Recommendations on Truss Members Retrofit

The following table lists the identified 13 fracture critical truss members on one half of each truss. Due to the double symmetry of the deck truss, there are a total of 52 fracture critical main truss members on the bridge structure. Figure 1 shows all the fracture critical members on one truss, or 26 members. These include the corresponding chord members on the opposing side of the zero-force vertical from the fracture critical members identified by the redundancy analysis.

Table. Infinite Fatigue Life Check of Fracture Critical Members on One Half of Each Truss

Truss Member	Dead Load Axial Stress	*Fatigue Guide Specs* Fatigue Truck Method				*LRFR Manual* Fatigue Truck Method			
		LL+I Stress Range S_r I = 10%	Factored Stress Range R_sS_r	Limiting Stress Range S_{FL} Cat. D	Limiting Stress Range S_{FL} Cat. E	LL+I Stress Range Δf I = 15%	Max Stress Range Factored $2.0R_s\Delta f$	Fatigue Threshold $(\Delta f)_{th}$ Cat. D	Fatigue Threshold $(\Delta f)_{th}$ Cat. E
	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)	(ksi)
L1-L2	1.50	1.53	2.58	2.60	1.60	1.63	3.10	7.00	4.50
L2-L3	1.50	1.42	2.38	2.60	1.60	1.51	2.86	7.00	4.50
U0-U1	9.76	1.19	2.00	2.60	1.60	1.30	2.48	7.00	4.50
U1-U2	8.54	0.68	1.15	2.60	1.60	0.74	1.41	7.00	4.50
U4-U5	11.61	1.17	1.97	2.60	1.60	1.25	2.37	7.00	4.50
U5-U6	10.95	1.16	1.95	2.60	1.60	1.24	2.35	7.00	4.50
L11-L12	15.73	0.71	1.20	2.60	1.60	0.75	1.42	7.00	4.50
L12-L13	15.73	0.71	1.19	2.60	1.60	0.75	1.42	7.00	4.50
L13-L14	17.54	0.58	0.97	2.60	1.60	0.61	1.16	7.00	4.50
U6-U7	18.06	0.38	0.65	2.60	1.60	0.41	0.78	7.00	4.50
U7-U8	18.58	0.43	0.73	2.60	1.60	0.46	0.88	7.00	4.50
U8-U9	17.45	0.36	0.61	2.60	1.60	0.39	0.74	7.00	4.50
U9-U10	17.33	0.34	0.58	2.60	1.60	0.36	0.69	7.00	4.50

The table also summarizes AASHTO criteria for infinite fatigue life check in accordance with the Fatigue Guide Specifications and the LRFR Manual using the fatigue truck method. The Fatigue Guide Specifications is more conservative than the LRFR Manual in that it applies a 1.75 reliability factor (vs. 1.0 in LRFR) to the calculated stress range due to the fatigue truck for fracture critical members and uses an infinite fatigue life limiting stress range of 0.367 times (vs. 0.5 times in LRFR) the constant amplitude fatigue threshold developed from fatigue tests. As shown in the table, all members satisfy the LRFR requirements for infinite fatigue life although the first six members fail to satisfy the Fatigue Guide Specifications for the Category E fatigue detail (U1-U2 is included in this group because of its counterpart U0-U1).

