CHAPTER 7
DYNAMIC LOAD ALLOWANCE RESULTS

7.1 Introduction

The purpose of this chapter is to present the results of the evaluation of the dynamic load allowances for the girders of the Little Buffalo Creek Bridge. As stated in Section 4.5.3, the dynamic load allowances were evaluated using the WIM bottom flange strains and mid-span deflections for Girders 1 and 2 of Load Cases 6 and 7, and all load cases in Test Set 3 (Refer to Section 3.5 for load case descriptions). The evaluation includes comparisons to the dynamic load allowances specified by AASHTO SSHB (1996) and AASHTO LRFD (1994).

7.2 Dynamic Load Allowance from Field Data

Table 7.1, following this section, presents the maximum measured WIM bottom flange strains and maximum mid-span deflections from the field data of the load cases used in the evaluation. The test vehicle and vehicle speed are included for reference purposes. The maximum responses for each girder in Load Cases PS-1 and PS-2 are nearly identical and were averaged to obtain the static response for use in Equation 4.10. Table 7.2, following this section, contains the dynamic load allowances (IM) determined for each girder using Equation 4.10.

Table 7.2 indicates that dynamic amplification of responses above the static response was not always achieved. The negative values represent instances were there was no dynamic amplification above the static response. Comparisons between the dynamic load allowances determined using strain and deflection data from Table 7.2 indicates that the deflection based values are greater than or equal to the strain based values for all cases but one (DYN-8 Girder 1). This follows the statement by Bakht and Pinjarkar (1989). The dynamic load allowances based on deflection show only one instance (DYN-6 Girder 1) where dynamic amplification was not achieved; however, the strain based, dynamic load allowances show five such instances with most occurring at

Girder 2, which was the girder with the highest static strains. Considering the load cases in Test Set 3, Girder 2, on average the most heavily loaded girder, shows closer values for tests with the same truck speed than Girder 1.Table 7.3, following this section, contains averages of the dynamic load allowances for common truck speeds from load cases in Test Set 3 with Truck 3. The averages indicate higher dynamic load allowance values for Girder 1 than Girder 2. Although the mid span WIM gauges and deflectometers for Girder 1 were in the influence zone (Reference Figure 4.6 and Table 4.4), they were farther from the point of application of load than the WIM gauges and deflectometers for Girder 2. The lower static responses in Girder 1 may have resulted in the slightly higher average dynamic load allowance values, but this conclusion is not precise because the data is limited.

Table 7.2 shows that the highest dynamic load allowances for Girders 1 and 2 are from Load Cases 6 and 7. These dynamic load cases were with Truck 2, which had the same axle configuration as Truck 3, but weighed 160 pounds less than Truck 3. Because there is such a wide scatter between dynamic load allowances for the various truck speeds and because the data is limited to three sets or less for each truck speed, it is impossible to draw any firm conclusion on how the dynamic load allowance varies with truck speed.

Table 7.1 Maximum Responses from Girders 1 and 2

Maximum Responses from Field Data					
Load Case/ Speed	**Truck No./ Test Set**	**WIM BF Strain**		**Mid-span Defl.**	
		Girder 1	**Girder 2**	**Girder 1**	**Girder 2**
PS-1	Truck 3 (Test Set 3)	93.0	104	0.113	0.134
PS-2	Truck 3 (Test Set 3)	92.9	109	0.112	0.140
DYN-3 (25 mph)	Truck 3 (Test Set 3)	93.9	99.1	0.114	0.139
DYN-4 (25 mph)	Truck 3 (Test Set 3)	107	94.4	0.129	0.136
DYN-5 (45 mph)	Truck 3 (Test Set 3)	115	105	0.139	0.148
DYN-6 (45 mph)	Truck 3 (Test Set 3)	85.2	101	0.108	0.149
DYN-7 (10 mph)	Truck 3 (Test Set 3)	97.6	116.3	0.118	0.151
DYN-8 (10 mph)	Truck 3 (Test Set 3)	106	111	0.126	0.145
Load Case 6 (47 mph)	Truck 3 (Test Set 1)	135	131	0.191	0.189
Load Case 7 (20 mph)	Truck 3 (Test Set 1)	136	143	0.183	0.195

