REPORT OF COMMITTEE ON RIGID PAVEMENT DESIGN

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SYNOPSIS

During 1940 certain investigational concrete pavement projects were built in Kentucky, Michigan and Minnesota. Similar projects were built during 1941 in California, Missouri and Oregon These projects were undertaken with the primary objective of studying the controversial feature of joints in concrete pavements.

No progress reports on the service behavior of these pavements have as yet been released since it will take time to develop definite conclusions because all are being tested under normal traffic conditions. However, it is expected that progress reports on some of these pavements will be presented at the next annual meeting

A progress report is being presented at this meeting on the previously-reported experimental pavement in Indiana designed to study the subject of steel reinforcement in concrete pavements

The extensive program of airport construction during the past two years has caused attention to be centered more upon airports than upon highways This has raised the question as to whether airport conditions are such as to require or permit substantial modification of the established principles of highway pavement design when applied to airports, notwithstanding the fact that both classes of pavement are subjected to the same kind of stress-producing conditions—namely, vehicular wheel loads and climatic exposure Such differences in conditions as do exist are embodied largely in the relative magnitudes of applied wheel loads, their corresponding areas of distribution on the pavement surface, and possibly the relative frequencies of critical stress repetition. It is possible that the differences between airport and highway loadings—although differences in degree only—might be of such a high order of magnitude as to require a fundamental modification of the commonly-used theory of stress analysis

In the highway field, certain information that is being disclosed by the service behavior of some of our pavements under wartime traffic may have an important influence on future design practice. In the case of trucks, more vehicles are using the highways and heavier loads are being carried. Whether due wholly to this over-loading or to a combination of causes, the fact is that some new concrete pavements built under wartime restrictions have, under wartime traffic, developed serious breakage after having been in service less than six months. Undoubtedly valuable lessons are to be learned from such cases.

At the twentieth and twenty-first annual meetings of the Highway Research Board, the Committee on Rigid Pavement Design sponsored the presentation of a group of reports describing the design features of five investigational concrete pavement projects that had been built during 1940 and 1941 in five different States—Kentucky, Michigan, Minnesota, Missouri and Oregon. These projects, as a group, constitute a comprehensive investigational program initiated by the Public Roads Administration in cooperation with the Highway Departments of the States in which the several projects were selected to be built. While the primary objective of the program was to study especially the controversial feature of joints in concrete pavements, most of the states have included in their respective projects many additional features of design and construction which are of special interest to them

The Kentucky, Michigan and Minnesota

projects have now been in service for about three years, the Missouri and Oregon projects for about two years. All have thus been subjected to from two to three years of traffic and at least two complete annual cycles of climatic exposure. The Committee, therefore, had hoped that progress reports on the service behavior of some of these pavements would be presented at this meeting but none have as yet been released. It is understood, however, that a considerable amount of observational data has been accumulated on most of the projects but some of those who are directing the research feel that the data thus far obtained are not sufficiently indicative to justify publication while others state that the compilation and analysis of field observations have been delayed by reason of a shortage in experienced personnel.

Naturally, it will take time for the service behavior of these pavements to develop definite conclusions because all are being tested under normal traffic. Nevertheless, the Committee is confident that this extensive and carefully-planned investigation ultimately will not only disclose much informative data on the specific design features embodied in each individual project but also, by reason of their geographical distribution, will permit comparisons under varying conditions of traffic, subgrade, and climate. It is expected that the first progress reports on some of these pavements undoubtedly will be available for presentation at the next annual meeting.

A progress report is being presented at this meeting on the experimental concrete pavement in Indiana. This is a special investigational project designed specifically to study the subject of steel reinforcement in concrete pavements and was constructed about two years prior to initiation of the joint-spacing program mentioned above. Several progress reports on the Indiana project have been presented at previous meetings. The report being presented today will reveal the latest observations on pavement behavior after about five years of service.

The above projects are specifically mentioned because they are so fundamental in scope, are of a long-time continuing nature, and especially because they have been previously reported under the sponsorship of this committee. There are, of course, many others covering a wide variety of still-unsolved problems. The subject of subgrade friction against concrete pavements is being studied with full-size pavement slabs by a certain state highway department. Another organization is investigating the flexibility of different types of load-transfer joints. Many other phases of joint design are being investigated. Curing, durability and maintenance are being studied for improved materials and methods. And marked investigational activity, both experimental and analytical, continues in the field of soil mechanics—a subject which is of major importance not only in the design of flexible pavements but in the design of rigid pavements as well.

In viewing this investigational activity in its over-all aspects, it is observed that not only the extent but particularly the character of much of the current research pertaining to pavements is being noticeably affected by wartime conditions. This is to be expected, for the war has caused many changes not only in the daily habits of all our people but also in the design and construction habits of our engineers.

The engineer, being no longer permitted to choose without restriction from the complete list of his customary materials of construction, has been forced to change many of his prewar concepts of design requirements so that those materials actually available to him during the emergency can be most effectively and economically employed.

Because of the many restrictions and limitations imposed by wartime regulations and being suddenly called upon to design unusual structures subjected to unusual conditions, both the design engineer and the construction engineer have been confronted with many urgent and unusual problems, such as the development and use of new materials, the adaptation of known materials to new uses, and the perfection of new construction methods and procedures. Naturally, a satisfactory solution of many of these problems is requiring the services of the research specialist and often calls for investigational technique of a very high caliber—both experimental and analytical. Accordingly, in practically every branch of military, industrial, and civilian construction, the exigencies arising out of the war effort have had a general tendency to stimulate rather than to retard research activity.

