Session Two

BRIDGE RESEARCH

Presiding: E. L. ERICKSON, Member, Bridge Panel, AASHO Road Test

The Road Test Bridges – History and Objectives

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• The early planning of the Road Test project did not include structures. It was planned as an investigation of pavements, both cement concrete and asphaltic concrete. This remained its primary purpose. The AASHO Committee on Bridges and Structures had, for many years, been searching for a project where structures carefully designed and built would be subjected to controlled truck traffic of known weight and vehicle dimensions. The Road Test provided the opportunity for a project that in magnitude and completeness exceeded the wildest dreams of the Committee. A proposal for the inclusion of test bridges in the Road Test project was prepared and submitted to the working committee by Raymond Archibald, then Chairman of the AASHO Committee on Bridges and Structures. The proposal was approved, and in December 1951 the Road Test project was expanded to include several bridge spans to be used for case studies of the effect of repeated overloads on the service life of highway bridge structures.

A subcommittee under the working committee of the AASHO Committee on Highway Transport with George M. Foster, then Chief Deputy Commissioner of the Michigan State Highway Department, as Chairman, was formed. Through efforts of this subcommittee, the bridge project was programed and arrangements made for its financing.

The over-all supervision of the Road Test project was assigned to the Highway Research Board which appointed, among other committees, an advisory committee to work with the Road Test staff on the design, instrumentation, testing, and analysis of data on the bridge test program. It was composed of bridge engineers from the States and the Bureau of Public Roads and faculty members from civil engineering schools of universities. The committee was formed early in 1957 and met from time to time upon request of the Road Test staff. The personnel of this Advisory Panel were G. S. Paxson, Chairman, and J. M. Biggs, C. P. Siess, Bruno Thurlimann, E. L. Erickson, O. L. Kipp, G. S. Vincent, and W. C. Hopkins. Prof. Thurlimann resigned in 1960 and Mr. Hopkins in 1961. After Mr. Kipp's death in 1958, he was succeeded by A. E. LaBonte.

The National Advisory Committee in 1957 enunciated, in broad terms, the specific objectives of the Road Test. The objectives of the bridge research were stated as follows: "To determine the significant effects of specified vehicle axle loads and gross vehicle loads when applied at known frequency on bridges of known design and characteristics. The bridges will include steel I-beam design, conventional reinforced concrete design and prestressed concrete design."

The principal objective of the bridge research program was to gather data on fatigue and overstress effects. The setup was such that it could be expanded to include a study of dynamic behavior of these bridges under the vehicles used in the Road Test. Upon the recommendation of the Bridge Advisory Panel, this extension was authorized by the National Advisory Committee.

The variables affecting dynamic behavior are so numerous and the fitting of the data into available theory so complex that specially qualified personnel was needed. The civil engineering staff of the University of Illinois had, for several years, been conducting theoretical and laboratory studies of dynamic effects on bridges similar in many respects to the Road Test bridges. They also had adequate electronic computer equipment available. A contract was entered into with the University of Illinois under which the analysis of dynamic test data and reporting of the results of dy-

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namic tests was done by the University. A Special Committee on Dynamic Behavior of Test Bridges was appointed by the Highway Research Board as an advisory group on the planning of the tests and the interpretation and reporting of the test data. The personnel of the Committee is given in HRB Special Report 61D.

The Road Test provided sufficient replication of identical pavement sections so that statistical analyses could be made. There were, however, only four sites available for test bridge installation. Each of these sites could be subdivided into four structures of identical span length making available 16 structures in all. Any statistical approach would have required that several structures of identical design and subjected to the same loading conditions would be provided. This was impractical as only two structures in each traveled lane were available and even these two structures would be loaded differently because of the impact effects caused by the deflection of the first structure in the two span series. One of the first meetings of the Bridge Advisory Panel was held jointly with the Statistical Advisory Panel. The problem was thoroughly discussed and it was decided that greater value could be had by abandoning any statistical study. Each structure was therefore considered separately and there were six different general types of structures built. There were at least two bridges of each general type.

