The Bump at the End of the Bridge

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ABRIDGMENT

•THE NATURE and causes of the differential settlements between a bridge deck and the adjoining highway approach pavement have been the subject of an increasing number of investigations in recent years. This settlement of the highway approach pavement not only presents a hazardous condition to rapidly moving traffic, but creates a rough and uncomfortable ride. These defects of the pavement surface require costly maintenance and, where a heavy traffic flow exists, these maintenance operations may tend to impede the normal flow.

Bridge abutments in Kentucky are usually founded on a relatively stable foundation, such as rock or point-bearing piles to rock, and, practically speaking, cannot settle. Highway approach pavements, on the other hand, are located on an embankment and foundation that are potentially free to settle. The extent to which either settlement of the embankment or foundation contributes to the approach settlement will obviously depend on the particular conditions at any given bridge site. Data obtained from a survey of existing bridge approaches conducted in the summers of 1964 and 1968 have provided general information as to the prevalence of the problem in Kentucky. In addition, these data imply that there is a general relationship between development of the approach fault and such possible causative factors as the type of abutment, geological conditions, and soils conditions. This report summarizes the general relationship between the occurrence of bridge approach settlement and various conditions at the bridge sites.

The approaches were classified according to one of the following settlement categories:

Group 1 settlement—no maintenance necessary and no approach fault noticeable.

Group 2 settlement—no maintenance performed; however, an approach fault was observed.

Group 3 settlement—maintenance performed on the approach.

The criterion used to distinguish between groups 1 and 2 was whether or not a bump was evident when an automobile passed onto or off the bridge deck. Additional information was obtained by visually inspecting each approach. In addition, the ages (approximate dates opened

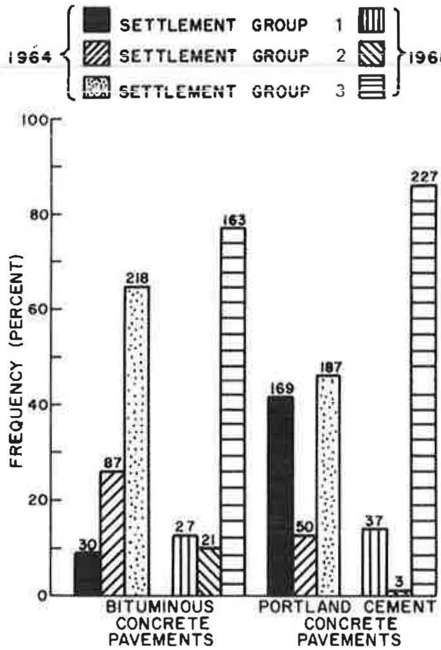

Figure 1. Comparison of bridge approaches by pavement type.

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to traffic) of the approaches were noted. The majority of approaches were at least 2 years old in the 1964 survey. From these data, it is evident that present design and construction procedures are not sufficient to guarantee smooth bridge approaches.

A comparison of portland cement concrete and bituminous concrete approaches (Fig. 1) shows a markedly higher percentage of bituminous concrete approaches with patching than rigid approach pavements with mudjacking in 1964. In addititon, there was a much greater percentage of smooth approaches (group 1) for concrete approaches than for bituminous approaches. However, in 1968, the difference in percentage of mudjacked and patched approaches, as well as smooth approaches, was almost insignificant. Furthermore, the 1968 data, when compared with 1964 data, showed that there was an appreciable percentage decrease in smooth approaches and an increase in maintained approaches for both types of pavements. Apparently, at least for a short period of time, the rigidity of portland cement concrete pavement reduced the occurrence of the approach fault by bridging the presumed depression behind the abutment. Generally, the approach settlement appeared to be confined within 100 ft of the end of the bridge, and settlement of the approach pavement seldom exceeded 6 in.

A comparison of the most commonly used types of abutments with respect to the three settlement groups (Fig. 2) revealed that the open-column (open-end) type was more commonly associated with settlement group 3 than either the pile-end-bent (open-end) type or stub (closed-end) type in 1964. The relationship between average height of embankment, average thickness of foundation soil, and type of abutment with respect to settlement groups is shown in Figure 2b and 2c. Notice that stub abutments are associated with smoother bridge approaches, smaller average heights of embankment and thinner foundation soils. The pile-end-bent abutments had greater average heights of embankment and thicknesses of foundation soils than the open-column abutment, but the pile-end-bent abutments had better bridge approaches. The better performance of approaches located behind stub abutments may be attributed to smaller settlements associated with shallower embankments and foundation soils. The comparatively larger time for consolidation before construction of the pavement and the need for less hand com-

