations, other than access roads and routes of the strategic network, which by reason of their proximity are likely to be frequently used in tactical maneuvers of local range; and (3) roads of similar character in areas selected as theaters of war games—areas that may not be near established reservations.

Roads of the first and second groups, and their bridges, will have to be made adequate for the expected military use. They will have to be designed to support frequent loads of military vehicles and equipment, with sufficient capacity to permit such frequent movements to occur without unreasonable interference with normal civil traffic. In respect to these first two groups of tactical roads, the urgency of improvement is substantially the same as that of access roads.

Tactical roads of the third group may lie in areas used only once or repeatedly as the theater of maneuvers. For repeated use, it would appear desirable that they be fitted for their expected military use. Where only a single use is anticipated, or in any case where timely provision for strengthening of the weaker roads at Federal expense is not possible, there should be an alternative assumption of responsibility for any road damage that may be caused.

It does not appear to be practicable, in any reasonably highway program, to strengthen all the lightly surfaced local roads in all areas that might be used for battle practice. Moreover, even if it were practicable, such strengthening of all road surfaces would not be desirable from the standpoint of troop training. Actual battlefields cannot always be chosen in advance, and roads that are not of the best must sometime be encountered by armies in combat. Military commanders expect to find some roads inadequate and even virtually impassable, and they have trained engineer troops for the purpose of coping with just such situations.

Observations during recent Army maneuvers in various parts of the country have indicated that, except for a few weak bridges and narrow surfaces, the main highways are reasonably adequate for Army transport. Some damage was reported, particularly in combat areas, to local roads improved with sand-clay, gravel, topsoil, and light bituminous surfaces, due chiefly to their use by trucks with tire chains and by large numbers of iron-shod cavalry horses.

Military traffic was observed to have about the same effects as ordinary civil traffic, and the damage done during maneuvers was in all probability no greater than would have resulted from an equally intensive use by civil traffic.

Observations in the States of Washington, Wisconsin, New York, Texas, and Louisiana showed that main highways already giving reasonably adequate service to substantial volumes of civil traffic were not damaged by military traffic. Addition of the military traffic to the normal civil traffic on the highways caused some inconvenience and delay to the latter, and on narrow surfaces some damage to road edges and shoulders resulted.

County and town roads in combat areas suffered damage principally because they were of light construction not designed for the intensive use to which they were subjected during maneuvers. In addition, three unusual features connected with the military use contributed to the damage: (1) Use of tire chains by trucks; (2) use of large numbers of iron-shod cavalry horses; and (3) maintenance operations were either suspended entirely or were not as intensive as the greater use required.

Damage was reported to dirt roads, gravel roads, and thin bituminous treatments on light bases, the latter suffering damage to both surfaces and bases. Failure of a few pipe and wooden culverts on county roads occurred in Wisconsin. In Louisiana the cost of necessary repairs was estimated at $68,000. In Texas the cost of repairing extraordinary damages as reported by the State highway department was $140,000.

The New York, Wisconsin, and Washington maneuvers were held in the summer when there was no extended period of rain. Even at the time of the spring maneuvers in Louisiana and Texas road subgrades were comparatively dry. It is probable that damage to light surfaces would have been greater had the maneuvers occurred in wet or thawing weather.

Plans of the War Department are not yet sufficiently revealed to determine the mileage of roads that will be subjected to tactical use; but the obligation of the Federal Government to make adequate provision for necessary improvements of roads thus regularly used and to pay for the repair of damage caused by similar occasional use is apparent.

The strategic network. The condition of the major lines of the strategic network in rural areas has been surveyed in detail by the Public Roads Administration and the State highway departments, and the results of these surveys have been recorded on sectional graphs, of which a typical example is presented in plate 5.[1]

On the basis of these surveys and the design requirements for adequate accommodation of both civil and defense traffic on each section of the network, it has been determined that the most critical deficiencies of the rural sections of the network consist of 2,436 bridges of load capacity inferior to the H-15 loading standard, which is a minimum requirement from both civil and defense standpoints. There are also on the network in rural areas approximately 5,090 miles of road with present surfaces less than 18 feet wide, and approximately 14,000 miles on which the existing surface is incapable of supporting in all weather, vehicles of 9,000 pounds wheel load, equipped with low-pressure pneumatic tires.

[1] Not printed.

These are the most serious deficiencies. They could be eliminated, and the rural main lines of the network could thus be put into acceptable condition for emergency use with a minimum expenditure of approximately $458,000,000.

Less critical deficiencies of the rural network consist of a large number of bridges of inadequate horizontal clearance, and a smaller number the vertical clearance of which is deficient; a very substantial mileage of roads the surfaces of which, though wider than the critical minimum of 18 feet, are still narrower than they should be for proper accommodation of the present and expected traffic volume; a common condition of excessive curvature and inadequate sight distance; and a general lack of shoulders of sufficient width to accommodate standing vehicles without obstructions of moving traffic.

Details of the deficiencies here briefly stated are given in appendix V.

To raise the entire rural network to the standard eventually desirable for safe and convenient use by both civil and military traffic, and provide further for the expensive improvements required on portions of the main lines of the network within the corporate limits of cities, and for essential improvements of auxiliary lines, would require a continuing expenditure as large as the minimum previously indicated for a period of several years.

ADDITIONAL PROVISIONS IMMEDIATELY REQUIRED FOR DEFENSE ROAD IMPROVEMENTS

As explained in detail in appendixes I and II, there are means presently available to the Public Roads Administration and the Work Projects Administration, which are being applied as fully as possible to the correction of the most serious deficiencies of defense roads, with the commendable cooperation of State highway departments and local road officials. However, because of inherent financial difficulties and legal restrictions, only a part of the needed improvement can be effected by these means. Many of the larger and most vital projects require contractors' organizations and extensive equipment for time-saving, efficient construction; and it is abundantly clear that the funds now available will be inadequate to effect all of even the most urgently required construction.

After a thorough canvass of the entire situation, the following additional provisions by the Federal Government are recommended as immediately required to permit a reasonably satisfactory accomplishment of the most urgent improvements of the several classes of roads.

Access roads.—There should be appropriated to the Public Roads Administration not less than $150,000,000 for access roads to military and naval reservations and defense-industry sites. This sum should be available to pay all costs, including right-of-way, of roads in the vicinity of reservations and industrial sites when such roads are certified to the Federal Works Agency as essential by appropriate major defense agencies. It should also be made available to pay the cost of constructing new sections of highways, replacing existing highway connections broken by necessary closures at reservations and industrial sites.

Tactical roads.—A fund of $25,000,000 should be appropriated to be used for the improvement of roads to be used regularly in the tactical

maneuvers of the Army, and for the reimbursement of the out-of-pocket costs of States and local governments for repairs necessitated by the occasional use of roads for the same purposes.

Strategic network.- To provide for the replacement of substandard bridges and the correction of other critical deficiencies of the strategic network at a desirable rate, a supplementary appropriation of not less than $100,000,000 is required. This appropriation should be prorated to the States on the existing Federal-aid basis, and used solely for designated defense projects. It should be available to pay all legitimate costs of the projects on a somewhat higher basis of Federal participation than the existing 50-50 basis, but otherwise should be expended under the provisions of the Federal highway legislation.

Strategic network advanced planning.-- For the making of engineering surveys and plans for development of the strategic network, including the extensions of the system into and through municipalities and metropolitan areas, an appropriation of $12,000,000 is required, to be prorated to the States and matched by them on the existing Federal-aid basis.

Supplementary legislation needed.--To facilitate the accomplishment of all necessary improvements, the Federal Highway Act should be amended to (1) authorize addition to the Federal-aid system of any roads conforming to the main lines of the strategic network, as designated by the War and Navy Departments; (2) make roads and bridges on auxiliary lines of the network eligible for improvement with Federal-aid secondary road funds; and (3) permit the use of Federal-aid funds in payment of part of the cost of acquiring necessary rights-of-way and attendant property damage.

APPENDIXES

APPENDIX I

EXISTING PROVISIONS FOR DEFENSE ROAD IMPROVEMENT BY THE FEDERAL GOVERNMENT

For road improvements important to the national defense, the Federal Government has thus far made special provisions of three general kinds, as follows:

1. In appropriations to the War and Navy Departments, funds have been provided which are available for the construction or improvement of roads and streets within military and naval reservations. In general, such funds are not available, under the terms of existing legislation, for road improvements made outside the boundaries of the reservations.

2. The Federal Highway Act of 1940 provides that—

(*a*) Funds authorized and made available under section 21 of the Federal Highway Act of 1921, as amended, may be used to pay the entire engineering costs of the surveys, plans, specifications, estimates and supervision of construction of projects for such urgent improvements of highways strategically important from the standpoint of the national defense as may be undertaken on the order of the Federal Works Administrator and as the result of request of the Secretary of War, the Secretary of the Navy, or other authorized national-defense agency.

(*b*) In approving Federal-aid highway projects to be carried out with any unobligated funds apportioned to any State, the Commissioner of Public Roads may give priority of approval to, and expedite the construction of, projects that are recommended by the appropriate Federal defense agency as important to the national defense.

3. By the Emergency Relief Appropriation Act, fiscal year 1941, the Commissioner of Work Projects is authorized in his administration of the act to use, on projects certified by the Secretary of War or the Secretary of the Navy as important for military and naval purposes, not to exceed $25,000,000 of the total sum appropriated by the act to supplement amounts normally authorized for expenditure to meet other than labor costs. This provision extends to projects of any nature that are certified by the defense officials named, and is not restricted to projects for the improvement of highways. With various amounts allotted to other classes of projects, only a part of the sum authorized for exceptional expenditure would be available for expenditure on defense-highway projects.