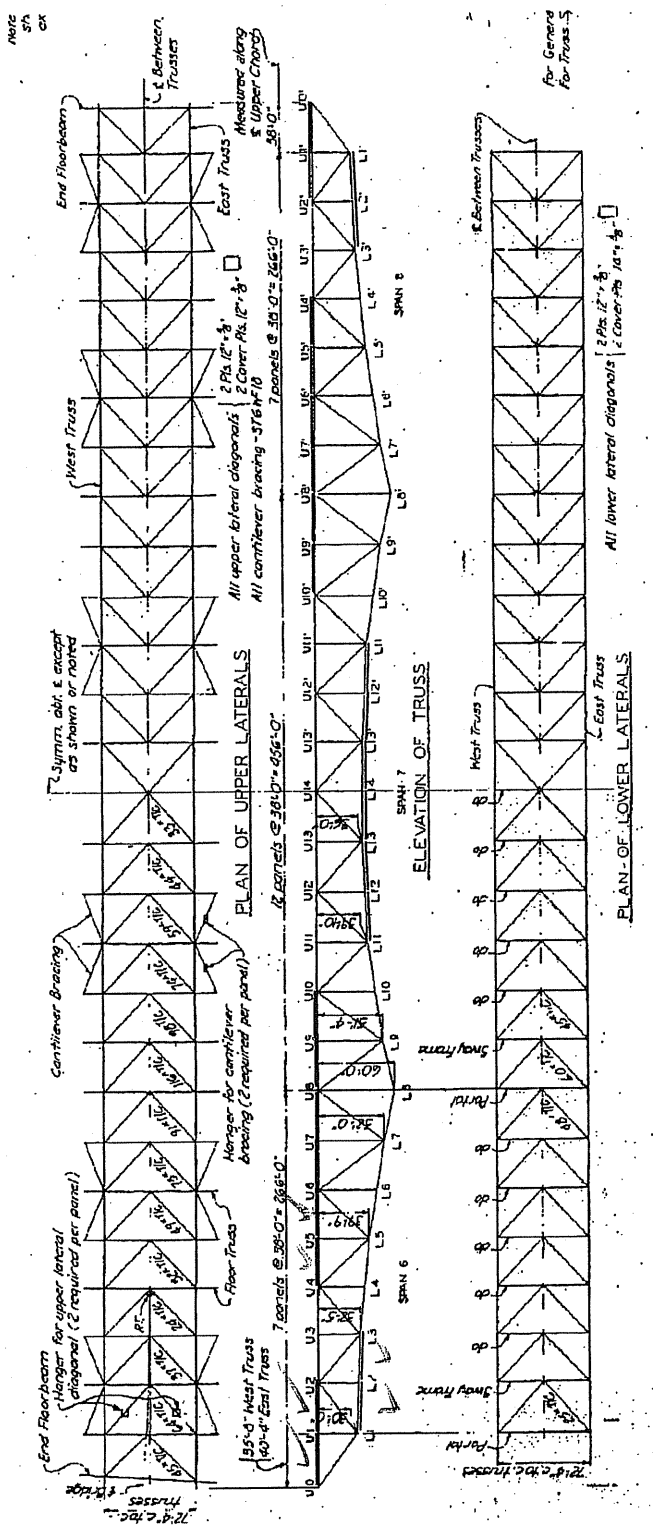

Figure 1: Deck Truss Framing Plan and Elevation from Original Contract Plans (Highlighted Members are Identified Fracture Critical Members)

The fracture critical members can be divided into two general groups: (1) relatively more fatigue sensitive members (L1-L2, L2-L3, U0-U1, U1-U2, U4-U5, and U5-U6), these members are subject to higher fatigue load stress ranges, not satisfying the Fatigue Guide Specifications' infinite fatigue life check for Category E, but are subjected to lower total stresses and have thinner web plates that are more forgiving for brittle fracture; and (2) relatively more fracture sensitive members (L11-L12, L12-L13, L13-L14, U6-U7, U7-U8, U8-U9, and U9-U10), these members have larger cross sections and are subject to very low fatigue load stress ranges, satisfying all AASHTO infinite fatigue life checks for Category E, but are subjected to higher total stresses and have thicker web plates that do not tolerate the existence of through-thickness cracks before the occurrence of brittle fracture.

It is very important to emphasize that neither a fatigue crack would propagate under repeated fluctuating load nor a brittle fracture would occur under some heavy load without a preexisting flaw or crack. As the results of a fracture mechanics analysis indicated in Section 9, the dimensions of preexisting cracks need to be quite large in order to propagate under the traffic load and grow to a critical size to induce a brittle fracture of the truss chord web plate. Since the locations of fatigue susceptible details are clearly known on Bridge 9340, one alternative retrofit approach to steel plating is to perform an in-depth non-destructive examination (NDE) of all the suspected details for existing cracks and flaws. For any weld-induced flaws or cracks discovered by the NDE efforts, a suitable procedure (e.g. grinding) should be carried out to remove the sources of localized stress concentration. After all the fracture critical members are assured of no existence of measurable cracks or flaws, confidence should be obtained for these members for infinite fatigue life under the traffic load.

Based on the analysis results described in this report, three equally viable retrofit approaches are recommended as follows:

(1) Steel plating of all 52 fracture critical truss members. This approach will provide member redundancy to each of the identified fracture critical members via additional plates bolted to the existing webs. The critical issue of this approach is to ensure that no new defects

are introduced to the existing web plates through the drilled holes. This approach is generally most conservative but its relatively high cost may not be justified by the actual levels of stresses the structure experiences.

(2) Non-destructive examination (NDE) and removal of all measurable defects at suspected weld details of all 52 fracture critical truss members. The critical issue of this approach is to ensure that no measurable defects are missed by the NDE efforts. The fracture mechanics analysis has indicated that the dimensions of preexisting surface cracks need to be at least one quarter of the web plate thickness in order to grow and subsequently cause member fracture under the traffic load. This approach is most cost efficient.

(3) A combination of the above two approaches: steel plating of the 24 more fatigue sensitive members (L1-L2, L2-L3, U0-U1, U1-U2, U4-U5, and U5-U6 in each half of each truss), and NDE of the 28 more fracture sensitive members (L11-L12, L12-L13, L13-L14, U6-U7, U7-U8, U8-U9, and U9-U10 in each half of each truss).