FINAL PROGRAM

11th International

DIANA Users Meeting

1-2 November 2017

Hosted by

Arcadis Nederland B.V.

ARCADIS Design & Consultancy for natural and built assets

Accessibility to Amersfoort

Amersfoort is located just 45 minutes by a direct train connection from Schiphol Airport Amsterdam. The Arcadis office is located nearby the railway station, the centre of Amersfoort city.

Venue

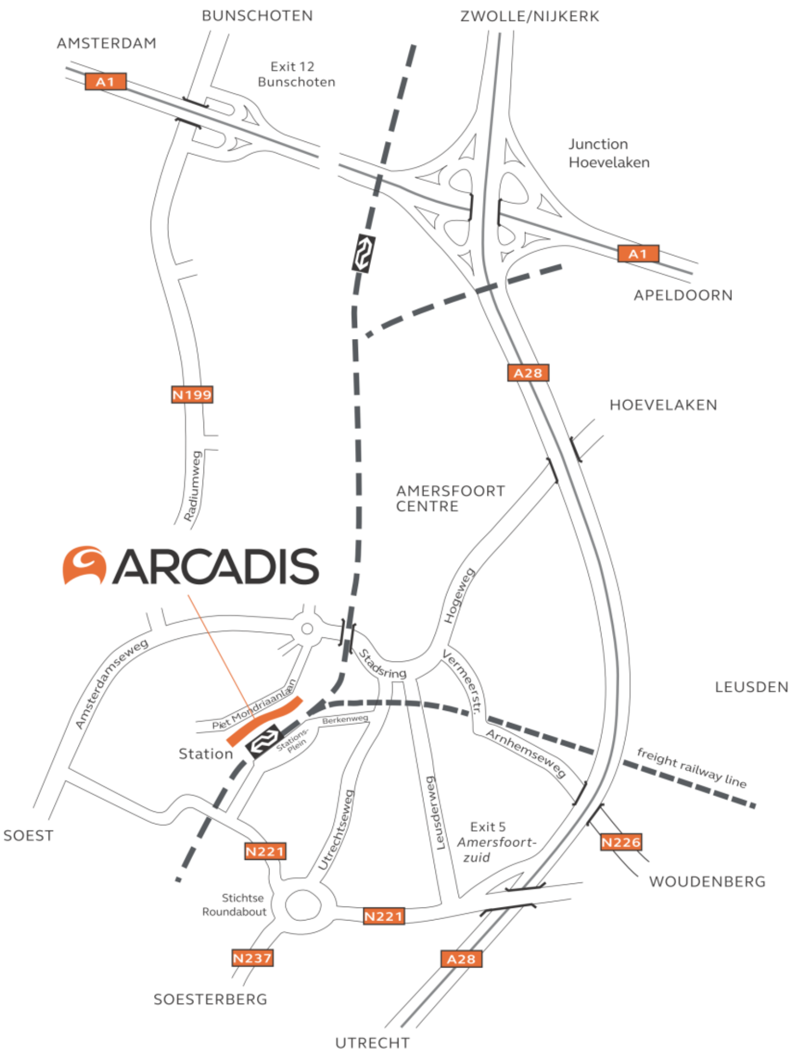
The meeting will take place at Arcadis, Piet Mondriaanplein 26, Amersfoort, The Netherlands.

Travel directions to Arcadis Amersfoort

BY PUBLIC TRANSPORT
Arcadis is located at Amersfoort Station. Leave the station via exit 'Piet Mondriaanplein' and turn right. You will see the ARCADIS office on your right.

BY CAR
From direction Amsterdam Follow the A1 and take exit 12 'Bunschoten'. At the roundabout turn left direction 'Amersfoort/Dierenpark'. You are now on the N199. At the end of the N199, at the junction 'Centrum-Dierenpark', turn left via Amsterdamseweg direction Centrum. Stay on this road until you reach the tunnel under the railway. Bear right before the tunnel and drive up the ramp to the roundabout. At the roundabout take the second exit 'Station Noordzijde'. The Arcadis office is located on your left.
From direction Utrecht Follow the A28 direction Amersfoort and take exit 5 'Maarn'. At the lights, turn left direction 'Amersfoort/ Dierenpark'. At the second lights (directly after the viaduct), continue straight ahead onto Leusderweg (direction Amersfoort). After 1300 m, at the roundabout, continue straight ahead (second exit). After another 1300 m, at the oundabout, continue straight ahead (second exit) onto Arnhemseweg. At the next lights, turn left onto the Stadsring (direction Amsterdam A1). Bear right as you drive through the tunnel under the railway and drive up the parallel road to the roundabout. Go three-quarters of the way round the roundabout, exit Station Noordzijde. The Arcadis office is located on your left.

