IOWA DEPARTMENT OF TRANSPORTATION

To Office: Bridges and Structures Date: October 31, 2002

Attention: All Employees Ref. No.: 521.2

From: Gary Novey

Office: Bridges and Structures

Subject: MM No. 23 - Length Limits and Prebore Depths for Integral Abutment Bridges

There has been considerable interest in the Office of Bridges and Structures in reexamining the length limits and analysis requirements for integral abutment bridges. For 178 overhead bridges designed by the office recently, about 70% meet present criteria for use of integral abutments without special investigation, but the limits could be extended to include a greater percentage, perhaps as much as 90%. Because of the benefits of jointless bridges the office would prefer to extend the use of integral abutments wherever feasible.

Based on consideration of the HR-273 report and addendum analysis with minor modifications, field testing described in the report for HR-292, and simple parameter studies, the following new limits for standard integral abutments are listed in the table. The new limits are for the three typical bridge types—pretensioned prestressed concrete beam (PPCB), continuous concrete slab (CCS), and continuous welded plate girder (CWPG)—designed by the office and the following conditions:

1. Integral abutments are placed at both ends of the bridge.

2. All abutment piles are A36 steel, HP 10x42 (HP 250x62) with webs oriented parallel with the abutment. For skews greater than 30 degrees, piles should be oriented for weak axis bending.

3. Each abutment pile is loaded to 37 tons (329 kN) or less.

4. All abutment piles for bridges longer than 130 feet (39.620 m) are placed in prebored holes 10-feet (3.050 m) deep and filled with bentonite slurry. (Prebored holes need not be used for bridges 130 feet (39.620 m) or less in length.) Bentonite slurry is assumed to provide no bearing capacity or lateral support for the piles.

5. Setting factors of 1.50 for concrete and 1.33 for steel bridges magnify thermal movement. The setting factors provide for construction temperatures of 25 to 75 degrees-F (-4 to 24 degrees-C).

6. All abutment piles are a minimum length of 2.5 times the prebore depth, from bottom of footing to bearing end.

7. Bridges that have parallel abutments and piers.

8. Bridges are straight or horizontally curved with straight beams or girders.

9. The controlling design condition is either (a) Service Load Group 4 with the stability, yield, and ductility checks of the HR-273 addendum Alternative 2 at 125% stress, or (b) Service Load Group 1 with stability and yield checks of the HR-273 addendum Alternative 1 (or 2) at 100% stress.

Superstructure Material	**Length and Skew Limits for Standard Integral Abutments**	**Maximum End Span**
Concrete (PPCB and CCS)	575 (167.640 m) feet at 0-degree skew to 425 feet (137.160 m) at 45-degree skew, with linear interpolation of length for intermediate skew	110 feet (35.530 m)
Steel (CWPG)	400 feet (121.920) at 0-degree skew to 300 feet (91.440 m) at 45-degree skew, with linear interpolation of length for intermediate skew	85 feet (25.910 m)

The following uses of integral abutments also are permitted:

1. If a working integral abutment is feasible at only one end of a bridge, the maximum length limit for the bridge shall be one-half the limit in the table, with no change in maximum end span length.

2. The office policy of allowing timber piles in integral abutments for bridge lengths to 200 feet (60.960 m) and skews to 30 degrees remains in effect. See Standard Sheets 2078-2085 (M2078-M2085).

3. If HP 10x42 piles are loaded to 55 tons (489 kN), the maximum end span length shall be reduced by 10 feet (3.050 m).

4. Prebored holes may be increased in depth to 15 feet (4.570 m) to reduce or eliminate downdrag forces.

5. For two-span bridges, prebored hole depth may be increased to permit longer end spans. For PPCB bridges, for each 1-foot (300 mm) increase in prebore depth, maximum end span may be increased by 15 feet (4.570 m), but the maximum end span length shall be limited to 140 feet (42.670 m). For CWPG bridges, for each 1-foot (300 mm) increase in prebore depth, maximum end span may be increased by 8 feet (2.440 m), but the maximum end span length shall be limited to 125 feet.

6. In cases where a MSE retaining wall is used near an integral abutment, each pile shall be sleeved with a corrugated steel pipe (CSP) to control compaction near the pile as the embankment and MSE wall are built. At the top, the CSP sleeve shall be blocked temporarily with framing lumber so that the pile remains at the center of the sleeve. The CSP sleeve shall be filled with sand to the elevation of the bottom of prebore and then with bentonite to the top of the CSP sleeve.

7. For bridges that exceed the limits, request an exception from the Chief Structural Engineer. (Because of the interest in extending the limits, especially for end spans of steel bridges, piles in one or more bridges may be monitored in the near future.)

The limits were drawn from parameter studies for a simple pile model using Conditions 1) through 9) for typical bridges with a 40-foot (12.000-meter) roadway. The limits are larger than those used by the Iowa DOT in the past. With setting factors the limits usually are less than the ±1.5-inch (±38-mm) limit for lateral pile displacement given in the AASHTO LRFD specifications. (The AASHTO limit is general and not specifically for integral abutments.)

Previous FHWA guidelines suggested limits for lengths of bridges with integral abutments. The guidelines have expired and have not been replaced.

The following were sources of conservatism in the parameter studies:

- Setting factors magnified the temperature displacement of the piles and the bending stresses in the piles. The setting factors allow for a reasonable range of construction temperatures, 25 to 75 degrees-F (-4 to 24 degrees-C).

- Soil at abutments was assumed to be stiff clay with N=40.

- Piles were assumed to be freestanding in the prebored holes and subject to impact.

- The overall stability term correction ($C_m/1\text{-}f_a/F'_e$) was limited to one or more as in the HR-273 Addendum.

- In most cases bridge lengths were rounded down to the nearest 25-foot (7.620-meter) increment.

- The check under Service Load Group 1 (not in HR-273) sometimes was the controlling case, with a 10 to 15% increase in capacity demand over Service Load Group 4.

The proposed limits extend to include the two Iowa steel and concrete bridges approximately 325 feet long with 30- and 45-degree skews that were tested under HR-292. The proposed limits generally are more liberal than the limits in surrounding states. Most states do not permit integral abutments for skews greater than 30 degrees. Kansas, however, apparently sets no limit for skew and allows concrete bridges nearly 500 feet long and steel bridges nearly 300 feet long.

Researchers at Iowa State University are completing the final report on testing of two Iowa PPCB bridges with integral abutments, and the report should be available in late 2002. A preliminary presentation on the testing indicated no significant problems with the bridges, one of which exceeded the present Iowa DOT length limit.

References:

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Girton, D.D., T.R. Hawkinson, and L.F. Greimann. *Final Report, Validation of Design Recommendations for Integral Abutment Piles.* Ames: Iowa Department of Transportation and College of Engineering, Iowa State University, 1989.

Tucker, W.D. "Integral Abutment Investigation and Excel Spreadsheet." Ames: Office of Bridges and Structures, Iowa Department of Transportation, 1994.

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