Each of the three special provisions thus far made by the Federal Government is surrounded by definite restrictions which prevent the free use of authority or funds for improvements of any kind required on roads important for the national defense.

As previously stated, the appropriations to the War and Navy Departments are not generally available for expenditure on roads outside of the boundaries of military and naval reservations.

Funds made available under the Federal Highway Act are of three classes: (1) Funds authorized for improvements on the Federal-aid highway system; (2) funds authorized for the construction of secondary or feeder roads; and (3) funds authorized for the elimination of hazards at railroad grade crossings.

The authorized appropriation of each fund is apportioned among all States in accordance with a formula specified in the law. Initiative in the expenditure of these funds rests, by law, with the States, and no use of them for any purpose is possible without initiation by the respective State highway departments. In any case, expenditure for necessary defense-road purposes cannot exceed in any State the total of the three funds apportioned to the State.

For the purpose of survey and planning and the supervision of construction of defense roads, each of the funds may be used to pay the full cost of any such work on any road or street. Construction costs can be paid in full only on work appropriately financed with the grade-crossing funds. The Federal-aid and secondary-road funds must be matched by the States. None of the funds is available for the purchase of right-of-way. Moreover each of the funds, insofar as they are expended for construction, is limited in application to legally specified purposes—the Federal-aid funds to roads included in the Federal-aid system, the secondary-road funds to roads that can reasonably be described as secondary or feeder roads, and the grade-crossing funds to the elimination or protection of railroad grade crossings.

As already stated, the authority given by the Emergency Relief Appropriation Act to the Commissioner of Work Projects to use not to exceed $25,000,000 of the relief appropriation in payment of other than labor costs on projects important to the national defense is practically available only in part for defense-road projects. Its use must always be modified by a reasonable regard for the primary purpose of the appropriation, which is to provide work relief for as many as possible of the unemployed. It cannot be used at all in any area except as the relief rolls afford an available supply of labor. Nor can it be used for any purpose except as that purpose is sponsored by some qualified and acceptable agency. Projects for road improvement within Army and Navy reservations may be sponsored by military and naval authorities. Improvements required outside such reservations must generally be sponsored by the civil authorities of State or local governments. In these authorities there is thus lodged a power of initiative somewhat similar to that possessed by State authorities under the Federal highway legislation.

APPENDIX II

MEASURES FOR THE IMPROVEMENT OF DEFENSE ROADS

Various measures have been devised to apply the provisions thus far made by the Federal Government for the improvement of roads

important to the national defense. These are now being employed for the several classes of roads, as follows:

Reservation roads.—Provision for the construction or improvement of roads and streets within Army and Navy reservations is being made in contracts awarded by the War and Navy Departments and financed by appropriations available for expenditure by these Departments. Other improvements within reservation limits are being provided through the medium of Work Projects Administration projects sponsored by the War and Navy Departments. For payment of the engineering costs of surveys, plans, specifications, estimates, and supervision of construction of such improvements on roads, the Federal-aid funds apportioned to the respective States are available with the consent of the State highway departments. These funds are being used in some instances for work of this character which the State highway departments have been able to [illegible]. Whether the provisions made [illegible] for improvement of roads and streets within the military [illegible] adequate [illegible] for determination [illegible] War and Navy Departments.

Access roads.—Early in 1940 the War Department indicated a number of Army posts and reservations of [illegible]. It requested the Public Roads Administration, in cooperation with the post commanders, to make preliminary studies of the condition and desirable improvement of all roads essential for adequate access to the posts indicated. From time to time the number of posts thus indicated was increased. Somewhat later the Navy Department made similar requests with respect to certain of its shore establishments.

Up to the date of this report such reconnaissance studies had been completed by district engineers of the Public Roads Administration in conference with the respective post commanders or commandants for 146 reservations. The report on each reservation specifies approximately the access-road improvements desirable with estimates of their cost. It is accompanied by a map of the reservation and vicinity scaled 2 inches to the mile, showing all existing roads in the area and all improvements recommended in the report.

A majority of the reconnaissance studies were made prior to the passage of the selective-service and National Guard mobilization acts. Some of the conditions originally assumed have therefore been altered, and the improvements recommended in the reports are now subject to revision.

In the Emergency Relief Appropriation Act, fiscal year 1941, and in the Federal Highway Act of 1940 similar conditions were laid down to govern application of the exceptional provisions made by each of the acts with reference to national-defense projects; viz, formal certification or recommendation of the projects as important to the national defense by appropriate defense agencies.

In conformity with these provisions of the two acts, the Secretary of War has from time to time certified the military importance of projects for the construction or improvement of access roads leading to 157 military posts, stations, and concentration areas. These reservations, included in identical priority lists furnished separately

to the Work Projects Administration and the Public Roads Administration, are identified as follows:

First Corps Area:
- Camp Edwards, Mass.
- Westover Field, Mass.
- Fort Ethan Allen, Vt.
- Fort Ethan Allen Artillery Range, Vt.
- Fort Devens, Mass.
- Harbor defenses of Portland, Maine: Fort Preble, Maine (headquarters).
- Harbor defenses of Narragansett Bay, R. I.: Fort Adams, R. I. (headquarters).
- Harbor defenses of Portsmouth, N. H.: Fort Preble, Maine (headquarters).
- Harbor defenses of New Bedford, Mass.: Fort Rodman, Mass. (headquarters).
- Harbor defenses of Boston, Mass.: Fort Banks, Mass. (headquarters).
- Harbor defenses of Long Island Sound, N. Y.: Fort H. G. Wright, N. Y. (headquarters).
- Manchester (Airport), N. H.
- Bangor (Airport), Maine.
- Hartford (Airport), Conn.

Second Corps Area:
- Fort Dix, N. J.
- Fort Hancock, N. J.
- Pine Camp, N. Y.
- Fort Monmouth, N. J.
- Picatinny Arsenal, N. J.
- Raritan Ordnance Depot, N. J.
- Mitchel Field, N. Y.
- United States Military Academy, West Point, N. Y.
- Fort Tilden, N. Y.

Third Corps Area:
- Fort Hoyle, Md.
- Fort Meade, Md.
- Fort Story, Va.
- Edgewood Arsenal, Md.
- Aberdeen Proving Grounds, Md.
- Camp Lee, Va.
- Fort Belvoir, Va.
- Arlington Cantonment, Va.
- Fort Myer, Va.
- Langley Field, Va.
- Fort Monroe, Va.
- Curtis Bay Ordnance Depot, Md.
- Fort Eustis, Va.
- New Cumberland General Depot, Pa.
- Nansemond Ordnance Depot, Va.
- Carlisle Barracks, Pa.
- Virginia Beach National Guard Camp, Va.
- Front Royal Quartermaster Depot, Va.
- Indiantown Gap, Pa.
- Bolling Field, Washington, D. C.

Fourth Corps Area:
- Camp Blanding, Fla.
- Camp Beauregard General Area, La.:
  - Camp Polk.
  - Camp Livingston.
  - Camp Claiborne.
  - Artillery Range.
  - Camp Beauregard.
- Camp Peay, Tenn.
- Fort Bragg, N. C.
- Fort McClellan, Ala.
- Camp Shelby, Miss.
- Fort Jackson, S. C.
- Fort Benning, Ga.
- Southeast Air Depot, Ala.
- Air Corps station at Savannah Municipal Airport, Ga.
- Fort Barrancas, Fla.
- Maxwell Field, Ala.
- MacDill Field, Fla.
- Fort Moultrie, S. C.
- Barksdale Field, La.
- Key West Barracks, Fla.
- Fort McPherson, Ga.
- Fort Oglethorpe, Ga.
- Toccoa National Guard Reservation, Ga.
- Augusta Arsenal, Ga.
- Camp Savannah antiaircraft firing area, Ga.
- Dale Mabry Field, Fla.
- Municipal Airport, Jackson, Miss.
- Macon replacement center, Ga.
- Spartanburg replacement center, S. C.
- Macon Airport, Macon, Ga.
- Augusta Airport, Augusta, Ga.
- General depot near Conley, Ga.
- Selma Airport, Selma, Ala.
- Wilmington antiaircraft firing center, N. C.
- Municipal Airport, Charlotte, N. C.
- Army General Hospital, Charleston, S. C.
- Atlanta General Hospital, Chamblee, Ga.

Fifth Corps Area:
- Fort Knox, Ky.
- Wright and Patterson Fields, Ohio.
- Columbus General Depot, Ohio.
- Fort Benjamin Harrison, Ind.
- Erie Ordnance Depot, Ohio.
- Fort Thomas, Ky.
- Bowman Field, Ky.

Sixth Corps Area:
- Camp Custer, Mich.
- Savanna Ordnance Depot, Ill.
- Chanute Field, Ill.
- Camp McCoy, Wis.

Sixth Corps Area—Continued.
Scott Field, Ill.
Fort Sheridan, Ill.
Camp Grant, Ill.
Selfridge Field, Mich.
Rock Island Arsenal, Ill.

