BUCKLAND
& TAYLOR LTD.
a COWI company

101-788 Harbourside Drive, North Vancouver, BC, Canada V7P 3R7
E-mail: mainoffice@b-t.com Tel: (604) 986-1222
Web: www.b-t.com Fax: (604) 986-1302

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Ministry of Forests, Lands and Natural Resource Operations
PO Box 9510 Stn prov Govt
3rd Flr - 1520 Blanshard Street
Victoria, BC V8W 9C3

Attention: Mr. Brian Chow, P.Eng., Chief Engineer

Dear Sirs,

Re: Logging Traffic Target Vehicles

At the request of the Ministry of Forests (MOF), Buckland & Taylor Ltd. (B&T) has developed the following recommendations for the load posting of forestry bridges.

Background

B&T has previously assessed logging traffic data provided by the MOF for various truck populations and based on this data, developed design vehicles for off-highway forestry bridges that are consistent for use with the provisions of the CAN/CSA-S6 bridge design standard. The results of this work are described in the following B&T reports previously provided to the MOF:

1. Design Vehicle Configuration Analysis and CSA-S6-00 Implication Evaluation, 2003 January 04.
2. Design Vehicle Configuration Analysis and CSA-S6-00 Implication Evaluation Phase II, 2003 June 27.
3. Design Vehicle Configuration Analysis and CSA-S6-00 Implication Evaluation Phase III, 2004 October 08.

To date, the design vehicles developed by B&T have not yet been implemented by the MOF.

The MOF is assessing the need to implement bridge load limit postings on the various MOF routes. Neither the L-Series of design vehicles currently employed by the MOF or the design vehicle configurations developed by B&T are intended to represent bridge load limit postings. Consequently, the MOF requested that B&T develop the following guidelines for bridge load limit postings based on the results of the above studies:

- Target Vehicle maximum GVWs, maximum single axle loads, maximum tandem axle group loads and maximum tridem axle group loads for MOF design vehicles including the L45, L75, L100, L165/150, Light-Off-Highway (LOH) and the Heavy-Off-Highway (HOH).
- Target vehicle Gross Vehicle Weight (GVW) and axle load limits shall be provided for both design levels (β = 3.75) and evaluation levels (β = 3.25).

- Review the L75 records assuming that Okanagan Falls Interior Off-Highway and Menzies Bay Off-Highway data reflect traffic operating under "Best Practices" and, if appropriate, provide advice on how to proceed with site specific posting limits.
- Provide guidelines for an "Alternative Design" vehicle if a truck population has characteristics that are substantially different from the general population.

Development of Target GVWs and Axle Limit Postings

The MOF L-Series design vehicles were developed for general application with the provisions of CAN/CSA-S6-88, while the LOH and HOH vehicles were developed for application with the provisions of CAN/CSA-S6-00 (including any revisions to date). However, these design vehicles were not intended to define load limits for either Gross Vehicle Weights (GVW) or axle group loadings. Therefore, development of a rationale for establishing load limits corresponding to each design vehicle is required.

Although the individual weights of the overall population of loaded highway trucks can vary widely, the mean weight of the loaded truck population is typically about 10% to 15% below the posted load limits. This represents the general level of adherence of the truck population to the posted limits with typical load limit enforcement measures being in place. For highway traffic the appropriate levels of design safety are obtained with a live load factor of 1.7 being applied to the CL-625 design vehicle. Note that while the CL-625 design vehicle GVW is equal to the legal highway load limit, the design vehicle axle loadings significantly exceed the legal axle load limits.

Off-highway forestry vehicles differ from highway trucks is two ways; the first being that forestry routes/bridges do not typically have posted load limits and the second is that the weight variations of forestry vehicles tend to be somewhat less than those for general highway traffic. The LOH and HOH design vehicles were derived from the survey weights of forestry vehicles to be applicable with a design live load factor of 1.7 to be consistent with the provisions of S6-00. However, since forestry traffic is less variable than highway traffic, the design live load factor could have been decreased to 1.5 with a corresponding increase in the weights of the design vehicles. Therefore, the GVW legal load limit for bridges designed for the LOH and HOH loadings could be increased by a ratio of the live load factors (1.7/1.5) = 1.133 over the design vehicle GVWs. The L-Series of design vehicles were applied with a live load factor of 1.6 and therefore, the GVW legal load limits for these bridges would be (1.6/1.5) = 1.067 over the design vehicle GVWs.

The previous assessment of forestry vehicles showed that axle group weights were significantly more variable than GVWs and that the design tandem axle group weight had to be increased by about 25% to be applicable with the same design live load factor as for GVW. Such increases were incorporated into the LOH and HOH design vehicle tandem axles but not on the L-Series design vehicles. Therefore, the legal limit for tandem axle groups requires that the heavy axle group on the design vehicles be reduced by a ratio of 0.8 to account for the higher variability of the axle loadings but then increased by the same ratios applied to the design vehicle GVWs. This results in the legal limit for a tandem axle group being 46% of the legal GVW for LOH and HOH design vehicles and 37% of the legal GVW for the L-Series design vehicles. Tridem axle groups spread the loading better than tandem axle groups depending on the span length being loaded. On a 6 m span tridems can be about 15% heavier than tandems and produce that same force effects. However, on 15 m spans the improvement reduces to being only 5% heavier. Since most bridge spans over 10 m in length are not governed by more than one axle groups, it is recommended that the limit for tridem axle group loading be set at 10% higher than the tandem loading. Single axle loadings do not typically govern over tandem axle groups but it is recommended that the single axle loading be set a 53% for the tandem loading.