In the concrete paving field, the extensive program of airport construction which was started so suddenly and which has progressed with such intense activity during the past two years or more has caused attention to be centered more upon airports than upon highways. As a result, there has developed a noticeable tendency to view the problems of airport pavement design as being greatly different from those involved in the design of highway pavements, notwithstanding the fact that both classes of pavement are fundamentally similar in that each consists of a series of jointed slab units resting upon a suitable subgrade and subjected to the same kind of stress-producing conditions—namely, vehicular wheel loads and climatic exposure.

The principles of concrete highway design as reflected by modern practice have developed through a long period of years as the result of extensive research and observed service behavior furnished by thousands of miles of pavement under widely-varying conditions of traffic, subgrade and climate. In attempting to apply to airport paving the knowledge thus obtained through long experience with concrete highways, the question arises as to whether conditions to which airport pavements are subjected are such as to require or permit any substantial modification of the established principles of design as applied to concrete pavements for highways—especially the analysis of stresses induced by wheel loads.

Certain conditions which govern the design requirements for airport paving obviously are very different from those to which highway pavements are subjected But these differences are embodied largely in the relative magnitudes of the applied wheel loads, their corresponding areas of distribution on the pavement surface, and possibly the relative frequencies of critical stress repetition

Offhand, distinctions such as these would appear to be differences in degree only—not differences in the basic theory of stress analysis. But, when it is realized that airports are now being planned to accommodate future aircraft expected to weigh as much as 300,000 lb , it is possible that the difference between airport and highway loadings—although a difference in degree only—might be of such a high order of magnitude as to appreciably affect the nature of pavement slab action.

Even with certain heavy aircraft loadings now in use, very high load stresses are obtained when computed by the customary theory. In order to hold slab thicknesses to practical values, it therefore becomes especially important in airport pavements to control warping stresses by utilizing very small slab units. Thus the trend in airport paving, as compared with highway paving, is toward smaller sizes of the slab unit accompanied by larger sizes of the loaded area—a combination which tends to depart very materially from the condition of a plate of infinite size supporting a highly-concentrated load. Hence, one is forced to at least question the validity of applying the customary plate theory of stress analysis to such cases without taking into account the size of the plate unit

If this is, as it appears to be, a legitimate element of doubt in our present commonly-used theory, then the question as to whether it is necessary or even permissible to modify our present theory of pavement stress analysis when applied to conditions peculiar to airports may possibly involve modifications of a very fundamental character and not merely departures in the procedure of its detailed application Unfortunately, this question has not as yet been satisfactorily answered. But it is a question that is being seriously asked by some engineers responsible for the design of airports —especially where extremely heavy aircraft loadings are involved and for which there is little or no precedent of experience or background of experimental data.

As this is apparently a fertile field for needed research, it is encouraging to note that the Army Engineers are now conducting, under field conditions, investigations which it is understood are planned to study the whole question of stresses in concrete slabs subjected to the heavy loads and other conditions involved in the design of airport paving. Very little information has as yet been made public on the scope and status of this work However, it is assumed that, as indicative findings are revealed by this investigation, progress reports will in due time be issued, and it is the hope of this committee that such reports will be released through the meetings and publications of the Highway Research Board.

Another effect of the war that may have an important influence on future design practice is the information that is being disclosed by the service behavior of some of our pavements under wartime traffic. As reported at the last annual meeting, nation-wide surveys show that a pronounced change has occurred in the character of the traffic that is now being carried by many highway routes. While gasoline and rubber shortages have materially reduced the volume of passenger car traffic, wartime transportation demands have caused an increase in bus and truck traffic. Particularly in the case of trucks, more vehicles are using the highways and heavier loads are being carried.

Accordingly, some of our pavements that were never intended to be experimental projects are actually proving to be just that, in the sense that they are undergoing a certain degree of accelerated loading test by reason of this unexpected increase in the volume and weight of wartime truck traffic. Whether due wholly to this over-loading or to a combination of causes, the fact is that some of these pavements are showing signs of structural weakness far ahead of their time, instances having been reported where new concrete pavements built under wartime restrictions have, under wartime traffic, developed serious breakage after having been in service less than six months.

Undoubtedly, there are valuable lessons to be learned from those cases where definite indications of premature failure have occurred. If intelligent conclusions are to be deduced therefrom, it is essential that all pertinent information as to design and construction details as well as subgrade, traffic and climatic conditions be adequately recorded while the data are still fresh and readily obtainable

Any pavement that fails prematurely or acts in an unpredictable manner, if carefully observed so that the causes of its behavior can be intelligently analyzed, is potentially a research project, whether it was originally intended to be such or not. The important thing, therefore, is to realize that such cases that do occur—deplorable as they are because of the economic loss incurred—can be made to serve as a valuable research windfall provided we take advantage of the opportunity of making every effort to determine the full significance of such premature failures and not consider them merely as unfortunate happenings to be charged off as inevitable wartime casualties.

EXPERIMENTS WITH CONTINUOUS REINFORCEMENT IN CONCRETE PAVEMENT—A FIVE-YEAR HISTORY[1]

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and

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SYNOPSIS

In the fall of 1938 a number of experimental sections of reinforced concrete pavement were constructed near Stilesville, Indiana, on U. S. Route No 40 as a cooperative research project Since that time frequent detailed observations have been made to obtain a record of the performance of the various sections This report, in presenting a 5-yr history of the behavior of the pavement is divided into 4 parts in which are discussed: (1) periodic elevation changes of the sections, (2) daily, annual and permanent changes in length of the sections; (3) development, distribution and present condition of cracks in the sections; (4) data pertaining to four 500-ft special sections in which weakened-plane joints are spaced at 10-ft intervals

The data obtained during the 5-year period shows that: (1) changes in pavement elevation have been generally small and non-uniform and there is nothing

[1] Condensed. A complete report of the data will be published in *Public Roads*.