Seventh Corps Area:
Seventh Corps Area training center, Rolla, Mo.
Camp J. T. Robinson, Ark.
Fort Riley, Kans.
Camp Clark, Mo.
Fort Snelling, Minn.
Fort Crook, Nebr.
Fort Leavenworth, Kans.
Fort Meade, S. Dak.
Jefferson Barracks, Mo.
Fort Des Moines, Iowa.
Fort Robinson, Nebr.
Camp Ripley, Minn.
Arcadia target range, Missouri
Camp Dodge, Iowa.
Camp Ashland, Nebr.
Camp Rapids, S. Dak.
Camp Grafton, N. Dak.
Fort Lincoln, N. Dak.
Fort Francis E. Warren, Wyo.

Eighth Corps Area:
Brownwood, Tex.
Fort Crockett, Tex.
San Angelo, Tex.
Fort Sam Houston, Tex.
Abilene, Tex.
Fort Bliss, Tex.
Camp Hulen, Tex.
Lowry Field, Colo.
Fort Sill, Okla.
Fort Huachuca, Ariz.
Fort Logan, Colo.
Fort Russell, Tex.
Wingate Ordnance Depot, N. Mex.
Fitzsimons General Hospital, Colorado
Fort Clark, Tex.
Brooks Field, Tex.
Duncan Field, Tex.
Kelly Field, Tex.
Randolph Field, Tex.
Normoyle Quartermaster Depot, Tex.
Fort Hitchcock, Tex.

Ninth Corps Area:
Camp Ord, Calif.
Hearst Ranch Reservation, Calif.
Fort Lewis, Wash.
March Field, Calif.
Presidio of San Francisco, Calif.

Ninth Corps Area—Continued.
Fort Winfield Scott, Calif.
Benicia Arsenal, Calif.
San Luis Obispo National Guard Camp, Calif.
Ogden Ordnance Depot, Utah.
Forts Worden, Casey, and Flagler, Wash.
Sacramento Air Depot, Calif.
Fort MacArthur, Calif.
Fort Rosecrans, Calif.
Muroc bombing base, Calif.
Fort Baker, Calif.
Fort Barry, Calif.
Fort Stevens, Fort Canby, Fort Columbia, and Camp Clatsop, Oreg.-Wash.
Mojave Desert antiaircraft range, Calif.
Fort Douglas, Utah.
Moffett Field, Calif.
Hamilton Field, Calif.
Fort Funston, Calif.
Columbia Municipal Airport, Portland, Oreg.
Fresno (Airport), Calif.
Boise Municipal Airport, Idaho.

Following submission of the lists of posts and stations to the two branches of the Federal Works Agency, the War Department, on November 2, 1940, instructed its several corps area commanders to arrange local conferences to consider the access-road necessities of each of the listed posts and stations. At each conference, the corps area commanders were instructed to arrange for representation of the corps area, the post or posts in question, the Public Roads Administration, the Work Projects Administration, and the State highway department, and county or city administrations if local roads or streets are involved. These conferences are now being completed as rapidly as possible.

By a similar process the Secretary of the Navy has certified the importance of access-road improvements, and arranged for the calling of like conferences to consider the detailed needs at the following 35 shore establishments:

First Naval District:
Quonsett Point Air Base, R. I.
Portsmouth Navy Yard, N. H.
Newport Naval Stations, R. I.

Third Naval District:
Lake Denmark Arsenal, N. J.
Iona Island Ammunition Depot, N. Y.
New London, Naval Station, Conn.

Fourth Naval District: Cape May Air Station, N. J.

Fifth Naval District:
Indianhead Powder Plant, Md.
Norfolk Operating Base, Va.
Portsmouth Navy Yard, Va.
Dahlgren industrial area, Va.
Quantico Marine Base, Va.
Naval Medical Center, Md.

Sixth Naval District:
Parris Island Marine Base, S. C.
Hilton Head Island Marine Base, S. C.
Red Bank Landing Munition Depot, S. C.
Macon Ordnance Plant, Ga.

Seventh Naval District:
Yukon Air Base, Fla.
Cocoa Air Base, Fla.

Eighth Naval District:
Pensacola Air Base, Fla.
Corpus Christi Air Base, Tex.
Dallas Air Station, Tex.

Ninth Naval District:
Burns City Ammunition Depot, Ind.
Canton Ordnance Plant, Ohio.
Louisville Ordnance Plant, Ky.
Detroit Naval Ordnance Plant, Mich.
Indianapolis Ordnance Plant, Ind.

Eleventh Naval District:
San Diego Operating Base, Calif.
Terminal Island Operating Base, Calif.
San Diego Ammunition Depot, Calif.

Twelfth Naval District: Alameda Air Base, Calif.

Thirteenth Naval District:
Seattle Air Station, Wash.
Tongue Point Air Station, Oreg.
Indian Island Ammunition Depot, Wash.
Puget Sound Naval Stations, Wash.

Finally, and more recently, a similar conference procedure has been adopted for various new and expanded industrial plants essential to the defense program. At these defense industry conferences the factory managers or their authorized representatives outline the access requirements of the plants. To the date of this report the Advisory Commission to the Council of National Defense has advised the Public Roads Administration that the following 55 plants or plant expansions are of importance to the national defense:

Alabama Ordnance Works, Childersburg, Ala.
Coosa Ordnance Plant, Childersburg, Ala.
Gadsden Ordnance Plant, Gadsden, Ala.
North American Aviation, Inc., Inglewood, Calif.
Consolidated Aircraft Co., San Diego, Calif.
Denver Ordnance Plant, Denver, Colo.
Bullard Co., Bridgeport, Conn.
Studebaker Corporation, Chicago, Ill.
Western Cartridge Co., East Alton, Ill.
Buick Motor Co. Aircraft Engine Plant, Melrose Park, Ill.
Kankakee Ordnance Works, Wilmington, Ill.
Elwood Ordnance Plant, Wilmington, Ill.
Delco-Remy (division of General Motors), Anderson, Ind.
Indiana Ordnance Works, Charlestown, Ind.
Hoosier Ordnance Plant, Charlestown, Ind.
Studebaker Corporation, Fort Wayne, ndI.

Jefferson Proving Ground, Madison, Ind.
Studebaker Corporation, South Bend, Ind.
Kingsbury Ordnance Plant, Union Center, Ind.
Iowa Ordnance Plant, Burlington, Iowa.
Ohio River Ordnance Works, Henderson, Ky.
Glenn Martin Airplane Co., Baltimore, Md.
Fairchild Aircraft Plant, Hagerstown, Md.
General Electric Co., Turbo-Electric Supercharger Plant, Everett, Mass.
Bohn Aluminum & Brass Corporation, Adrian, Mich.
Detroit Ordnance Plant, Center Line, Mich.
Bohn Aluminum & Brass Corporation, Detroit, Mich.
Vickers, Inc., Detroit, Mich.
N. A. Woodworth Co., Ferndale, Mich.
Lake City Ordnance Plant, Independence, Mo.
McDonnell Aircraft Corporation, Robertson, Mo.
St. Louis Ordnance Plant, St. Louis, Mo.
Weldon Springs Ordnance Works, Weldon Springs, Mo.
Bomber Assembly Plant, Fort Crook, Nebr.
Otis Elevator Co., Harrison, N. J.
Wright Aeronautical Corporation, Paterson, N. J.
Link Aviation Devices, Inc., Binghamton, N. Y.
Standard Gage Co., Poughkeepsie, N. Y.
Savage Arms Co., Utica, N. Y.
Ohio Crankshaft, Inc., Cleveland, Ohio
Thompson Aircraft Products Co., Euclid, Ohio
Wright Aeronautical Corporation, Lockland, Ohio
Ravenna Ordnance Plant, Ravenna, Ohio
Plum Brook Ordnance Works, Sandusky, Ohio
Bomber Assembly Plant, Tulsa, Okla.
Lycoming Motors, Williamsport, Pa.
Wolf Creek Ordnance Plant, Memphis, Tenn.
Baytown Ordnance Works, Baytown, Tex.
North American Aviation, Inc., Dallas, Tex.
Bomber Assembly Plant, Fort Worth, Tex.
Bryant Chucking Grinder Co., Springfield, Vt.
Jones & Lamson Machine Co., Springfield, Vt.
New River Ordnance Plant, Dublin, Va.
Radford Ordnance Works, Radford, Va.
Morgantown Ordnance Works, Morgantown, W. Va.

In some cases more than one reservation, military or naval or both, and possibly also one or more industrial plants are located in close proximity. An outstanding instance of this sort is the group of military and naval reservations and defense industries in the Hampton Roads area in Virginia. In this vital defense area, including the cities of Norfolk, Portsmouth, and Newport News, the following important reservations and industries are closely grouped: Fort Story, Norfolk naval base, Norfolk Navy Yard, Nansemond ordnance depot, Langley Field, Fort Eustis, Fort Monroe, and the Newport News shipbuilding plant.

A similar case is the San Diego, Calif., area in which are located Fort Rosecrans, United States naval training station, United States

Marine Corps base, United States destroyer base, Army and Marine cantonments, three airplane plants, and housing projects for military personnel and for aircraft employees.

In such cases as these, arrangements are being made to consider jointly the access-road necessities of all reservations and industries within the defined areas.

At all conferences, regardless of the type of establishments under consideration, effort is being made to reach definite decisions in respect to: (1) The location, general character, and approximate costs of the access-road improvements and other road changes that are necessary and the order of each in priority of need; (2) the money available for such improvements from each of the several classes of Federal funds, and the State or local funds available to match the Federal funds where such matching is required; (3) the amounts of State or local funds available for expenditure without Federal matching; and (4) the particular project application of all available funds. Such decisions are facilitated in most areas by the reconnaissance studies of the Public Roads Administration.