PARKING
All visitors can park on the P+R site, which can be reached by following Piet Mondriaanlaan, past the NS Stationsplein, up to the end of the road. You will see the P+R site right in front of you. On the P+R site only can be paid with chip card, credit card or NS Business Card.



BUNSCHOTEN
ZWOLLE/NIJKERK
AMSTERDAM
A1
Exit 12
Bunschoten
Junction
Hoevelaken
A1
APELDOORN
A28
N199
HOEVELAKEN
Radiumweg
AMERSFOORT
CENTRE
ARCADIS
Hogeweg
LEUSDEN
Amsterdamseweg
Stadsring
Vermeerstr.
Piet Mondriaanlaan
Berkenweg
Station
Stations-
Plein
Arnhemseweg
freight railway line
Leusderweg
Utrechtseweg
Exit 5
Amersfoort-
zuid
N226
SOEST
N221
WOUDENBERG
Stichtse
Roundabout
N221
N237
A28
SOESTERBERG
UTRECHT

Program International DIANA Users Meeting

Wednesday, 1th November

13:30 Registration

Workshop **'Seismic Analysis with DIANA'**

The workshop on Wednesday 1 November aims at bringing together specific knowledge and expertise on the field of seismic analysis. The programme is a combination of inspiring lectures and open discussions / work sessions.

14.00 Opening

14.10 *Sander Meijers, Royal HaskoningDHV, The Netherlands*
Seismic nonlinear time-history analyses for retrofitting in Groningen

15.10 *Rick Bruins, ABT Wassenaar/BORG, The Netherlands*
How Python scripting facilitates the postprocessing at the Boterdiep project

15.40 Break

16.10 *Miranda Kamphuis, Sweco, The Netherlands*
Special NLTH-issues – how to…?

16.55 *Tuba Tatar, Universidade do Porto, Portugal*
Detailed numerical characterization of damage states of RC members

17.40 *Gerd-Jan Schreppers, DIANA FEA BV, The Netherlands*
Development wishes

18.00 Closing, and departure to restaurant 'Hoog Vuur'
The restaurant is located in an old factory building at a 15 min. walking distance from the workshop venue. The dinner is offered by Arcadis.

Program International DIANA Users Meeting

Thursday, 2 November 2017

8.30 Registration

9.00 Opening by Ane de Boer, chairman DIANA Users Association

9:10 Welcome by Bart Duijvestijn, Arcadis Nederland B.V.

Theme: Assessment Requirement Approaches

9:30 *Max A. N. Hendriks, Delft University of Technology / NTNU Norway, The Netherlands*
Recent Developments of the NLFEA Guideline

10:00 *Jiangpeng Shu, NTNU, Norway*
Multi-level assessment of a full-scale tested bridge deck slab

10:30 Break

Theme: Assessment Applications

11:00 *Hikmet Uysal, Arcadis Nederland B.V., The Netherlands*
Numerical and experimental strength assessment of 45-year-old prefab culvert

11:30 *Richard Roggeveld, Witteveen+Bos, The Netherlands*
Stability assessment of a masonry arch

12:00 Lunch

Theme: Additional Assessment Applications

13:30 *Yuguang Yang, Delft University of Technology, The Netherlands*
Critical loading position for proof load testing of reinforced concrete slab bridges based on scripted FEM analysis

14:00 *Niels Kostense, Arcadis Nederland B.V., The Netherlands*
In search of additional load bearing capacity

14:30 *Break*

Theme: Stability and Fiber Reinforced Concrete

15:00 *Sebastiaan Ensink, Delft University of Technology, The Netherlands*
Assessment of structural concrete behaviour with advanced numerical modelling

15:30 *Kris Riemens, ABT bv, The Netherlands*
Modelling of young hardening underwater concrete with steel fibers

16:00 *Gerd-Jan Schreppers, DIANA FEA BV, The Netherlands*
New options in DIANA Release 10.2

16:45 Closure event

17:00 Refreshment and Farewell

THEME: Assessment Requirement Approaches

Recent Developments of the NLFEA Guideline

Max A.N. Hendriks, Delft University of Technology, The Netherlands / NTNU, Norway
Ane de Boer, Consultancy, The Netherlands
Beatrice Belletti, University of Parma, Italy

Summary
The Dutch Ministry of Infrastructure and the Environment is concerned with the safety of existing infrastructure and expected re-analysis of a large number of bridges and viaducts. Nonlinear finite element analysis can provide a tool to assess safety using realistic descriptions of the material behavior based on actual material properties. In this way, a realistic estimation of the existing safety can be obtained utilizing “hidden” capacities.

