Reduction of the life expectancy of bridges and viaducts as a result of increased truck traffic in the Netherlands

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1. Introduction

In the Netherlands, the motorway network has a large number of bridges and viaducts that were built in the ’60 and ’70 or even earlier. These civil structures were built with the knowledge of construction and materials, and the design criteria of that time, available traffic forecasts and vehicle loads, to achieve a structure lifetime of at least 60 to 80 years.
Truck traffic is an indicative criterion for the constructive design and practical behavior of these structures (bridges and viaducts). Truck traffic determines, *inter alia*, the structural strength of these structures and is as a result a dominant factor for the damage development, and resulting from that in maintenance costs. Changes in axle loads, frequency of burden passages, positioning of the axles, tire pressure and suchlike are then also of direct influence on the speed of the damage development. For a good management of the main road network, it is very important for the Dutch Ministry of Transport, Public Works and Water Management to have a good insight into the development of the truck traffic and the influence of this on the growth of damage to bridges and viaducts.

2. Type of civil structures

The Ministry of Transport, Public Works and Water Management currently manages over 5,300 civil structures. These structures can be sub-divided into a number of categories, which are depicted according to type of structure. Over 4,000 of these are present in or on the major highway network; what is striking is the large number of concrete structures, especially viaducts, bridges and underpasses. The proportion of steel in relation to those of concrete is a relationship of 1:12½
In addition to the division into categories and types of structures, it is important to know the year in which the constructions were designed.

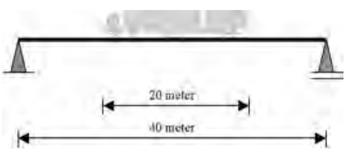

Fig. 1: Idealized bridge/viaduct

The year of design or the year of erection has a direct relationship with the recommendation which were then in force. It can be seen from the development of the recommendation to which the designs at that time complied with and where improvements were necessary, as a result of a growth in the number of vehicles, the vehicle weights and the axle loads. From this it becomes clear that relatively many structures are at an advanced age.

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3. Forms of damage

Damage that is determined on the basis of the design requirements of the new recommendation can, in the case of civil structures, be reported for both the main bearing system (the principal beams + possible transverse supports) and for the sub-support system (longitudinal beams + covering sheet). By the damage determination, the vehicle weight is coupled to the main load bearing system. Also by the damage determination, use is made of an earlier study performed by TNO-Built and Environment Geosciences, regarding the effect of equivalent fatigue loading of bridge decks.

4. Image of damage

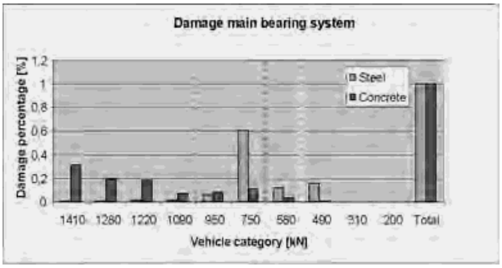

Fig. 2: Image of damage to the main bearing system

In figure 2, on the right hand side it is shown that the total maximum annual damage percentage amounts to 1%, comparable with a lifetime of 100 years. The other vertical columns in the diagram indicate the damage percentage per vehicle category. The yellow vertical line, to the left of the 490 kN, indicates the maximum vehicle weight, prescribed in the Road Traffic Laws of The Netherlands for regular truck traffic. The vehicles above the 500 kN in The Netherlands must have a permit. The Line to the left of the 580 kN, indicates the border of the outside category, whilst the green vertical line shows the border between singular trip permit exemptions and multiple trip permit. This is valid for all structures. It is clear that vehicles in the vehicle categories from 580 to 750 kN cause the most damage, and that particularly to the steel structures. It is also clear to note that damage to concrete structures can be expected from vehicles from higher categories. By growth exclusively of freight vehicles within the Road Traffic Act, the effect on the damage to steel structures will be larger than to concrete structures. With the expected increase of the 490 kN category (S=1,137) and the outside category of 580 kN, the life span will fall in the case of steel structures of 100 years by a maximum of a factor S=1+((44.0+29.6)-(16.0+12.1))/100=1.45. This means a minimum expected life span of 68 years. The influence on concrete structures is negligibly small (S=1.09). On growth of all categories of freight vehicles, the expected growth by both types of structures is now 370%, which means that the minimum life span does not amount to 100 years but 100/3.7 = 27 years. It must be remarked that the calculation method used is an upper limit approximation; the reserve capacity, which is included in a design of a structure, will increase the life span once again. A follow-up study will need to bring this reserve capacity further in view.

5. Conclusions

- The growth of the truck traffic, which falls within the Road Traffic Laws of 500 kN, will inflict very limited damage to the civil structures (bridges and viaducts).
- With growth of all categories of truck traffic, the damage to the civil structures will reach a maximum upper limit, whereby the life span can reach a minimum of 27 years.
- The categories 750 kN and 950 kN cause the greatest damage to steel structures, and the higher categories above the 1090 kN to the concrete structures.

6. References

[1] BOER A. DE, DJORAI M.H., and NOORDZIJ R., 'Consequences growing truck traffic on civil structures to 2020', CT07-R-7144-001, Centre for Public Works, Utrecht, April 2007. p. 56.