To the extent that funds are found to be available, arrangements are made at the conferences for the initiation of Federal-aid or W. P. A. projects by State or local authorities. Such projects may cover the survey and planning of improvements, or their construction, or both.

Generally, it is found that the State highway departments are willing to agree to the use of the apportioned Federal-aid funds for the survey and planning of the necessary improvements. These funds are available for such purposes, unmatched with State funds. Wherever there is reasonable assurance that plans thus developed by the State highway departments and approved by the Public Roads Administration will be carried out, the Public Roads Administration has indicated that it will approve the necessary survey projects to be initiated by the State highway department. The Work Projects Administration also has indicated its willingness to approve Work Projects Administration survey projects in areas where the availability of qualified relief personnel and other conditions permit.

In respect to the actual construction of needed improvements, conferences thus far held indicate that the effort to apply each of the several classes of Federal funds now provided will encounter serious obstacles.

Many of the roads involved are not now included in the Federal-aid highway system and are not of such character as to make them eligible for inclusion in that system. For the construction of such roads, the apportioned Federal-aid highway funds are, therefore, not available.

In many cases, these roads outside the Federal-aid system can be considered secondary or feeder roads only by a very liberal interpretation of the act making provision for the construction of roads so defined. For these roads, then, the use of the apportioned secondary- or feeder-road funds is of questionable propriety.

Very generous reductions of normally required sponsors' contributions to W. P. A. projects will to an extent supply the inducement necessary for obtainment of State and local cooperation in access-road improvement. These reductions are permissible under the authority conferred by the 1941 Emergency Relief Appropriation Act. However, the limit imposed on the use of this authority to make reductions

will definitely circumscribe the extent to which W. P. A. funds can provide the means for access-road construction, as will a reduced availability of qualified relief workers where most needed.

Tactical roads.—No special measures have yet been devised for the improvement of tactical roads. Some consideration has been given to the needs of a few roads of this class in conferences thus far held for the determination of access-road programs, notably certain roads in the vicinity of Camp Edwards on Cape Cod, Mass. In this case it has been determined that there will be frequent military use of roads extending from the reservation to outside firing points on the north and south shores of the cape. It is also indicated that there will be frequent maneuvering of motorized equipment on the cape roads, extending all the way to Provincetown. Any such usage will necessitate a substantial improvement of these roads. In their present condition, they are scarcely adequate for the public traffic they are required to serve during the summer season. However, no definite provision has been made to deal with the road problem on the cape. Nor has it yet been possible to ascertain the scope of the similar problems elsewhere, and no procedures have been developed for dealing with these problems.

Strategic network.—By formal certification, the Secretaries of War and of the Navy have advised the Public Roads and Work Projects Administrations that projects for the improvement of any roads conforming to the approved strategic network are important to national defense. These certifications enable the Federal Works Administration to invoke for such projects the exceptional provisions of the Federal Highway Act of 1940 and the Emergency Relief Appropriation Act, fiscal year 1941, that apply to projects of importance to national defense. Measures are being taken to give effect to these provisions to the fullest practicable extent.

Almost completely, the main lines of the network coincide in their general direction with the roads—generally the most important roads—included in the Federal-aid and State highway systems. In view of this duality of interest, the Public Roads Administration has requested the State highway departments to include in their programs for the expenditure of currently available Federal-aid funds as many projects as possible on roads conforming to the strategic network. It is expected that this request will meet with the sympathetic response of all State agencies.

The Work Projects Administration has instructed its State administrators to give priority to defense-highway projects in their programs and to expedite construction in every possible way. It has informed these administrators of the studies of necessary improvements on the strategic network made by the Public Roads Administration and the State highway departments. It has also instructed them to obtain advice from the district engineers of the Public Roads Administration concerning desirable projects for the improvement of the network, and to cooperate closely at all times with the Public Roads Administration and the State highway departments.

The measures thus taken, it is believed, give assurance that currently available Federal-aid and emergency relief funds will be employed to the greatest practicable extent for essential improvements of maximum utility on roads conforming to the strategic network.

APPENDIX III

DESIGN STANDARDS FOR BRIDGES AND HIGHWAYS

The design standards for bridges and roads adequate to serve the national-defense requirements have been the subject of consultation with representatives of the War Department over a long period. As here presented, the desirable minimum requirements have the endorsement of the War Plans Division of the General Staff. The design requirements as to structural capacity of bridges and standard pavements which have been applied to Federal-aid projects are consistent with the minimum requirements approved by the War Plans Division. Through the years there have been frequent criticisms that the Federal-aid policies required unnecessarily high standards. An adequately improved road system for a State or a nation is the product of long years of construction effort and the expenditure of vast sums. Now suddenly confronted with a great national emergency, every really adequate bridge or mile of paved road is an asset of greater value than its cost in terms of national security. This report indicates a considerable volume of work of an emergency character. It is relatively small when account is taken of the large number of Army and Navy reservations for many purposes, the huge production programs, new housing developments, and the 74,600 miles of the strategic network. For example, of the 16,692, bridges on rural sections of the strategic network, only 2,436 are listed as substandard in their capacity to carry the heaviest equipment and ordnance yet proposed.

The recommended design standards for military usage are discussed in detail for the purpose of estimating the present adequacy of roads certified as important to the national defense, locating definitely the places at which improvements are desirable, and determining the character and costs of such improvements. Roads and bridges conforming in their design to these standards will generally be completely adequate for the service of both the normal civil and extraordinary defense needs.

DESIGN STANDARD APPLICABLE TO RURAL AREA

For bridges and highways in rural areas the desirable standards are as follows:

Bridges.

Load capacity.—Load capacity conforming to the recently revised standard H-15 live loading recommended by the American Association of State Highway Officials. This design loading consists of a standard truck having a total weight with load of 15 tons, or of lane loads equivalent to the truck train loading included in the 1935 specifications of the American Association of State Highway Officials.

The manner in which these truck and lane loadings are to be applied in the design of structures is specified as follows:

The lane loadings or standard trucks shall be assumed to occupy traffic lanes, each having a width of 10 feet corresponding to the standard truck clearance width. Within the curb-to-curb width of the roadway, the traffic lanes shall be assumed to occupy any position

which will produce the maximum stress, but which will not involve overlapping of adjacent lanes, nor place the center of the lane less than 5 feet from the roadway face of the curb.

Each lane loading shall consist of a uniform load per linear foot of traffic lane combined with a single concentrated load so placed on the span as to produce maximum stress. The concentrated load shall be considered as uniformly distributed across the lane on a line normal to the center line of the lane. For computation of moments and shears, different concentrated loads shall be used, as indicated in plate 8.[1] The lighter concentrated loads shall be used when the stresses are primarily bending stresses, and the heavier concentrated loads shall be used when the stresses are primarily shearing stresses.

Either truck or lane loading shall be used, depending upon which gives the larger stress. In computing stresses, each 10-foot traffic lane loading or a single standard truck per lane shall be considered as a unit. The number and position of loaded lanes shall be such as to produce a maximum stress, subject to reductions hereafter specified. Fractional lane widths are not to be considered.

On any series of continuous spans, discontinuous lengths of lane loading shall be used where necessary for maximum stress, but only one concentrated load shall be used.

Where maximum stresses are produced in any member by loading any number of traffic lanes simultaneously, the following percentages of the resultant live-load stresses shall be used in view of improbable coincident maximum loading:

	Percent
1 or 2 lanes	100
3 lanes	90
4 lanes or more	75

The position and number of loaded lanes used shall be such as to produce maximum stresses in all cases.

The reduction in intensity of floor-beam loads shall be determined as in the case of main trusses or girders, using the width of roadway which must be loaded to produce maximum stresses in the floor beam.

Bridges built by State and Federal highway agencies in recent years on the primary rural roads of the country, outside of metropolitan areas, are generally of H–15 design, and the adoption of higher standards for ordinary rural roads would not be justified by any apparent requirements. For major intercity routes and metropolitan areas the H–20 designs are justified and a number of the States have already adopted this higher standard.

Within the usually assumed tolerance of overloads, bridges of design and condition capable of supporting H–15 loading will safely support the loads of all commonly used commercial vehicles in the frequency with which they are normally applied. They will also similarly support the loads of all military equipment other than heavy and medium tanks, without special control of the movement. Load diagrams of the principal types of military equipment are shown in Plates 9 and 10.[1]

Regarding the support of tanks, special studies have been made from which the following conclusions can be drawn as to the effects

[1] Not printed.

of the specific classes of tanks diagrammed in Plate 10,[1] on standard H–15 bridges of width equal to two or more traffic lanes:

Light (13½ ton) tanks.—Simultaneous loading of two lanes with these tanks does not produce greater than allowable stresses.

Medium (20 and 25 ton) tanks.—If the movement is controlled so that there will be no more than a single file of such tanks following approximately the center line of the bridge and spaced at least 40 feet apart, no greater than allowable overstresses will result. There will be no necessity to limit the speed of the tanks.

Heavy (55 ton) tanks.—Such tanks will be safely supported if the movement is controlled so that there will be no more than a single file following approximately the center line of the bridge, with separating interval of not less than 50 ft., and with speed (on the bridge) reduced to not more than 4 miles per hour.

Horizontal clearance.—Existing bridges and underpasses on two-lane roads having a horizontal clearance of less than 18 ft. should be replaced or widened as promptly as possible.