Table 7.2 Dynamic Load Allowances from Field Data for Girders 1 and 2

Dynamic Load Allowance, IM					
Load Case/ Speed	Truck No./ Test Set	WIM BF Strain		Mid-span Defl.	
		Girder 1	Girder 2	Girder 1	Girder 2
DYN-3 (25 mph)	Truck 3 (Test Set 3)	0.010	-0.070	0.012	0.016
DYN-4 (25 mph)	Truck 3 (Test Set 3)	0.155	-0.114	0.151	-0.007
DYN-5 (45 mph)	Truck 3 (Test Set 3)	0.242	-0.019	0.236	0.080
DYN-6 (45 mph)	Truck 3 (Test Set 3)	-0.083	-0.054	-0.037	0.091
DYN-7 (10 mph)	Truck 3 (Test Set 3)	0.051	0.091	0.047	0.101
DYN-8 (10 mph)	Truck 3 (Test Set 3)	0.140	0.038	0.122	0.062
Load Case 6 (47 mph)	Truck 3 (Test Set 1)	0.456	0.232	0.701	0.383
Load Case 7 (20 mph)	Truck 3 (Test Set 1)	0.458	0.340	0.629	0.424

Table 7.3 Average Dynamic Load Allowances from Test Set 3

Average Dynamic Load Allowances from Test Set 3				
	WIM BF Strain		Mid-span Defl.	
Truck Speed	Girder 1	Girder 2	Girder 1	Girder 2
10 mph	0.082	-0.092	0.082	0.004
25 mph	0.080	-0.036	0.099	0.086
45 mph	0.095	0.064	0.085	0.082

7.3 Comparison of Dynamic Load Allowances to AASHTO Specifications' Values

Girder 2 had the largest average static strain and average static deflection from the pseudo-static tests; therefore, comparisons between the dynamic load allowances from the field data and the AASHTO specifications are centered on Girder 2.

The impact allowance, or dynamic load allowance, from AASHTO SSHB (1996) was determined using Equation 4.11 with the span length (L) equal to 53.31 ft (center-to-center of bearings). The resulting value was 0.28. This value was used in the design calculations of the Little Buffalo Creek Bridge provided by VDOT. The value of IM = 0.28 is larger than all the dynamic load allowances for Girder 2 in Table 7.2 except for a majority of those in Load Cases 6 and 7. The strain based dynamic load allowance for Girder 2 in Load Case 6 (IM = 0.232) is approximately 17 percent less than the AASHTO SSHB (1996) value. The same dynamic load allowance based on mid-span deflection (IM = 0.383) exceeds the AASHTO SSHB (1996) by 37 percent. The dynamic load allowances from both the strain (IM = 0.340) and deflection (IM = 0.424) data for Girder 2 of Load Case 7 exceed the AASHTO SSHB (1996) by 21 percent and 51 percent, respectively. Based on the maximum dynamic load allowances from the field data (either strain or deflection based), the AASHTO SSHB (1996) dynamic load allowance seems to be unconservative for the Little Buffalo Creek Bridge.

