

PROGRESS REPORT ON SPECIAL INVESTIGATION ON THE ECONOMIC VALUE OF STEEL REINFORCEMENT IN CON- CRETE ROAD SURFACES

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As indicated by its title, the object of this investigation is to determine if the cost of steel reinforcement is warranted in concrete road construction by increased life of road, reduced maintenance cost, or possibly by both. This is an unsettled question as evidenced by the variety of present surface designs, some of which specify no steel, others only several bars, while still others call for considerable amounts. These designs indicate that steel in road surfaces is used for several different purposes, namely, to hold the concrete together, to stretch the concrete apart, or to act simply as a load distributing agency at cracks and joints.

With expansion joints separating the pavement into comparatively short slabs, steel is expected to expand and contract with the concrete and thus resist the formation of temperature cracks, increase the structural strength of the surface and hold pieces of cracked slabs together.

In the absence of expansion joints and when the longitudinal reinforcement is continuous, the steel can be expected to stretch the concrete, thus increasing the number of transverse cracks but reducing their width so that they are hardly discernible. This type of reinforcement is intended also to distribute wheel loads across cracks and joints and, in theory at least, practically doubles the corner resistance.

When expansion joints are eliminated and continuous longitudinal bars are so prepared as to prevent bond with the concrete, they are expected to act independently of movements caused by contraction and expansion in the concrete and serve only to distribute wheel loads across cracks and joints, thus affording the advantage of increased corner resistance.

It is the method of attack on this problem that I would particularly call to your attention. During the past two days you have listened to and considered reports of experiments carried on by individual organizations such as Federal, state, and educational, and while the information developed was contributed to the Research Board for the benefit of the public good, the responsibility of the research rested with the producing party.

In the present instance, however, the Board assumes a new character in that it becomes a producer of research instead of a coordinator, and thereby assumes responsibility for this investigation. This responsibility, of course, concerns the methods used as well as the results obtained, and therefore I am submitting in detail what we are doing and how we are doing it, asking for frank discussion and constructive criticism so that this research will be truly representative of the Board's best thought.

The procedure submitted for your consideration consists of two parts. The first involves a study of the effects of steel as it has been used in roads up to the present time. The second should include the construction of especially designed slabs. For determining the effect or value of steel as it has been used, we have recourse to major highway experiments, reports of previous surveys and service test roads, construction and maintenance costs, and present condition of specially selected pavements subjected to various conditions of traffic, climate, and subgrade.

The major highway experiments have given most valuable information, but there are not enough of them, and they have not been carried far enough. Owing to the pressing need of information on a variety of surface designs, the test specimens, in general, consisted of but a short section of road or a small slab representing each.

Every effort has been made to have a uniform subgrade, but we have not yet developed the art of acquiring complete uniformity. Under ordinarily good working conditions, we have not mastered the art of making uniform concrete. Cores from the same slab, made from the same materials, by the same force of men, with same inspection, show a considerable variation in strength of concrete. Experience indicates that in any considerable length of road, breaks occur at some places before they do at others. We do not know what causes them, but we are aware that sections at some particular locations have less resistance or are subjected to more serious conditions than exist throughout. When single specimens are tested, it is possible for a 6-inch thickness to fail before a 5-inch, or a 7-inch before a 6-inch, but final conclusions would not be drawn until additional tests were made. For this reason, test results have been used only when definite comparisons could be made and mainly when the specimens showed considerable difference in behavior.

Maintenance costs of plain and reinforced concrete roads in the same state are indicative, but comparing costs in one state with those in another seems impractical. G. F. Schlesinger has a uniform system of recording maintenance costs. In investigations involving the economics of roads, maintenance costs are of prime importance, and if tabulated uniformly would be valuable.

In regard to roads built up to the present, we do not assume that either in type, placement, amount of steel or in design of slab, reinforcement has been used most efficiently. Light on these questions is expected from the second part of the investigation. The present condition of a considerable number of plain and reinforced concrete surfaces, so selected as to eliminate all possible variables, will supply very definite indications on how the behavior of the pavement is influenced by steel. Elimination of variables is the most difficult part, since subgrade, traffic, slab design, age, and every other factor which influences the behavior of a road surface enters into this problem. The specimens selected for study are those having both plain and reinforced sections in the same road. A considerable number of these surfaces exist and are so distributed as to show the effects of varying climatic, subgrade, and traffic condi-

tions Also, they represent different ages, mixes, slab designs and types of reinforcement Their selection was made possible through the cooperation of the Portland Cement Association, which furnished construction records of practically every road and street built in the United States prior to 1920

In the field inspections, topography and drainage are carefully noted The condition of the surface is recorded by detailed sketches and supplemented by photographs Subgrade soil samples are obtained and sent to the U S Bureau of Public Roads for analysis

In the final study of the selected sections the core-drill will be used for checking strength and thickness of concrete and also placement of steel The conditions of sections will be compared in regard to area of breakage, length and character of cracking, and then salvage values will be computed At present, no definite method for such computation exists, but we feel confident that the Committees on Structural Design and Maintenance will have something definite to offer when we are ready for it

When the status of the investigation has reached that stage we shall feel justified in offering definite conclusions This question of reinforcement has occupied the minds of highway engineers for 10 years and they have not yet reached a definite agreement It is apparent that results obtained from studies made by one person in a short time, could have little or no significance

To date the following work has been done

- 1 Conferences were held with all available engineers interested in the subject
- 2 Letters were written to the highway officials and engineers who might have information to offer
- 3 All engineering literature dealing with the subject was scrutinized, including contributions to the technical press and proceedings of various engineering societies
- 4 Results from previous surveys and highway experiments have been studied and correlated
- 5 Available maintenance costs have been collected and tabulated
- 6 Approximately 100 miles of road surfaces, located in 5 different states, have been examined and the information filed

The outlook for securing definite results is most encouraging, but we are not in a position to give conclusive results at this time

I wish to express appreciation for the cooperation accorded by the various organizations with whom I had contact Both in the form of supplying information and in the more material aspect, such as personal assistance, or transportation, it has been most liberal

I would point out that discussion is not limited to this meeting Suggestions and information sent in concerning the work will be appreciated When in your own mind you accept or reject the results of an experiment, you do so not because of the conclusions drawn, but because of the manner in which the experiment was conducted It is for this reason that we invite your discussion at this time