New and widened bridges on two-lane roads should have at least the minimum, and if feasible the preferred horizontal clearances indicated in the following table, of widths corresponding to various classes of present average 24-hour traffic volume:

Present average 24-hour traffic volume	Horizontal clearance of new or widened bridges	
	Minimum feet	Preferred feet
Number of vehicles:		
Less than 600	24	26
600 to 1,500	26	28
More than 1,500	28	30

The minimum two-lane bridge clearances specified are substantially adequate, and the preferred clearances completely adequate for civil traffic, including the usual small percentage of vehicles of width equal to and slightly exceeding 8 feet. They are similarly adequate for the accommodation of most military equipment, the maximum width of which (exclusive of the 25- and 55-ton tanks) is approximately 8½ feet.

Existing two-lane bridges affording horizontal clearance of less than 20 feet, if not widened, should be posted as narrow bridges. Existing bridges on three- and four-lane roads should be replaced or widened as promptly as possible if, in horizontal clearance, they afford less than 30 and 40 feet, respectively.

New and widened bridges on three- and four-lane roads should have horizontal clearances of at least 40 and 52 feet, respectively, and preferably horizontal clearances between extreme lateral curbs 6 feet greater than the width between the outer edges of an approach pavement or pavements designed for 12-foot lanes. Bridges on 4-lane roads having a wide central dividing strip may be built as dual bridges, each bridge providing horizontal clearance of at least 26 and preferably 30 feet.

New and widened underpasses on two-lane roads should have at least the minimum, and if feasible the preferred, horizontal clearances

[1] Not printed.

indicated in the following schedule of widths corresponding to various classes of present average 24-hour traffic volume:

Present average 24-hour traffic volume	Horizontal clearance of new or widened underpasses	
	Minimum feet	Preferred feet
Number of vehicles:		
Less than 600	30	40
600 to 1,800	30	42
More than 1,800	30	44

New and widened underpasses on three- and four-lane roads should have horizontal clearances at least 6 feet and preferably 20 feet wider than the width between outer edges of an approach pavement or pavements designed for 12-foot lanes.

Vertical clearance.—Existing bridges and underpasses having a vertical clearance of less than 12½ feet should be heightened as promptly as possible.

New and heightened bridges and underpasses should have vertical clearance of at least 14 feet. A vertical clearance of 14 feet is sufficient for the passage of all military equipment and substantially al civil vehicles.

Existing bridges and underpasses affording vertical clearance of less than 14 feet, if not heightened, should have their minimum clearance plainly posted upon them.

Roads.

Surfaces and foundations.—All road surfaces should be dustless; and all surfaces and foundations should be designed in accordance with the present practice of each State for the all-weather support of repeated applications of 9,000-pound wheel loads on pneumatic tires, wheel load being defined as half the axle load where dual wheels are used.

Road surfaces designed in accordance with this recommended standard will be completely adequate for the accommodation of all normal civil traffic and all traffic of military vehicles, including all classes of tanks at present in use and projected.

Two-lane pavement width.—Existing two-lane roads having a pavement width of less than 18 feet should be widened as promptly as possible.

Newly constructed and widened pavements on two-lane roads should be designed according to the following schedule of widths corresponding to various classes of present average 24-hour traffic volume:

Present average 24-hour traffic volume	Width of new or widened pavements
Number of vehicles:	*Feet*
Less than 600	20
600 to 1,800	22
More than 1,800	24

The widths specified are substantially adequate for all normal civil traffic, including the usual percentages of wide and heavy vehicles, with range of speed from 15 to 70 miles per hour. They are completely adequate for all anticipated military usage.

Three- and four-lane pavement widths.—New three- and four-lane pavements should be constructed to provide a width of 12 feet per lane. Pavements so constructed will be completely adequate for all civil and military traffic. It will be unnecessary to widen any serviceable existing three- and four-lane pavements, the lane width of which is less than this recommended standard.

Shoulders.—On roads carrying a present average daily traffic of more than 1,800 vehicles and on less heavily traveled roads wherever feasible, it is desirable that shoulders be provided continuously on both sides of the pavement of sufficient width to permit parking. For this purpose a minimum width of 8 feet is essential. Such provision is desirable for the accommodation of normal civil traffic; it is highly desirable on roads that are likely to be used with some frequency by military convoy movements, to prevent excessive interference with moving traffic by halted convoys unable to clear the traffic lanes.

If, on roads that are likely to be frequently used by convoys, it is not feasible to provide continuous shoulders of a width sufficient for parking, shoulders of such width should be provided on sections not less than 2,000 feet in length at intervals of not more than 4 miles. Such shoulder sections should be staggered on the two sides of the road, so as to provide space for parking on one side or the other at intervals averaging not more than 2 miles in length. On roads carrying more than 1,800 vehicles per day this should be regarded as a minimum requirement, and exception should be considered only in mountainous locations involving the heaviest grading.

At no point should shoulders be less than 4 feet wide.

Grades (over 500 feet long).—It will be unnecessary to change the grades of any road otherwise adequate.

On roads which it is necessary for other reasons to construct or reconstruct, it is desirable to hold maximum grades (in excess of 500 feet long) within the limits of 6 percent in mountainous locations and 4 percent in nonmountainous locations.

Grades of the recommended limiting percentages will permit operation by the majority of all passenger automobiles at speeds of 60 and 70 miles per hour, respectively. They will permit operation by the majority of motortrucks, with reasonable carried loads, at speeds in excess of 25 miles per hour, and by the majority of tractor-semitrailer combinations, reasonably loaded, at speeds not less than 15 miles per hour.

Curvature.—It will be unnecessary to revise the curvature of any road otherwise adequate.

On roads which it is necessary for other reasons to construct or reconstruct, it is desirable to hold maximum curvature within the limits of 6 degrees in mountainous locations and 4 degrees in nonmountainous locations.

Curvature corresponding to the recommended limits, combined with maximum practicable superelevations, will permit safe operation at speeds of 60 and 70 miles per hour, respectively. In mountainous areas where heavy grading is required, and on low-priority routes where traffic is light, maximum curvature may be increased to 14 degrees. On low-priority routes in nonmountainous areas where traffic is light, maximum curvature may be increased to 10 degrees.

TABULAR RECAPITULATION OF STANDARDS

The standards previously defined and explained in detail are recapitulated in brief tabular form as follows:

	Acceptable for existing structures	Desirable for new or reconstructed structures	
Bridges:			
Strength	H-15	H-15	
Vertical clearance, in feet	12[2]	14	
		Minimum	Preferred
Horizontal clearance, in feet:			
Bridges on 2-lane roads:			
Present average, 24-hour traffic:			
Less than 600	18	24	26
600 to 1,800	18	26	28
More than 1,800	18	28	30
Bridges on 3-lane roads	27	40	42
Bridges on 4-lane roads	36	52	(1)
Underpasses on 2-lane roads:			
Present average, 24-hour traffic:			
Less than 600	18	30	40
600 to 1,800	18	30	42
More than 1,800	18	30	44
Underpasses on 3-lane roads	27	42	56
Underpasses on 4-lane roads	36	54	(1)

[1] Out-to-out pavement width plus 6 feet. [2] Out-to-out pavement width plus 20 feet.

Surfaces and foundations.—Dustless surfaces and surface and foundation designed according to the present practice of each State, for the all-weather support of 9,000-pound pneumatic-tired wheel loads (the wheel load being considered as half the axle load where dual tires are used):

	Acceptable for existing roads	Desirable for new or widened roads	
Pavement width:			
2-lane roads:			
Present average 24-hour traffic:			
Less than 600	18 feet	20 feet.	
600 to 1,800	18 feet	22 feet.	
More than 1,800	18 feet	24 feet.	
3-lane roads	Any existing	36 feet.	
4-lane roads	do	48 feet.[1]	
		Minimum	Preferred
Shoulders:			
Present average 24-hour traffic less than 1,800:			
Mountainous areas:			
Heavy grading	do	4 feet continuous	4 and 8 feet staggered.
Other	do	do	8 feet continuous.
Nonmountainous areas	do	do	Do.
Present average 24-hour traffic 1,800 and over:			
Mountainous areas:			
Heavy grading	do	do	Do.
Other	do	4 and 8 feet staggered.	Do.
Nonmountainous areas	do	do	Do.

[1] To be separated into dual lanes, where practicable, by the use of a center dividing strip of the width and type recommended by the American Association of State Highway Officials.

	Acceptable for existing roads	Desirable for new or widened roads
Grades (over 500 feet long):		
Mountainous areas	Any existing	6 percent.
Nonmountainous areas	do	4 percent.
Curvature:		
Mountainous areas:		
Heavy grading	do	14 degrees.
Other	do	6 degrees.
Nonmountainous areas:		
Present average daily traffic less than 600.	do	10 degrees.
Present average daily traffic 600 and over.	do	4 degrees.

STANDARDS APPLICABLE TO URBAN AREAS

For the improvement of bridges and roads located in urban areas, the only items of the foregoing rural-area standards that are directly applicable are those for vertical clearance of bridges and underpasses and for the strength of pavements. The only other feature of design for which it is practicable to prescribe a general urban-area standard is the load capacity of bridges, and for that feature the standard H 20 design loading of the American Association of State Highway Officials (see pls. 7 and 8) is recommended as more consistent with the greater frequency of application of extremely heavy gross loads to be expected generally in such areas. The horizontal clearance of bridges, width of pavements, gradients, and curvature in urban areas can be determined only after consideration of conditions peculiar to each location, and shoulders are not employed in urban street construction.