The dynamic load allowance from AASHTO LRFD (1994) for the steel girders of the Little Buffalo Creek Bridge is a set value of IM = 0.33. The AASHTO LRFD (1994) dynamic load allowance is 18 percent higher than the value specified by AASHTO SSHB (1996). All the dynamic load allowances for Girder 2 from load cases in Test Set 3 are at least 60 percent below the AASHTO LRFD (1994) value for IM. However, when compared to Load Cases 6 and 7 the AASHTO LRFD (1994) dynamic load allowance is exceeded for Girder 2 in both of the deflection based values and for Load Case 7 of the strain based dynamic load allowances. The dynamic load allowance for Girder 2 of Load Case 7 only exceeds the specified value by three-percent, which is smaller than the percentage of error expected due to errors in gauge measurements (5 to 8 percent). Thus, the maximum, strain based dynamic load allowances for Girder 2 are considered to be within an acceptable range of the AASHTO LRFD (1994) dynamic load allowance. The deflection based dynamic load allowances for Girder 2 of Load Case 6 (IM = 0.383) and Load Case 7 (IM = 0.424) exceed the AASHTO LRFD (1994) dynamic load allowance by 16 percent and 28 percent, respectively. Thus, the dynamic load allowances based on the available mid-span deflections indicate the AASHTO LRFD (1994) dynamic load allowance seems to be unconservative for the Little Buffalo Creek Bridge.

7.4 Limitations of Dynamic Load Allowance Evaluation

The dynamic load allowance evaluation presented above is extremely restricted because of the limitations of the field data. Several aspects of the collected field data do not allow for solid evaluations and limit the use of the data in future evaluations of the Little Buffalo Creek Bridge.

The data was collected from tests using only test trucks, which allowed for only a basic evaluation of the dynamic amplification of responses and the dynamic load allowance. Initially it was felt that the data collected from Test Set 3 could serve as the calibration phase for future testing under normal traffic; however, after inspecting the maximum strain and deflection responses for Load Cases 6 and 7 several problems arise concerning the behavior of the bridge. Load Cases 6 and 7 were load cases with the test truck in the right lane of the Little Buffalo Creek Bridge, which is the same as the load cases in Test Set 3. Table 7.1 shows that the maximum bottom flange strains and/or deflections from Load Cases 6 (47 mph) and DYN-6 (45 mph) differ by percentages as high as 50 percent. Although is has been concluded by past researchers, such as Hwang and Nowak (1991) and Nassif and Nowak (1995), that the dynamic load allowance decreases as gross vehicle weight increases, Truck 3 only outweighed Truck 2 by 160 pounds. The extreme differences in the maximum responses from the field data for load cases with nearly identical trucks and nearly identical speeds is unexplainable and serves to undermine the evaluation of the data.

In addition, the range of speeds tested only included three basic truck velocities (10, 25, and 45 mph) which does not seem to be broad enough velocity range. Paultre et al (1992) recommended that tests performed under controlled traffic be performed over a sufficient range of speeds to assure that critical speeds are included in the dynamic load allowance evaluation.

7.5 Summary and Need for Future Research

Based on the field data, the dynamic load allowance for Girders 1 and 2 ranges considerably amongst the load cases. Load cases with common speeds and common test trucks do not result in consistent dynamic amplification of responses, and often show that dynamic amplification does not even occur. Dynamic amplification of responses for certain load cases resulted in dynamic load allowances well above the AASHTO SSHB (1996) and the AASHTO LRFD (1994) dynamic load allowance values.

Two trends present within the field data that seems to be consistent with past research are that under similar conditions the dynamic load allowances determined from deflections are greater than those from strains, and that girders with lower static responses tend to show higher dynamic amplifications. The limited field data did not allow for any distinct conclusions to be drawn concerning the effect of speed on the dynamic load allowance.

As listed previously, there are numerous parameters that affect the dynamic behavior between a vehicle and a bridge. Testing under controlled traffic from test trucks does not seem to be a practical or reliable way of evaluating the dynamic load allowance for a particular bridge. Based on the conclusions of past researchers, the dynamic load allowance for the Little Buffalo Creek Bridge should be determined from data collected from normal truck traffic. Paultre et al (1992) concluded that the dynamic amplification factor (dynamic load allowance) is not a deterministic quality and thus should be determined using probabilistic approaches from full-scale testing under normal truck traffic. Bakht and Pinjarkar (1989) proposed a method for collecting pertinent data from normal truck traffic and presented statistical equations to determine the dynamic load allowance for a bridge. It is suggested that future research on the dynamic load allowance for the Little Buffalo Creek Bridge employ similar statistical methods.