Nonlinear finite element analyses have intrinsic model and user factors that influence the results of the analysis. This document provides guidelines to reduce these factors and to improve the robustness of nonlinear finite element analyses. The guidelines are developed based on scientific research, general consensus among peers, and a long-term experience with nonlinear analysis of concrete structures by the contributors.

The new version of the guidelines 2017 can be used for the finite element analysis of basic concrete structural elements like beams, girders and slabs, reinforced or prestressed. The guidelines can also be applied to structures, like box-girder structures, culverts and bridge decks with prestressed girders in composite structures. The guidelines are restricted to be used for existing structures.

The guidelines have been developed with a two-fold purpose. First, to advice analysts on nonlinear finite element analysis of reinforced and prestressed concrete structures. Second, to explain the choices made and to educate analysts, because ultimately the analysts stays responsible for the analysis and the results. An informed user is better capable to make educated guesses; something that everybody performing nonlinear finite element analyses is well aware of.

The deliverables in this context are:
1 - Guidelines for Nonlinear Finite Element Analysis of Concrete Structures
2 - Validation of the Guidelines for Nonlinear Finite Element Analysis of Concrete Structures, Part: Overview of results
3 - Validation of the Guidelines for Nonlinear Finite Element Analysis of Concrete Structures, Part: Reinforced beams
4 - Validation of the Guidelines for Nonlinear Finite Element Analysis of Concrete Structures, Part: Prestressed beams
5 - Validation of the Guidelines for Nonlinear Finite Element Analysis of Concrete Structures, Part: Slabs

Multi-level assessment of a full-scale tested bridge deck slab

Jiangpeng Shu, NTNU Norwegian University of Science and Technology, Norway

Summary

Reinforced concrete slabs without shear reinforcement are commonly used in many structural systems, such as bridge deck slabs. Punching/shear is usually the governing failure mode at ultimate of those RC slabs subjected to concentrated load. However, previous study has shown that existing models are too conservative. Thus, the aim of this study is to evaluate and improve the existing calculation model.

In this study, a "Multi-level Assessment Strategy" has been applied to a 55-year old existing reinforced concrete bridge deck slab with concentrated load near the girder. The punching/shear strength was calculated based building codes, Critical Shear Crack Theory and Nonlinear FE analyses. The difference between assessment methods at different levels has been discussed regarding punching and one-way shear behavior of slabs. In addition, a full-scale test was carried out to the bridge to calibrate the calculation model. Furthermore, the failure mode between one-way shear and punching was discussed. The influence of boundary condition, location of concentrated loading and arch action were investigated in the model. The shear force distribution was analyzed in different cases to evaluate the influences to the failure mode. The choice of effective to calculate the one-way shear resistance was discussed based on shear force distribution.

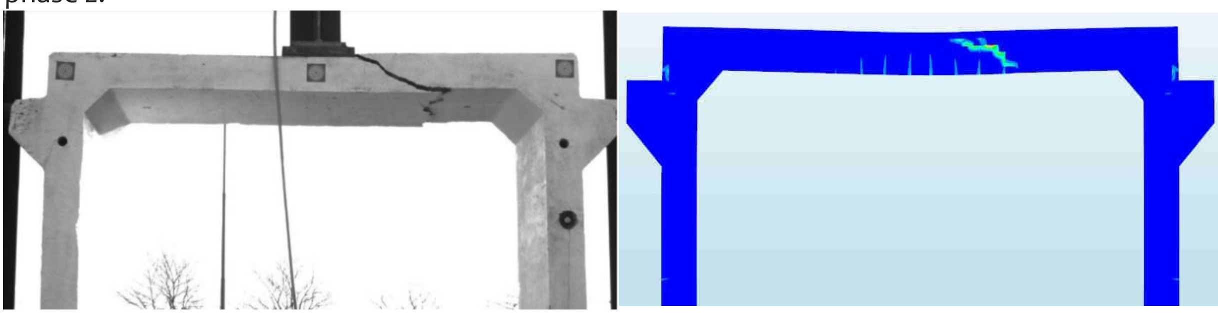
Results show that the failure mode to the slab was between punching and one-way shear. Shear force distribution is influence by cracking and the failure mode would be affected by factors such as boundary condition and location of concentrated loading.