THE APPLICATION OF DESIGN STANDARDS

Some apprehension has been evidenced that the foregoing standards of design for roads and bridges might be arbitrarily enforced on all defense projects without reference to the particular conditions surrounding each project undertaken as a defense facility. No such policy has been given consideration. It would be a very unintelligent approach to the solution of the many problems. For the purpose of securing a reasonable measure of the adequacy of the highways to serve the needs of the defense operations, it has been necessary to use an accepted yardstick. The actual planning of the individual projects is being, and will be, worked out in full cooperation with the State highway departments. The organized engineering and administrative abilities of these organizations are essential to the success of the defense-highway programs and constitute the most important contribution to the strengthening of the national security.

APPENDIX IV

GENESIS AND CHARACTER OF THE STRATEGIC NETWORK

The strategic network in its present form is not a haphazard or theoretical collection of lines on a map. Its conception goes back more than two decades, and through this period the earnest attention of both State and Federal agencies has been devoted to perfecting the plan of interconnected routes that would best serve civil needs in times of peace and the defense needs in times of a national emergency.

The Federal Highway Act, approved November 9, 1921, provided as follows:

SEC. 3. All powers and duties of the Council of National Defense under the act entitled "An act making appropriations for the support of the Army for the fiscal year ending June 30, 1917, and for other purposes," approved August 29, 1916, in relation to highway or highway transport, are hereby transferred to the Secretary of Agriculture, and the Council of National Defense is directed to turn over to the Secretary of Agriculture the equipment, material, supplies, papers, maps, and documents utilized in the exercise of such powers. The powers and duties of agencies dealing with highways in the national parks or in military or naval reservations under the control of the United States Army or Navy, or with highways used principally for military or naval purposes, shall not be taken over by the Secretary of Agriculture, but such highways shall remain under the control and jurisdiction of such agencies.

The Secretary of Agriculture placed the responsibility for the detailed action required by this legislation upon the then Bureau of Public Roads, and the Bureau at once sought the advice of the War Department on the location and character of highways necessary to meet the military requirements of the national defense; first, with respect to those sections of highway which for military reasons it was desirable to include in the Federal-aid system, and second, with respect to the standards of road and bridge design which military necessity might require.

The War Department's findings on the first point took the form of the so-called "Pershing map" of 1922. This map indicated, for the first time, a system of national routes deemed by the responsible military authorities to be of special importance from the standpoint of national defense.

Upon the second point, the War Department stated that military requirements would impose no standards for roads or bridges superior to those required to accommodate all classes of commercial traffic.

In the designation and improvement of the Federal-aid highway system, the Public Roads Administration and the State highway departments have been guided by this advice, which was promptly given and which has since been consistently supplemented by the military authorities. The routes indicated to be of military importance have been included in the system designated for improvement with joint Federal and State funds. Policies regarding types and degrees of improvement have been shaped on the assumption that the forms of construction meeting normal peacetime requirements would generally suffice for any probable military or defense use. These policies, adopted within the findings and conclusions of the military authorities and carried into effect over a long period by the State and Federal highway improvement programs, impose certain reciprocal obligations upon those responsible for the design of all types of heavy equipment and ordnance proposed for movement over the highways and particularly over the bridges.

When the first World War began in 1914, the motor vehicles in use in the United States numbered only 1,711,000; by 1925 this number had grown to the startling total of 19,937,000 units, and in 1940 to the highest record of 31,800,000 registered units. The Federal-aid, and the major exclusively State-highway programs have developed simultaneously with this rapid growth in the numbers and use of the motor vehicle.

In building roads to serve the expanding needs of the resulting traffic, the extensive mileage requiring improvement and the relatively limited funds available have at all times prevented the adoption of

standards superior to those required by the currently realized or immediately expected traffic. These two considerations have instead generally forced the adoption of "stage construction" as a practical expedient.

Under this policy, initial improvements have often been designed to meet only the imperative requirements of the realized traffic. More adequate improvements have been delayed by sheer necessity. Roads previously unimproved have been partially improved by grading and drainage, with surfacing deferred until a later date. Narrow surfaces have been built where it was definitely anticipated that later widening would be required. Initial thin surfaces have been constructed with the intention later of superimposing thicker or more durable surfaces. Existing weak and narrow bridges too costly to replace at once have been retained as long as possible, with safeguards to permit continued use without excessive hazard. And, finally, narrow rights-of-way, and grades and alinement known to be somewhat inadequate, have had to serve.

All of these expedient measures were adopted so that available funds could be spread over a greater mileage and provide at least a reasonable degree of improvement on many sections of road that otherwise would have remained wholly unimproved for an indefinite period. As a result, the primary highway system was steadily, if inadequately, improved over a period of about 15 years. By 1935, these most important roads presented no positive obstruction at any point to the normal flow of ordinary traffic. Conditions at many points, however, still imposed definite limitations on the convenience and safety of traffic.

The end of the pioneer period of road improvement may be said to have been reached by 1935. Then, but not until then, it became possible to do far-sighted planning of the construction that will eventually be required to improve the entire system adequately and consistently.

Prior to that time, any appraisal of the adequacy of the main highway system for national defense, or for ordinary civil and commercial uses, would have revealed numerous weaknesses. The greatest of these would have been the entire lack of improvement on many sections. The superior necessity of initial improvement where no improvement whatever existed would have rendered largely impracticable any really effective attention to the many other weaknesses.

This initial improvement had been completed by 1935, but in considerable part the other defects still remain. However, it is now possible by careful and consistent planning, steadily to reduce the number of such defects, bring the entire network up to modern standards, and meet the needs of a mature system of highway transportation. This statement applies, of course, to the relation between highway conditions and the needs of all civil and commercial traffic. In view of present plans for a modern mechanized army, it is especially pertinent to the relation between the roads and their probable uses for the national defense.

In 1935, in view of the considerable changes that had occurred since the preparation of the "Pershing map," the War Department reconsidered the network indicated on that map, and issued a revision. This revised map was then used by the Public Roads Administration and the State highway departments as a guide in their subsequent

operations, until it was again revised under date of September 15, 1939, by issuance of a new map entitled "Highway map showing main traffic routes of military importance."

Shortly thereafter, at the suggestion of the War Department, the Public Roads Administration undertook, with the aid of the highway planning surveys of the States, a study of the condition of existing roads conforming closely to the routes shown on this latest revision of the map. The feasibility and general adequacy of the indicated network also were carefully weighed, following which the Public Roads Administration prepared and submitted to the War Department for its consideration a further revision of the map.

With a few additional changes, this revised map was endorsed by the Secretary of War on November 20, 1940, as representing the principal routes of military importance. With further slight amendments by the Navy Department, it is included as plate 1 [1] in this report. It is still subject, however, to further amendment by the deletion or addition of routes and the revision of general directions, as studies still in progress show this to be advisable.

As viewed by the War and Navy Departments, this map is considered to represent a system of general routes. No precise definition is given of the location of roads comprising the routes between major "controlling points," which generally are large cities. In fact, in its broadest conception, the network consists not of a single road between each of the controlling points, but rather of a main line and approximately parallel auxiliary lines, with suitable connections between them at frequent intervals. The purposes of the auxiliary lines are: (1) To permit, if necessary, a division of traffic, especially military convoy movements, among at least three roads between any points, and (2) to provide alternate routes for use in case of obstruction of the main road by any cause.

The main lines of the network, as now approved by the War and Navy Departments, include all sections of the interregional highway system recommended by the Public Roads Administration in the report, Toll Roads and Free Roads. With few exceptions they are also in close conformity with roads included in the Federal-aid highway system.

While all of the routes designated are considered important to the national defense, an order of relative importance within the network is indicated by classification of the routes into first, second, and third priorities. The approximate extent of the main lines of the network is 74,600 miles, composed of about 42,400 miles of first priority, 23,100 miles of second priority, and 9,100 miles of third priority.

APPENDIX V

EXTENT AND CHARACTER OF IMPROVEMENTS REQUIRED ON THE STRATEGIC NETWORK

Existing roads and streets conforming most closely to the main lines of the strategic network total 74,626 miles. Of this total, 66,869 miles consist of rural highways, 7,757 miles of highways and streets in cities. Routes designated as of first priority total 42,422 miles. Of this mileage 29,331 miles consist of routes included in the interregional system recommended by the Public Roads Administration

[1] Not printed.

and 13,091 miles of roads not included in the interregional system. Second priority routes total 23,072 miles, and third priority routes 9,142. No part of the mileage designated as of second and third priority was included in the interregional system recommended by the Public Roads Administration.

Conditions of bridges.—Included in the total mileage there are upwards of 18,000 bridges and underpasses more than 20 feet in length. In the larger rural portion the number of such structures is 16,692, consisting of 15,813 bridges and 879 underpasses.

The condition studies thus far made by the Public Roads Administration and the State highway departments have been confined to the rural portion of the network. On this portion the more extreme deficiencies consist of 5,995 miles of surface less than 18 feet in width, approximately 14,000 miles of surface rated as incapable of supporting the frequent, year-round application of 9,000 pound wheel loads on low-pressure tires, and 2,436 bridges of load capacity inferior to the H-15 standard.

In table 2, these 2,436 bridges have been grouped into rated-capacity classes—rated capacity is the gross vehicle load for which a bridge is designed. This table also shows the average gross weight of the heaviest vehicles passing over the bridges of each capacity class with an average frequency of 1 a day, and indicates the large degree to which some of the structures are overloaded by normal civil traffic. This overloading is evidenced by the ratio of the gross weights of such vehicles to the respective rated capacities of the bridges, and varies all the way from gross loads only a fifth greater than the bridges in the 27,000- and 28,000-pound rated-capacity classes were designed to carry, to loads nearly 22 times as heavy as those for which the bridge in the 2,000-pound capacity class was designed.

