Management of overweight vehicle traffic on road bridges

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Summary

Bridges in service in most Western Countries were built according to codes with design loads that are now inconsistent with today's traffic demands. Currently, transportation agencies do not know how to respond to transit applications on their bridges. This contribution focuses on the legal issues entailed by overweight/oversize load permits issued by transportation agencies. Indeed, correct decision-making should consider the legal liabilities involved in possible catastrophic events. In this paper we illustrate how this problem is addressed by the Department of Transportation of the Italian Autonomous Province of Trento (APT), a medium-sized agency managing approximately one thousand bridges across its territory. In their basic approach, APT does not authorize movement of overweight loads unless it is demonstrated that the effect is less than that of the nominal design load. When this condition is not satisfied, a formal evaluation is carried out in an attempt to assess a higher load carrying capacity for the bridge. If, after the reassessment, the capacity is still insufficient, the bridge is classified as sub-standard and a formal evaluation of the operational risk is performed in order to define a priority ranking for future reinforcement or replacement.

Keywords: overweight vehicles, bridge management, multi-level assessment

1. Introduction

In this paper we illustrate how the Autonomous Province of Trento (APT) addresses the legal issues entailed by the issue of transit permits by the DoT, and focuses on the problem of girder bridges.

2. APT overweight permit issue procedure

The objective APT DoT is to provide simple, practical rules for deciding whether an overweight load permit can be issued or not, and if so, under what restrictions. The APT predefined load model reproduces a multi-axle load in the most unfavorable configuration, which is a set of 5 to 8 130kN concentrated loads spaced at 1.3 m, applied to a 3.0 m wide lane. Permits for extra-legal loads can be issued under the following two load movement conditions: (1) free movement, the vehicle can move freely with no traffic restriction - restrictions on time and number of trips may apply; (2) movement with traffic restriction, the road is closed to free traffic and the vehicle is required to cross the bridge at the center of the roadway.

3. Criteria for re-assessing bridges for overweight loads

Once defined the overweight load models and the movement conditions, the problem is how to define a procedure to assess the capacity of the individual bridges of the stock. The APT approach is to estimate the capacity of the stock, using first a simplified and conservative approach, and then refining the analysis only if a higher assessed capacity is needed. The assessment procedure includes various simplified levels of refinement, from Level 0 to Level 3, as summarized in Table 1. All the methods are based on the following principle:

The bridge is rated for an overweight load if it is demonstrated, even conservatively, that the overweight load does not cause effects that are more severe than the original bridge design code

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loading.

Particularly, Level 0 assessment consists in an unsupervised conservative estimate of bridge capacity based on knowledge of its geometry and of the design code. The analysis is carried out assuming that the bridge was built exactly to the nominal design load (in other words, there is no overstrength factor), thus the bridge is automatically deemed satisfactory for the overweight load if it is demonstrated that the stresses produced on the bridge are everywhere equal or lower than those considered at the design stage.

Table 1: Level of refinement of bridge assessment under overweight loads

Assessment Level	Capacity Models	Calculation Models
Level 0	Bridge is assumed verified with no overstrength	Statically determinate condition is assumed
Level 1	As per design	As per design
Level 2		Refined model, load redistribution is allowed, provided that ductility requirements are fulfilled.
Level 3	Material properties can be updated based on in-situ testing and observations	

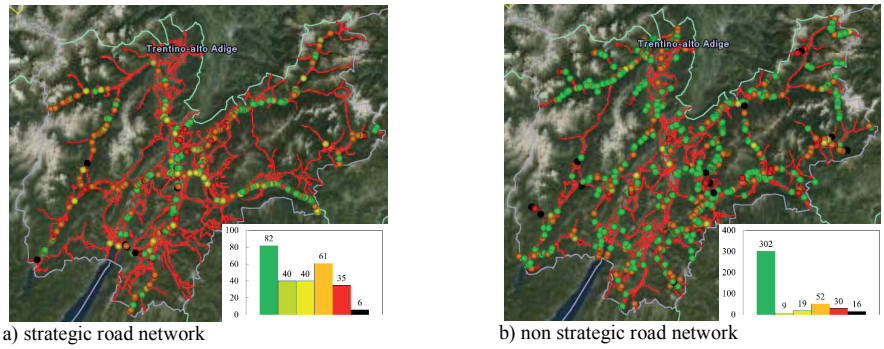
To classify substandard bridges, we need to know how far they are substandard; we introduce the so called *lack in capacity* α, defined as the percentage of missing capacity needed to deem the bridge to be satisfactory. For girder bridges this coefficient suggests how much the most critical bending moment or the shear stress should increase for positive verification.

4. Level 0 analysis results and demand for re-assessment

The mid-term APT objective is to assess in the next 10 years: the strategic road network for 72 ton free movement loads and 104 ton restricted movement loads; the non-strategic network for 56 ton free movement loads and 72 ton restricted movement loads. Fig. 1 shows the results of Level 0 assessment using the overweight loads as above for the strategic and non-strategic networks. In the map each dot corresponds to one bridge location, while the dot color encodes the outcome of the assessment in terms of index α with the following meanings: dark green: the bridge is formally assessed at level 0 and does not require further assessment; light green: the bridge is not formally assessed at level 0, with a lack in capacity $\alpha \leq 4\%$, however α is acceptably small and no further assessment is formally required; yellow: the lack in capacity is $4\% < \alpha \leq 8\%$; orange $8\% < \alpha \leq 14\%$; red $14\% < \alpha \leq 47\%$; black $\alpha > 47\%$; estimated less than 10% chance of being formally assessed even after Level 3 evaluation, a full formal re-assessment is needed, with possibly a retrofit.

5. Conclusions

We note that for non-strategic roads 311 of 428 bridges are automatically accepted, while in the case of strategic network only 122 of 264 bridges pass after Level 0 analysis. APT has also defined a protocol for reassessing existing bridges, based on a multi-level verification procedure. To re-assess substandard strategic bridges, APT has launched a re-assessment program, expecting to find about 27 substandard bridges in need of retrofit strengthening.



a) strategic road network b) non strategic road network

Fig. 1: lack in capacity for target APT load models on strategic network