THEME: Assessment Applications

Numerical and experimental strength assessment of 45-year-old prefab culvert

Hikmet Uysal, Arcadis Nederland B.V., The Netherlands

Summary
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 The 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 access 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 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 non-linear FEM model. The advanced non-linear calculation has been carried out by means of a 2D DIANA-model. Using this model, I have made a prediction, a plan of action and a set-up for the test load that is carried out. 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
In short, the culvert meets the test for assessing the structural safety for both calculation 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 existing culverts in their area. 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 with FEM is recommended, such as DIANA. The same material properties are assumed as in phase 2.



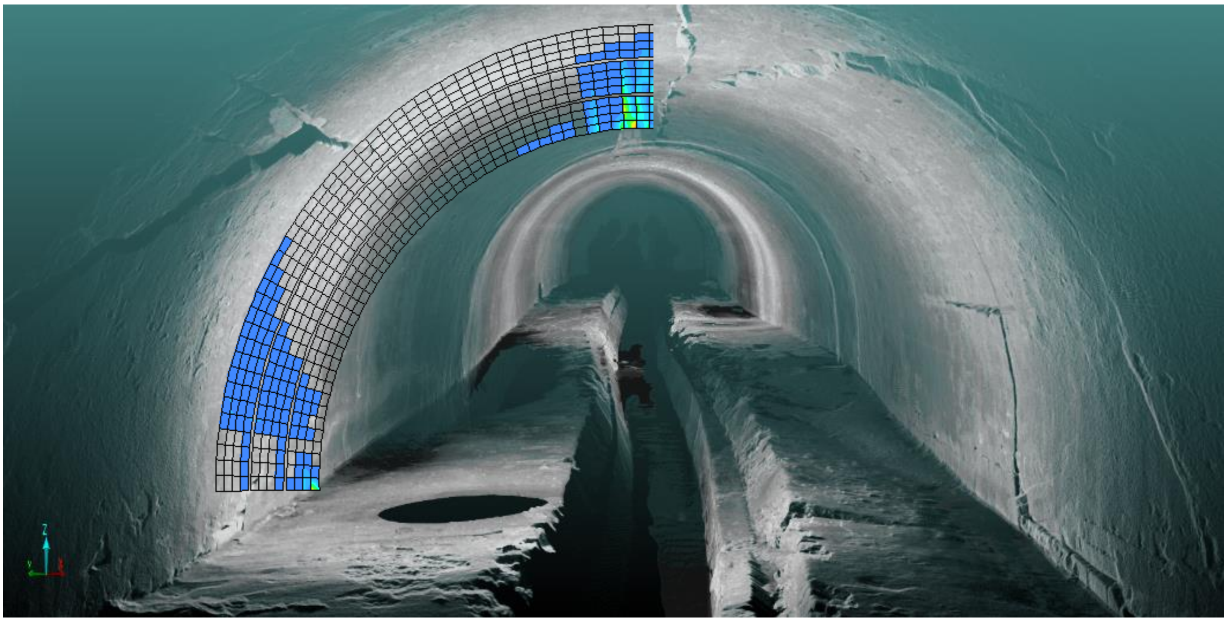
One of the most important results of the experimental (left) and numerical assessment (right).

Stability assessment of a masonry arch

Richard Roggeveld, Witteveen+Bos, The Netherlands
Frank Kaalberg, Witteveen+Bos, The Netherlands

Summary
In Arnhem (NL) rainfall in the northern part of the city is being transported by a main sewer called Moerriool. This sewer was built approximately 150 years ago, and consists of concrete slabs with a masonry arch. During inspection of the sewer, alarming damages were found. The masonry structure suffered severe subsidence, cracking, deformation and material deterioration.
A complete renovation was likely to be very costly, therefore remedial works needed prioritizing. No archives were available, all basic information needed to be gathered on site. In addition, various tests have been undertaken to find the propelling mechanisms, in order to be able to assess the stability of the structure and finally to list appropriate measures.
Geometrical and physical non-linear Diana-models were used to assess the stability of the arch under various circumstances, for instance due to variance in soil stiffness, wall thickness and material degradation.
The feasibility of 3 measures has been studied in more detail. Based on the results, the renovation plan was made and gave start to the works.

Figure 1: Diana-results, combined with a picture and laser scan



THEME: Additional Assessment Applications

Critical loading position for proof load testing of reinforced concrete slab bridges based on scripted FEM analysis

Yuguang Yang, Delft University of Technology, The Netherlands

Summary
As the bridge stock in The Netherlands and Europe is ageing, various methods to analyse the capacity of existing bridges are being studied. Proof load testing is one of the method to test the capacity of bridges by applying loads on the existing concrete bridges with small spans. Because of the fact that neither the actual traffic load nor the design traffic load required by Eurocode can be directly applied on the target bridge in real-life proof load testing, an equivalent wheel load has to be applied instead. The magnitude and the location of the equivalent wheel load is determined in such a way that it generates the same magnitude of inner forces in the cross section. Such calculation is usually done by linear finite element analyses (FEA). Whereas, different bridges have different geometry such as length, width, thickness, angles, number of spans and lanes etc. For each configuration, FEA has to be done first to determine the loading position. The main aim of this paper is to study the relation between bridge geometry and unfavourable loading positions (ULP). Based on that, a guidance tool is developed for the determination of the critical proof load testing locations for the practice.