TABLE 2.—*Bridges with a rated capacity under 30,000 pounds that are located on rural roads conforming to the main lines of the strategic net work; their distribution by rated-capacity classes; and the average gross weight of the heaviest vehicles passing over those of each class with an average frequency of 1 a day*

Rated capacity of bridges	Number of bridges	Average gross weight of heaviest daily vehicle	Ratio of average gross weight of heaviest daily vehicle to rated capacity
1,000 pounds		*1,000 pounds*	
2	1	43.5	21.7
4	9	29.7	7.4
6	13	33.6	5.6
7	2	28.3	4.0
8	9	30.3	3.8
9	7	32.3	3.6
10	73	27.4	2.7
11	6	35.3	3.2
12	54	32.5	2.7
13	62	34.9	2.7
14	175	33.9	2.4
15	62	35.3	2.4
16	143	33.6	2.1
17	5	21.7	1.3
18	48	37.1	2.1
19	8	43.0	2.3
20	957	32.3	1.6
21	3	41.5	2.0
22	39	36.7	1.7
24	663	42.5	1.8
25	70	29.4	1.2
26	7	42.9	1.7
28	20	33.2	1.2
Total less than 30,000 pounds	2,436		
Weighted average		35.41	1.81

Less critical deficiencies than weak bridges and weak and narrow road surfaces consist of a substantial number of bridges and underpasses of inadequate horizontal and vertical clearance and a considerable mileage of road graded and surfaced to widths less than those called for by the prescribed standards for the traffic they serve.

On 2-lane sections of the rural network, the planning-survey inventories show 819 bridges and underpasses with horizontal clearances less than 18 feet; on 3-lane sections, 46 with horizontal clearances less than 27 feet; and on 4-lane sections, 35 with horizontal clearances less than 36 feet. This makes a total of 900 bridges and underpasses with horizontal clearances less than the acceptable minima for the respective road widths.

Table 3 shows an accumulative numerical distribution of these and additional bridges and underpasses which have various horizontal clearances less than the 30-, 42-, and 54-foot widths recommended as desirable and preferable for structures on 2-, 3-, and 4-lane roads of the strategic network. This table indicates the large extent to which existing bridges and underpasses are inferior in horizontal clearance to the standards recommended as desirable for new structures on the strategic network, and the smaller extent to which they fall below minimum acceptable standards.

As for vertical clearance, the survey shows 134 bridges on the rural network on which less than the acceptable minimum of 12½ feet is provided.

TABLE 3.—Accumulative distribution of all structures, including underpasses, located on rural routes corresponding to main lines of the strategic network and having horizontal clearances of less than 30 feet on 2-lane highways, 42 feet on 3-lane highways, and 54 feet on 4-lane highways

Horizontal clearance (feet)	Accumulated number and percent of structures on 2-lane highways		Accumulated number and percent of structures on 3-lane highways		Accumulated number and percent of structures on 4-lane highways	
	Number	Percent	Number	Percent	Number	Percent
9	2	0.015				
10	10	.075				
11	20	.15				
12	38	.28				
13	60	.45				
14	99	.74				
15	320	2.4				
16	505	3.8				
17	819	6.1	1	0.3		
18	1,766	13.2	2	.6		
19	3,064	23.0	4	1.2	1	0.3
20	6,369	47.8	10	2.9	6	1.8
21	7,081	53.1	11	3.2	6	1.8
22	7,733	58.0	13	3.7	8	2.5
23	8,569	64.2	16	4.6	9	2.8
24	11,825	88.7	40	11.5	10	3.1
25	12,130	90.9	44	12.7	12	3.7
26	12,508	93.8	46	13.3	13	4.0
27	12,865	96.5	51	14.7	13	4.0
28	13,122	98.4	59	17.0	13	4.0
29	13,338	100.0	67	19.3	14	4.3
30	(1)		129	37.2	23	7.1
31			133	38.3	24	7.4
32			147	42.4	24	7.4
33			150	43.2	26	8.0
34			196	56.5	33	10.2
35			219	63.1	35	10.8
36			237	68.3	44	13.5
37			238	68.6	49	15.1
38			248	71.5	50	15.4
39			252	72.6	53	16.3

[1] Number of structures with clearance in excess of 29 feet, 2,550.

TABLE 3.—*Accumulative distribution of all structures, including underpasses, located on rural roads conforming to main lines of the strategic network and having horizontal clearances of less than 30 feet on 2-lane highways, 42 feet on 3-lane highways, and 54 feet on 4-lane highways*—Continued

Horizontal clearance (feet)	Accumulated number and percent of structures on 2-lane highways		Accumulated number and percent of structures on 3-lane highways		Accumulated number and percent of structures on 4-lane highways	
	Number	Percent	Number	Percent	Number	Percent
40			344	99.1	142	43.7
41			347	100.0	145	44.6
42			(2)		177	54.5
43					187	57.5
44					242	74.5
45					251	77.2
46					269	82.8
47					270	83.1
48					292	89.8
49					292	89.8
50					319	98.2
51					320	98.5
52					322	99.1
53 [3]					325	100.0
Total number structures	15,888		416		388	

[2] Number with clearance in excess of 41 feet, 69.
[3] Number with clearance in excess of 53 feet, 63.

Table 4 illustrates the very satisfactory condition regarding vertical clearance. As will be noted, the 133 structures with vertical clearance below the recommended minimum acceptable standard are less than 1 percent of the total number of bridges. The number with clearances less than the 14 feet recommended as desirable for new or reconstructed bridges is considerably less than 5 percent. By showing that less than 10 percent of all bridges have vertical clearances of 17 feet or less, the table indicates the very great extent to which vertical clearances of existing bridges on the network is practically unlimited.

In part, the bridges deficient in vertical clearance are also deficient in horizontal clearance, and those deficient in either or both of these respects are included in the [illegible] among the 2,432 bridges found load capacities. The totals given for each class of deficiency are not additive. The number of different bridges [illegible] less than 2,500

TABLE 4.—*Accumulative distribution of the number and percent of all structures, including underpasses, located on rural roads conforming to main lines of the strategic network and having vertical clearances of less than 18 feet*

Vertical clearance (feet)	Accumulated number	Accumulated percent
8	1	.01
9	4	.02
10	12	.08
11	34	.20
12	113	.68
12½	133	.80
13	231	1.38
14	872	5.22
15	1,342	8.04
16	1,597	9.57
17	1,650	9.88
(1)	16,692	100.00

[1] More than 17 feet.

In addition, however, to these defective bridges which should be rebuilt or altered, a minimum acceptable improvement of the rural network also requires the building of a number of other structures for various reasons. These include grade-separation structures required at existing grade intersections, bridges to replace existing fords and dips, and new bridges necessitated by desirable changes in the location of existing roads. Including these additional structures, the total number of bridges and underpasses involved in a minimum acceptable improvement of the rural network is 3,648.

Conditions of roads.—Of the 66,869 miles of existing rural roads conforming to main lines of the strategic network, 18,613 miles serve a normal traffic averaging less than 600 vehicles per day.

Of this latter mileage, roads included in the proposed interregional system make up 3,825 miles, or approximately 21 percent. The remaining 14,788 miles consist of roads not included in the interregional system.

Roads serving average daily traffic ranging between 600 and 1,800 vehicles total 29,273 miles. Of this, 11,750 miles, or approximately 40 percent, are included in the interregional system.

Roads serving traffic averaging 1,800 vehicles per day and more total 18,983 miles. Nearly 47 percent of this—9,979 miles—is in the interregional system.

These traffic-volume classes are associated with the standards of width for new work previously defined. These standards call for pavements not less than 20 feet wide where average daily traffic is less than 600 vehicles, not less than 22 feet where traffic averages between 600 and 1,800 vehicles per day, and not less than 24 feet for daily traffic averaging 1,800 vehicles or more.

In tables 5 and 6 the entire rural mileage conforming to the network is classified into traffic-volume and pavement-width groups. The tables indicate the extent to which existing pavements conform to the prescribed standards.