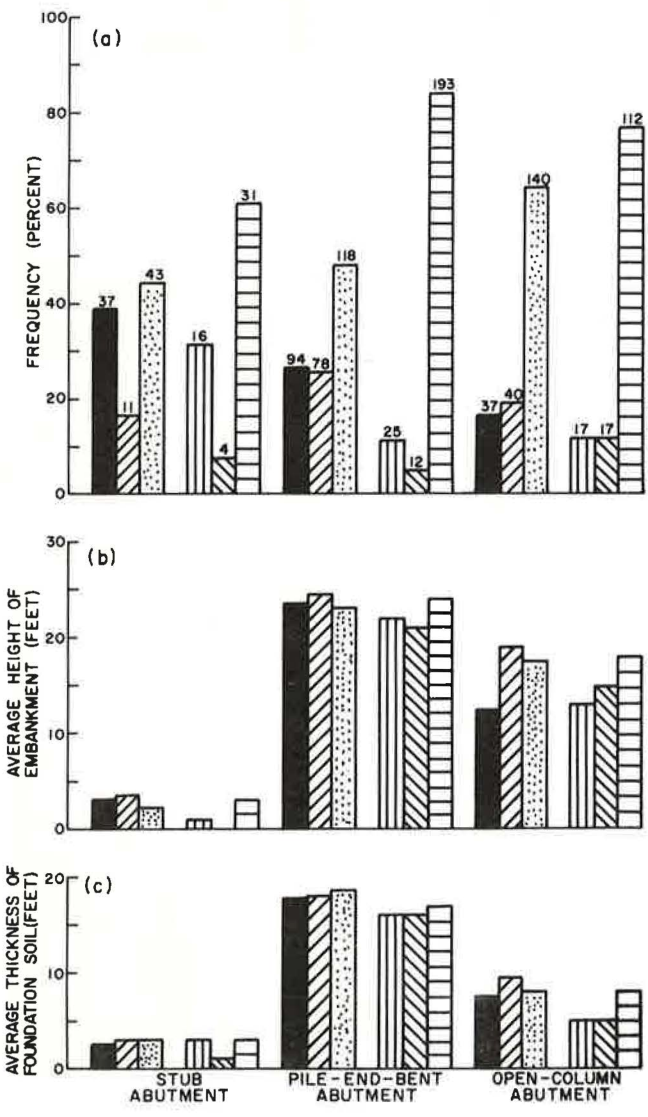

Figure 2. Comparison of bridge approaches by abutment type.

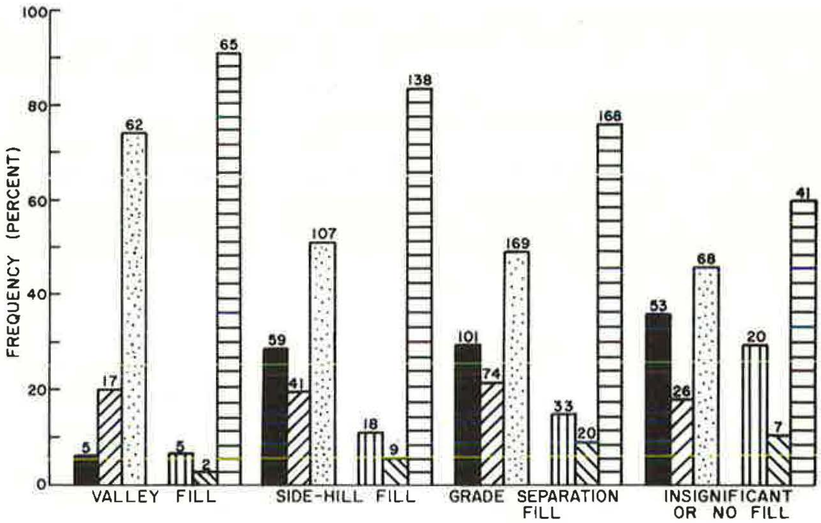

Figure 3. Comparison of bridge approaches by type of embankment.

paction near the abutment may account for the better performance of approaches associated with pile-end-bent abutments than those approaches at open-column abutments. However, in 1968 there was an increase in percentage of faulted approaches for all types of abutments with the percentage for pile-end-bent types increasing the most. There were small differences in percentages between the pile-end-bent and open-column abutments. Although the percentage of faulted approaches increased, stub abutments still had a comparatively high percentage of smooth approaches in 1968. For both surveys, there was a large number of defective bridge approaches associated with all types of abutments.

Different types of embankments were studied with respect to the settlement groups. These data (Fig. 3) show that embankments located in valleys of major streams had a much greater percentage of settlement group 3 approaches than embankments at other locations. Side-hill fills were considered to be those embankments that were generally part fill and part cut. Grade separation embankments were those considered to be built-up on a relatively flat plain. It is reasonable to assume that valley fills were located on foundations that were thicker than the other types of fills. Hence, these data probably reflect the importance of the foundation as a variable in bridge approach settlement. Those faulted approaches with embankments 3 ft or less in height may reflect improper backfill placement and compaction and such other causative factors as erosion or swelling and shrinkage.

