ABSTRACT

The main question of this thesis is the result of a survey by 'provincie Zuid-Holland' (PZH), that has developed a 'uniform model' for the assessment of the structural safety of existing prefabricated culverts. PZH is considering the possibility of using generic parameters to decide on the strength of existing culverts in the area. The province wants to show that all culverts, given their size and other material characteristics, are strong enough to carry the traffic loads prevailing in Netherlands. The PZH has decided to provide some elements of a replacement culvert (Schaapswegduiker) for the (destructive) determination of the strength. This has been realized based on the results of this thesis. The aim of the thesis is to determine the maximum load that can be carried and to assess the structural safety of the Schaapswegduiker, in accordance with current regulations.

In order to answer this research question, a literature study was conducted to assess the structural safety of existing structures. Schaapswegduiker is assessed for traffic loads LM1 and LM2 in accordance with RBK1.1, NEN 8700, NEN 8701 and NEN-EN-1991-2.

First, a materials research has been performed (by Nebest) based on my plan of action, to determine the proper output parameters for the calculations. Hereafter two calculation models have been prepared to validate the uniform model of PZH: a framework model (comparable to uniform model) and an advanced nonlinear FEM model. The advanced non-linear calculation has been carried out by means of a 2D-model DIANA. Using this model, I have made a prediction, a plan of action and a set-up for the test load that is carried out (by Heijmans). The DIANA-model is calibrated with the results of the test. Lastly, the influence of the by ground enclosed culvert on the load-bearing capacity has been analyzed

For all calculation models, the spread of the traffic load on the deck of the culvert is considered as uniformly distributed load. The load-bearing capacity and the assessing of the structural safety for the framework model (calculation model 1) is as follows. Applying the material properties assumed by PZH (design values), the culvert does not meet (UC = 1.09 for shear force). Applying the design values of the measured material properties by the material research (with a non-exact reinforcement configuration) are used, the culvert still does not meet (UC = 1.02 for shear force). Applying the (material properties of the calibrated model) upper limit of the design values of the measured values including spread and the exact reinforcement configuration, the culvert meets the assessment (**UC = 0.92** for shear force). The associated load-bearing capacity is **443 kN**.

With framework models, sufficient strength can be demonstrated using the measured values and exact reinforcement configuration. However, with an advanced model, a higher strength **(in this case an increase of a factor 1.9)** can be determined. With the calibrated DIANA-model, a load-bearing capacity of **840 kN** has been determined with a corresponding **UC of 0.53**. The upper limit of the design values of the measured values including spread and the exact reinforcement configuration have been used for this calculation as well. This determined strength is including the maximum negative influence of the load-bearing capacity for culvert which is enclosed by ground. This reduced the load-bearing capacity by 10%.

In short, the culvert meets the test for assessing the structural safety for both models. An advanced model with a nonlinear calculation in EEM calculates a factor of 1.9 higher load-bearing capacity and UC, compared with a framework model which is linear-elastic. This factor includes the maximum negative influence of the culvert in the ground and a conservative calibration of the model (DIANA-model is calibrated up to a maximum of 81%). That means that this determined factor can actually be even higher.

PZH is recommended to go through the following phases when assessing other culverts. Phase 1, design values should be used when there is enough information available about the culvert. When the UC does not meet, there should be continuation to phase 2. Here a materials research will be done. Precise determination of the material properties is important, especially the reinforcement configuration. It has been shown that it is worth paying extra attention to the reinforcement configuration. When the UC does not meet with the design values of the under limit of the design values of the measured values, there should be continuation to phase 3. Here, an advanced non-linear calculation is with FEM recommended, such as DIANA. The same material properties are assumed as in phase 2.