To achieve this goal, a Python script has been developed using Diana FEA. The script enables the automatic generation and analysis of a bridge model with different geometries and loading conditions. By applying the Eurocode Load Model 1 at variable locations, the most unfavourable loading positions for the proof load are obtained at the corresponding boundary conditions. The output of the study provides a convenient tool for future proof load testing.

In search of additional load bearing capacity

Niels Kostense, Arcadis Nederland B.V., The Netherlands
Coen van der Vliet, Arcadis Nederland B.V., The Netherlands

Summary
Due to increasing traffic loads and modifications in concrete design rules existing bridges suffer from the potential risk not complying to the present building codes. In particular bridges with small spans are vulnerable to the increase of traffic load because of the higher ratio of live load compared to dead load. Arcadis is assigned to assess the structural safety of a relatively small pedestrian tunnel where refinements with respect to the analysis- and modeling approach are subsequently adopted.
In this project specific attention is given to the analysis approach to conduct a non-linear analysis with limited resources. This entails that the adopted strategy must be proportional to the size of the object, but reflects the real structural behavior with sufficient accuracy. The chosen analysis approach has to be proportional to the scale of the structure and requires an efficient strategy that determines the capacity to redistribute forces, but entails a limited modelling and computational effort.
The structure considered is a small pedestrian tunnel built up from prefabricated prestressed elements with a cast in place compression layer. The size of the structure does not automatically imply that the structural behavior is straightforward. For this particular object modeling and structural analysis should take into account the effects of prestressing, non-orthogonal reinforcement, orthotropy due to skewness and geometric discontinuities, different concrete properties of the composed slab and different construction phases. Accounting for all these properties in a physically nonlinear analysis resulted in a certain redistribution of forces where the required safety level has been verified. The effectiveness of the modeling techniques and practical use of the applied safety formats play a crucial part in this project and are evaluated.

THEME: Stability and Fiber Reinforced Concrete

Assessment of structural concrete behaviour with advanced numerical modelling

Sebastiaan Ensink, Delft University of Technology, The Netherlands

Summary
In The Netherlands, approximately 150 prestressed concrete T-beam bridges with cast-in-between decks are present. Upon assessment, the strength of these bridges is often too low, partly due to increased traffic loads and partly due to changes in codes, for example in the Eurocode provisions for shear. However, for these types of bridges several mechanism could possibly contribute to a higher load bearing capacity that are usually not taken into account. One of these mechanism is compressive membrane action (CMA), in transverse direction, in the concrete deck slab. In previous research a full 3D model of the complete bridge was used to analyse the local CMA behaviour of the cast-in-between slab. In the current research a local, much smaller DIANA model of the slab is adopted. The connection of the cast-in-between slab with the prestressed concrete beams is modelled using interface elements. Furthermore, the membrane action can be analysed using composed elements in the concrete deck slab. A direct comparison with the previous research can be made, both in terms of the ultimate load capacity and the CMA behaviour. Ultimately, the goal of this research is to improve the calculation methods for the existing T-beam bridges in The Netherlands.

Modelling of young hardening underwater concrete with steel fibers

Kris Riemens, ABT bv, The Netherlands

Summary
For basement structures, use is traditionally made of unreinforced underwater concrete as a temporary seal of the building site. Because the concrete is placed under water, the quality however remains uncertain and the material can behave brittle. Though meant to ensure a watertight building site, leakage problems often occur due to thermal shrinkage cracking. Use of traditional reinforcement in underwater concrete can be considered but is complex and expensive. Recent projects, such as Groninger Forum and Albert Cuypgarage, however have shown that the application of steel fibers in the concrete mixture present a possible solution to this problem. Predicting the structural behaviour of the young hardening concrete mixture with steel fibers is a complex issue however, many different factors influence the structural behaviour and crack formation. Some of these factors include: thermal boundary conditions, mechanical boundary conditions, heat development of the concrete mixture, development in time and spatial variations of the mechanical properties and that of the post-cracking behaviour. Using the finite element program DIANA, a first attempt is made of modelling this complex phenomenon.