A summary of the suggested posted load limits for bridges designed for each design vehicle (β=3.75) are provided in the following table. Note that GVW values should be rounded to the nearest tonne and Axle Loads to the nearest 0.5 tonne.

Bridge Design Vehicle	GVW Load Limit (tonnes)	Single Axle Load Limit (tonnes)	Tandem Axle Load Limit (tonnes)	Tridem Axle Load Limit (tonnes)
LOH	83.2	20.3	38.3	42.1
HOH	129.4	31.5	59.5	NA
L75	72.6	14.3	26.9	29.6
L100	96.7	19.0	35.8	39.4
L150	145.2	28.5	53.7	NA
L165	159.6	31.3	59.1	NA
L45*	43.5	8.5	16.1	17.7
BCL-625**	63.5	9.1	17	24

* Data for forestry truck populations using L45 bridges was not present in the previously referenced studies. Therefore, the variability of the L45 population was assumed to be relatively similar to that for the L75 to L165 populations.

** As per BC Commercial Transport Act.

The above load limits are based on a bridge being appropriately designed, constructed and maintained to carry the indicated design loading. Any known reductions in the expected capacities whether due to design, construction or deteriorations need to be appropriately addressed in the posted load limits.

Many of the logging trucks in a population are expected to be heavier than the design vehicle weights. However, if the number of logging trucks with weights exceeding the weights of the design vehicles are maintained within the following limits, the expected level of safety can be considered to be achieved for the LOH, HOH and L-Series vehicles:

- Less than 2.5% of the logging trucks should have weights (GVW) that exceed the weight of the design vehicle by more than 19%.
- Less than 0.15% of the logging trucks should have weights that exceed the weight of the design vehicle by more than 27.5%.
- No logging trucks should have weights that exceed the weight of the design vehicle by more than 36%.

If these limits are consistently being exceeded, consideration should be given to reducing truck weights, strengthening the bridge(s) as required or conducting a more detailed assessment of the logging truck population using the bridge.

Evaluation Load Limits

The above bridge load limits apply to design conditions where the reliability index, β, is 3.75. Under bridge evaluation conditions the target reliability index can be reduced based on the expected structural behaviour of the bridge and the implementation of a regular bridge inspection program. We understand that for forestry bridges a reliability index of 3.25 is typically considered appropriate for bridge evaluation. Reducing the reliability index from 3.75 to 3.25 would result in a 9% increase in the above load limits in cases where all the loading on a component is live load. The increase in load limits would be somewhat higher when dead load produces a significant component of the total loading.

If the original bridge design exceeded the design requirements, even higher evaluation load limits may be possible.

Best Practices Operations

The available data for the Okanagan Falls Off-Highway and Menzies Bay Off-Highway was reviewed to determine if site specific loadings for forestry bridges could be beneficial.

For both of these locations only limited data had been obtained during the initial study, 2003 January, with a 26 truck sample for Okanagan Falls and a 40 truck sample for Menzies Bay. No weigh scale data for these locations was obtained during Phase II of the study.

Although the available data is considered to be insufficient to form the bases for alternative load limits, the data indicates the following:

- The Okanagan Falls population provides a lower mean value but a somewhat higher coefficient of variation on GVWs. This suggests that slightly more beneficial load limits could be possible if these results are representative of the long-term behaviour.
- The Menzies Bay population provides a lower mean value and a lower coefficient of variation on GVWs. This suggests that a more significant benefit could be appropriate for the load limits if these results are representative of the long-term behaviour.

Extensive weight scale data over an extended period of time would be required to justify significant modifications to the load limits on the bridges servicing these locations.

Guidelines for an Alternative Design Vehicle

If a forestry truck population has characteristics that differ substantially from those used in the derivation of the LOH and HOH design vehicles, use of alternative design or evaluation vehicle models may be appropriate. Although the derivation of alternative design vehicles can be a complex procedure, the following simplified approach provides appropriate if somewhat conservative results. The procedure is as follows:

1. Collect GVW data from forestry trucks transiting the route being evaluated. Minimally, the data sample should include at least 60 trucks obtained under all operating conditions over a period of at least a year. Greater amounts of truck weight data are preferred and the data sample should exclude empty or partially loaded vehicles.
2. The Coefficient of Variation (population standard deviation divided by the mean) of the data sample shall be 0.075 or less.

3. The mean value of the population represents the design or evaluation vehicle GVW. The posted GVW load limit for the route shall be 1.1 times the population mean.

Closing

Please contact us if you have any questions or comments.

Yours truly,

BUCKLAND & TAYLOR LTD.

Darrel Gagnon, P.Eng.