At 54 bridge approaches located on Interstate 64 between Frankfort and Louisville, the approach embankments were constructed of a special granular fill material extending approx-

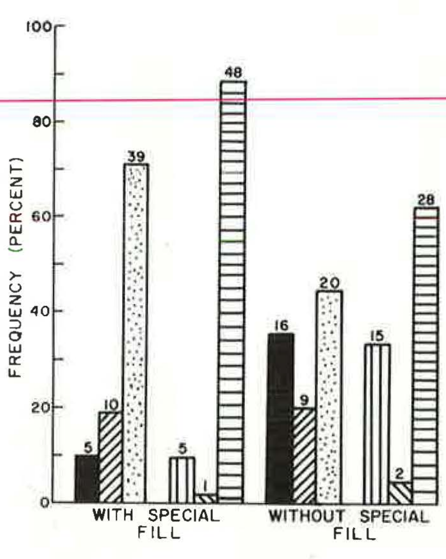

Figure 4. Comparison of bridge approaches by use of special backfill material.

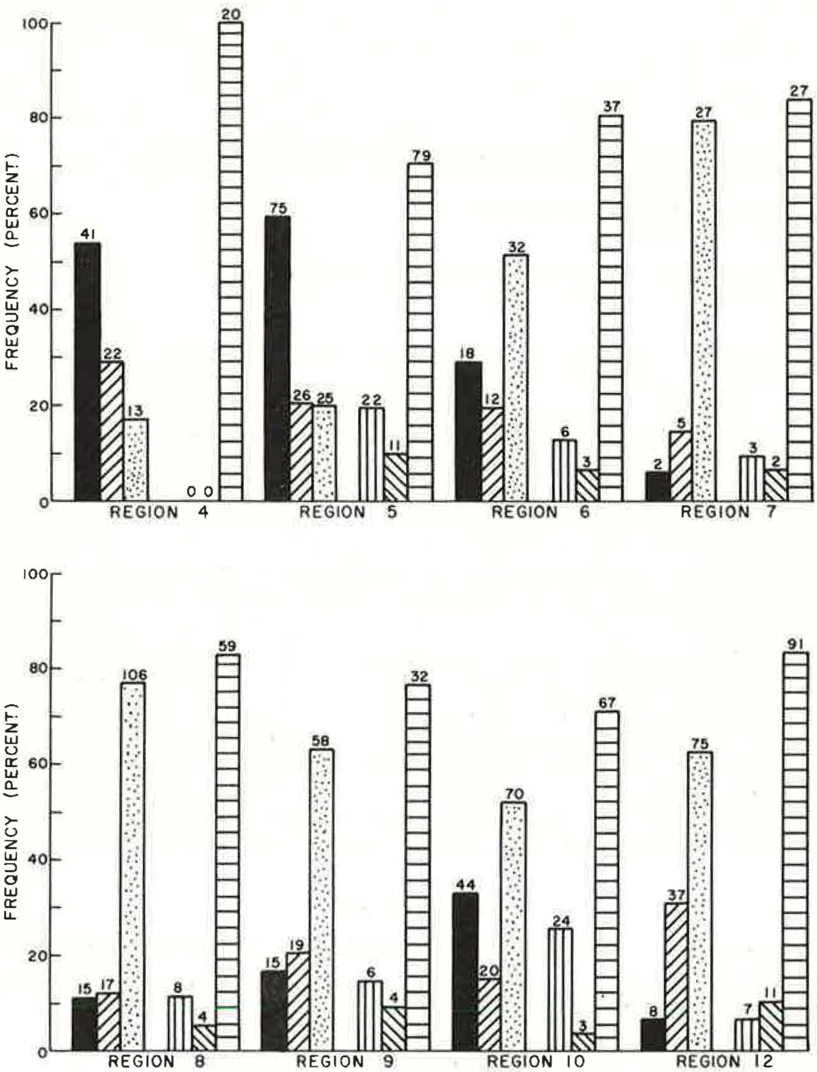

Figure 5. Comparison of bridge approaches by physiographic regions.

imately 20 to 60 ft behind the abutments. The special fill was formed and placed around the abutments, primarily open-column, in accordance with Kentucky Standard Drawing SF-1, which is no longer in use. The performance of bridge approaches associated with the special granular backfill is shown in Figure 4 and is compared with bridge approaches not associated with the special backfill on the same route. The data show that backfilling behind abutments in a manner specified by Kentucky Standard SF-1 did not check the development of faulted approaches. Moreover, for cases involving the special backfill when compared with cases without the special fill, there was an increase in frequency of faulted approaches.

A general relationship between approach settlement and different geological and soil conditions (Fig. 5) seemed apparent in 1964. Approaches passing through areas of soils containing large amounts of granular material did not fault as frequently as approaches passing through areas of soils with large amounts of plastic clays. However, in 1968 the influence of different geological and soil conditions was only slightly noticeable.