The adopted program included three different modifications of rolled wide-flange steel beams; prestressed concrete I-beams, both pretensioned and post-tensioned; and conventional reinforced concrete T-beams. There were eight steel beam structures. Three of these were noncomposite with cover plates varying in length from 19 ft to 20 ft 6 in. One was designed to develop a stress of 27,000 psi and two to develop a stress of 35,000 psi under the loads to which they were subjected. Three steel beam spans were noncomposite without cover plates, two at 35,000-psi stress level and one at 27,000-psi stress level. The two composite spans both had cover plates, one span stressed to 35,000 psi and one to 27,000 psi.

These stress levels are both considerably in excess of the unit stress used in highway bridge design. They were chosen to insure that fatigue failures would occur under the limited number of loadings available in the operation of the project. The prestressed concrete structures were designed so that for one span of the pretensioned bridges and for one span of the post-tensioned bridges the concrete would be under tension above its strength. The other two bridges were stressed approximately to one-half of the modulus of rupture. This insured that at least one structure of each type would be cracked, giving opportunity to observe the action of cracked beams under repeated loading. The four conventionally reinforced concrete bridges were designed to give information on the fatigue life of the reinforcement under repeated loads causing stress near the yield point of the steel. Two of the four were stressed to 40,000 psi and two to 30,000 psi.

Early in the test program four of the steel bridges designed for a stress level of 35,000 psi failed by yielding. Two of these structures were replaced with noncomposite steel spans designed at the 27,000-psi stress level. Thus the test included 10 steel bridges and the total number of test bridges was 18.

In studying the test data, it must be kept in mind that these Road Test bridges were not typical highway bridges. They were purposefully designed to fail, for it is only through failure that information could be gained as to why failure occurred and the way in which failure takes place. Another very important limitation upon the use of the data is that no comparison of one type of bridge with another can be made. One cannot infer that because one bridge failed at a half-million cycles of loading and another was still in service after a million cycles, one type is better than another. These were case studies of individual structures, subjected to different loading conditions, and each designed to give information of some particular aspect of highway bridge problems.

Some of the steel beam spans had welded cover plates and some did not. An answer was sought as to the effect of sudden stress variation at the ends of the cover plate. There are many data available on the fatigue life of steel from laboratory tests on small specimens. Such tests cover wide ranges of stress variation. Could these laboratory fatigue life results be applied to bridges in actual service so that, given the characteristics of the material and reasonable estimate of the number, weight, and arrangement of the vehicle loads to which the bridge would be subjected, a reasonably good prediction of the usable life of the strucure could be made? In some of the bridges the decks acted compositively with the beams. Information was wanted as to whether this composite action continued up to the point of fatigue failure of the beam itself and what the method of failure was in such structures. The prestressed concrete bridges gave data as to the permanence of bond between steel and concrete in both pretensioned and post-tensioned beams; the effect of cracking of the concrete on steel stress; and the type of failure at ultimate load. The conventionally reinforced concrete bridges gave opportunity to study the fatigue life of the reinforcing steel and the method of failure under repeated overstress and at ultimate load. The combination of precise knowledge of the material and design of the structures and the control of the loading made possible a study of

these and other items that had never before been done.

As mentioned previously, the test program was expanded to include a study of the dynamic action of the bridges under vehicular traffic. The field data were gathered during periods when for one reason or another normal test traffic was suspended. Vehicles especially instrumented to record axle load, vehicle vibration, speed, and other variables were used. The structures were instrumented to measure both permanent and transient strains. The data were recorded by the best electronic equipment available.

There have been a number of theoretical studies made of the effect of rolling loads on the vibration of structures. Some of these studies have been tested by model studies. There have also been a number of observations made on actual highway bridges. It was known that there are many parameters that must be taken into account before any accurate prediction of structural behavior can be made. The opportunity to control these parameters and in some measure to isolate their effect could certainly not be overlooked. A very valuable practical result was the opportunity to compare the actual stress increase due to dynamic effects, commonly called impact, with the empirical impact formula used in highway bridge design.

The information presented in the Conference papers, and which will show in greater detail in the published reports, is basic data. It cannot be applied indiscriminately to practical design problems. It does provide a better understanding of the fundamental factors that affect the adequacy and service life of highway structures. As new materials become available, new types of structural design are evolved and changes in the vehicles that use highways come about, the results from this test program will be of inestimable value in the work to come.