TABLE 5.—*Distribution of the length of rural roads conforming to main lines of the strategic network, by traffic volume and pavement width groups*

RURAL ROADS INCLUDED IN INTERREGIONAL SYSTEM

Average daily traffic volume (vehicles per day)	Width of pavements											
	Less than 18 feet		18 feet to less than 20 feet		20 feet to less than 22 feet		22 feet to less than 24 feet		24 feet and over		All widths	
	Miles	*Per-cent*	*Miles*	*Per-cent*	*Miles*	*Per-cent*	*Miles*	*Per-cent*	*Miles*	*Per-cent*	*Miles*	*Per-cent*
0 to 600	52	0.2	1,107	4.3	2,187	8.6	155	0.6	324	1.3	3,825	15.0
600 to 1,800	521	2.1	5,433	21.3	4,559	17.8	431	1.7	806	3.1	11,750	46.0
1,800 and over	361	1.4	3,731	14.6	2,686	10.5	437	1.7	2,764	10.8	9,979	39.0
Total	934	3.7	10,271	40.2	9,432	36.9	1,023	4.0	3,894	15.2	25,554	100.0

RURAL ROADS NOT INCLUDED IN INTERREGIONAL SYSTEM

0 to 600	1,952	4.7	4,250	10.3	5,728	13.9	1,016	2.5	1,842	4.5	14,788	35.9
600 to 1,800	1,528	3.7	7,240	17.5	7,112	17.2	857	2.1	786	1.9	17,523	42.4
1,800 and over	676	1.6	2,828	6.8	3,067	7.4	670	1.6	1,763	4.3	9,004	21.7
Total	4,156	10.0	14,318	34.6	15,907	38.5	2,543	6.2	4,391	10.7	41,315	100.0

TABLE 5.—*Distribution of the length of rural roads conforming to main lines of the strategic network, by traffic volume and pavement width groups*—Continued

ALL RURAL ROADS

Average daily traffic volume (vehicles per day)	Width of pavements											
	Less than 18 feet		18 feet to less than 20 feet		20 feet to less than 22 feet		22 feet to less than 24 feet		24 feet and over		All widths	
	Miles	*Percent*	*Miles*	*Percent*	*Miles*	*Percent*	*Miles*	*Percent*	*Miles*	*Percent*	*Miles*	*Percent*
0 to 600	2,[illegible]04	3.0	5,357	8.0	7,915	11.8	1,171	1.7	2,166	3.2	18,613	27.8
600 to 1,800	2,049	3.1	12,673	19.0	11,671	17.5	1,288	1.9	1,592	2.4	29,273	43.8
1,800 and over	1,037	1.5	6,559	9.8	5,753	8.6	1,107	1.7	4,527	6.8	18,983	28.4
Total	5,090	7.6	24,589	36.8	25,339	37.9	3,566	5.3	8,285	12.4	66,869	100.0

TABLE 6.—*Accumulative distribution of the length of rural roads conforming to main lines of the strategic network, by traffic volume and pavement width groups*

RURAL ROADS INCLUDED IN INTERREGIONAL SYSTEM

Average daily traffic volume (vehicles per day)	Width of pavements									
	Less than 18 feet		Less than 20 feet		Less than 22 feet		Less than 24 feet		24 feet and over	
	Miles	*Percent*	*Miles*	*Percent*	*Miles*	*Percent*	*Miles*	*Percent*	*Miles*	*Percent*
0 to 600	72	0.2	1,159	4.5	3,336	13.1	3,501	13.7	3,825	15.0
600 to 1,800	[illegible]	[illegible]	[illegible]	23.1	[illegible]	41.2	10,944	42.9	11,75[illegible]	[illegible]
1,800 and over	[illegible]	1.4	4,062	16.0	[illegible]	26.5	[illegible]	28.2	[illegible]	[illegible]
Total	934	3.7	11,205	43.8	[illegible]	80.8	[illegible]	[illegible]	25,554	[illegible]

RURAL ROADS NOT INCLUDED IN INTERREGIONAL SYSTEM

0 to 600	1,952	4.7	6,202	15.0	11,940	28.9	12,966	31.4	11,788	55.8
600 to 1,800	1,528	3.7	8,768	21.2	15,880	38.4	16,727	40.5	17,523	42.4
1,800 and over	676	1.6	3,504	8.5	6,571	15.9	7,241	17.5	9,004	21.8
Total	4,156	10.0	18,474	44.7	34,381	83.2	36,924	89.4	41,315	100.0

ALL RURAL ROADS

0 to 600	[illegible]	3.0	7,361	11.0	[illegible]	22.8	16,[illegible]7	24.6	[illegible]	27.8
600 to 1,800	2,049	3.1	14,722	21.0	26,393	39.5	27,681	41.4	29,273	43.8
1,800 and over	[illegible]	1.5	7,596	11.3	[illegible]	20.0	11,45[illegible]	21.6	[illegible]	28.4
Total	[illegible]	7.6	29,679	44.4	55,018	82.3	58,584	87.6	66,869	100.0

Table 5 shows how the entire mileage breaks down into each of four pavement-width classes, each subdivided into traffic-volume groups. Table 6 shows an accumulative distribution which gives for each traffic-volume class the total mileage at present improved with pavements or surfaces less than 18, 20, 22, and 24 feet wide, and 24 feet wide and over. In both tables roads included in the proposed interregional system and those not included in that system are separately classified.

Both tables 5 and 6 show that the roads of the strategic network most seriously deficient in pavement width are the 5,090 miles paved less than 18 feet wide. Only 934 miles of such extremely narrow surfaces are part of the interregional system; 4,156 miles are on other roads conforming to the strategic main lines.

Table 5 shows that pavements 24 feet wide and wider are found on 8,285 miles of the network—on 3,894 miles of the interregional system and on 4,391 miles of other roads. Practically all roads in this group are fully adequate in pavement width for their present normal traffic.

Between these two extremes of roads—those seriously inadequate and those in the main fully adequate—there are, on the basis of traffic volume, 10,374 miles of the rural network with adequate pavement widths and 43,120 miles with inadequate widths. This latter mileage and the 5,090 miles with pavement less than 18 feet wide make a total of 48,210 miles of roads in the entire rural network, as shown by table 7, with existing surfaces inferior in width to the standards prescribed.

Of this 48,210 miles of inferior roads, 18,887 are included in the proposed interregional system and constitute 73.9 percent of its total mileage; and 29,323 miles are outside the interregional system and form 71.0 percent of the total mileage of all other roads in the strategic network.

As table 7 shows, the extremity of inadequacy is reached on 1,037 miles of the network on which existing surfaces less than 18 feet wide are subjected to traffic averaging more than 1,800 vehicles per day. Of this extremely inadequate mileage, 361 miles are included in the interregional system. On the entire mileage, the prescribed standards call for 24-foot pavements.

TABLE 7.—*Length of rural roads conforming to main lines of the strategic network surfaced with pavements of various widths inferior to the prescribed standards, by traffic volume classes*

Portion of network	Annual average traffic in vehicles per day								
	0-600		600-1,800			1,800 and over			
	Deficient pavement width		Deficient pavement width			Deficient pavement width			
	Less than 18 feet	18 to less than 20 feet	Less than 18 feet	18 to less than 20 feet	20 to less than 22 feet	Less than 18 feet	18 to less than 20 feet	20 to less than 22 feet	22 to less than 24 feet
Rural roads:									
Included in interregional system	*Miles* 52	*Miles* 1,107	*Miles* 521	*Miles* 5,433	*Miles* 4,559	*Miles* 361	*Miles* 3,731	*Miles* 2,686	*Miles* 437
Not included in interregional system	1,952	4,250	1,528	7,240	7,112	676	2,828	3,067	670
All rural roads	2,004	5,357	2,049	12,673	11,671	1,037	6,559	5,753	1,107
Total deficient by traffic volume classes	7,361		26,403			14,456			

Portion of network	Annual average traffic in vehicles per day—Con.				Total deficient in width	
	0 1,800 and over					
	Deficient pavement width					
	Less than 18 feet	18 to less than 20 feet	20 to less than 22 feet	22 to less than 24 feet	Length	Percent of rural network
Rural roads:						
Included in interregional system	*Miles* 934	*Miles* 10,271	*Miles* 7,245	*Miles* 437	*Miles* 18,887	73.9
Not included in interregional system	4,156	14,318	10,179	670	29,323	71.0
All rural roads	5,090	24,589	17,424	1,107	48,210	72.1
Total deficient by traffic volume classes	48,210					

In contrast, deficiencies of least degree are found on 12,778 miles, all of which are improved with pavements at least 20 feet wide and in no case more than 2 feet narrower than the standard width prescribed for the volume of traffic served.

To raise the entire rural network to the standards of pavement width prescribed, table 7 shows that it will be necessary to widen existing pavements as follows:

To 20-foot width:
- 2,004 miles now less than 18 feet wide.
- 5,357 miles now 18 but less than 20 feet wide.

To 22-foot width:
- 2,049 miles now less than 18 feet wide.
- 12,673 miles now 18 but less than 20 feet wide.
- 11,671 miles now 20 but less than 22 feet wide.

To 24-foot width:
- 1,037 miles now less than 18 feet wide.
- 6,559 miles now 18 but less than 20 feet wide.
- 5,753 miles now 20 but less than 22 feet wide.
- 1,107 miles now 22 but less than 24 feet wide.

The strength of existing road surfaces approaches the desirable standard more nearly than their width. It has not been possible to determine with great accuracy the strength of all surfaces; but the facts available regarding their general type indicate that not more than about 14,000 miles of the rural network are incapable of supporting 9,000-pound wheel loads on pneumatic tires the year round. In very large part the surfaces deficient in strength are also deficient in width and other qualities.

Excessive curvature and inadequate sight distances are among the more common defects of existing improvements. Perhaps the most common defect is a general lack of shoulders of sufficient width to accommodate standing vehicles. The construction of narrow shoulders has been considered in the past a permissible cost-saving expedient. As a result there are few roads today where the space between the pavement and ditch or edge of fill is sufficient to insure the safety of parked vehicles and the traffic moving by them.

Entirely apart from considerations of defense usage, adequate provision for normal civil traffic on the more heavily traveled routes will require in the future a rather general widening of existing shoulders. But the possibility of more or less frequent use of a substantial part of the strategic network by motorized and mechanized Army convoys adds another important reason for building wider shoulders.

As a practical approach to this generally desirable condition, many of the State highway departments have indicated a preference for constructing wider shoulders at staggered intervals on the two sides of the road. But even so, the sections of the rural network on which they report immediate shoulder widening to be desirable, aggregate more than 42,700 miles.

○