Diana Users' Association

Annual report 2006

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ir. A. de Boer
Chairman DIANA User's Association

ANNUAL REPORT 2006

Contents

1. Aim of the Association

The members of the Association are all users of the DIANA software package of TNO-DIANA BV.
In this capacity, they have a considerable interest in gaining knowledge in the Finite Element Method and (numerical) mechanics, as well as in the further development and extension of DIANA.

To achieve this, the Association fulfills a coordinating role by taking stock of the members' needs in terms of research and development, and initiating new projects.

The Association is also a meeting place for the exchange of experiences with the software package.

Furthermore, TNO-DIANA BV utilizes the Association to inform the Users on the DIANA package development progress.

2. Executive Committee 2006

During this reporting year, the Executive Committee consisted of:

Chairman:	ir. A. de Boer, Civil Engineering Division, Department of Transport, Public Works and Water Management, Utrecht
Secretary/ Treasurer:	ir. N. Vollema, Royal Haskoning, Nijmegen
Committee member:	dr.ir. A. Vervuurt, TNO Bouw until 13 juni 2006, followed by dr.ir. F. Galanti, also from TNO Bouw

The Executive Committee has mainly dealt with the following:

1. Discussion on the start-up of possible new research projects on the basis of a national and international user's wish list
2. Giving a more international imprint to the users' association
3. Organizing of the 3rd International DIANA Users' Meeting in Essen, Germany
4. Providing contributions for DIANA Elements / 2
5. Contributing to the setting up of a database with publications related to DIANA
6. Extending the existing e-mail database with foreign users in the fields of concrete, concrete mechanics, bridges and tunnels
7. Preparation of general and technical meetings
8. Association finances
9. Setting up a new concrete mechanics examples report in collaboration with CUR, resulting in the CUR report 200x-x, *Advanced analysis of civil engineering structures*. This will be a broader report than the previous one(CUR-C2003-3), as it will include examples where different software packages are used and will be supported also by other Users' associations. Only the Users of Geodelft software are interested to contribute to this new report.

3. Activities

3.1 General

The association holds a general meeting of members twice a year, followed if possible by a technical meeting (lectures).

3.2 Technical lectures 13 June 2006

3.2.1 Simulation of the detachment of carbon fibre reinforcement externally bonded to concrete

Ernst Klamer – Eindhoven University of Technology

Strengthening concrete structures by means of externally bonded carbon fibre reinforcement is a relatively new and promising reinforcement technique. Despite the extensive research that has been carried out both nationally and internationally, there are still several unresolved issues concerning this technique. In most cases, detaching the carbon fibre reinforcement appears to be the cause of its failure. One of these issues, which have not yet been adequately studied, is the effect of temperature on the detachment of externally bonded carbon fibre reinforcement.

Within the framework of doctoral research at the Eindhoven University of Technology two types of experiment were carried out on small-scale concrete structures strengthened with carbon fibre reinforcement: pure shear tests and three-point bending tests. It was expected that in both cases detachment would occur because of excessively high shear stresses in the concrete layer, just above the bond. Temperature changes influence the bonding properties of the concrete adhesive and adhesive carbon fibre reinforcement joint. In particular, the properties of the adhesive layer will change, especially when the glass-rubber transition temperature of the adhesive is reached. In addition, there is a considerable difference in the thermal coefficient of expansion between concrete and carbon fibre reinforcement, which will cause additional thermal stress. Both effects may affect the load that produces detachment. In the presentation a comparison will be made between the results of the experiment and those of a numerical simulation of the detachment of the carbon fibre reinforcement at different temperatures.

3.2.2 Geotechnical analyses with Msheet and Mpile

Dirk Luger, Geodelft Delft

The difference between four arithmetical models will be demonstrated using an example with a relatively simple pile group. Attention will also be paid to mechanics in the group, which shows some surprising aspects. Moreover, on the basis of some practical examples, details will be given of possible applications for the various models.

3.2.3 Exploratory calculations of aircraft impact on LPG storage tanks

Sander J.H. Meijers, *Protected Storage Engineers (subsidiary of DHV BV and Royal Haskoning)*

Aircraft impact on an LPG storage tank has been analysed with a finite element model. The studied tank has a diameter of 60 m and a height of 38 m, while the impact load is a civil aircraft of 90 tons that flies into the roof of a tank at a speed of 103 m/s and at an angle of 3°. The load is transformed into a static force, so the strain energy of the tank as a result of the collision is not bigger than the kinetic energy of the aircraft just before the collision. Secondary loads such as explosions and fire were not considered. In the present exploratory study, node movements and element stresses are calculated, based on a linear elastic analysis with the DIANA program and a subdivision into geometric parts with different elastic moduli and Poisson ratios. Furthermore, geometric non-linear effects are estimated with a linear Euler stability analysis. The provisional results obtained invite expansion of the complexity of the study; at the same time they appear to indicate that the modelled impact load is critical for the LPG storage tank, in the sense that whether or not the tank collapses depends on a small variation from the input impact load.

3.2.4 In-Plane Loaded Glass Panes in Façades

Ir. Edwin M.P. Huveners, Eindhoven University of Technology

Glass is a popular building material for architects, because the material is transparent, aesthetic and durable. Glass also has good mechanical properties. Its best known less good property is its tendency to shatter. Therefore structural glass must always be laminated and possibly reinforced. Examples of structural glass are staircases, balustrades, floors, beams and columns. These structures are made using common sense, because current normative standards are inadequate.

In-plane loaded glass is relatively strong and rigid. This means that the glass can be used as a transparent pane to resist lateral load. The glass is therefore capable of stiffening an unstable frame. An essential element is the joint between the glass pane and the surrounding framework. Reduction of tensile stresses and non-metallic contact is important for structural glass and there is therefore a preference for an adhesive joint.

During the research three different adhesive joint geometries were studied and two types of adhesive, namely a flexible adhesive (polyurethane) and a rigid adhesive (epoxy). The relation between the shear stress and shear angle of the two adhesives were determined in an experiment at different temperatures and load velocities. These results act as input for a finite element model. The construction system comprising an unstable frame, glass pane and adhesive joint type is to be experimentally tested and simulated in a numerical model.

3.2.6 Bentley Structural at DHV

Michel Beliën, DHV Bouw en Industrie Zaandam

Whereas in the past we calculated and drafted structural designs independently of each other, we are now getting ever closer to an unambiguous integrated 3D model that forms the basis for both the drawings (2D and 3D) and the calculations.

At Bentley Structural both a 3D graphic model and a 3D analytical model are being created that will be linked to analytical software (which will itself be fully integrated in the future). By setting up the 3D model in a structured fashion and with the help of reference files we can calculate not only the entire 3D model but also individual parts of the structure. No more errors occur when data is transferred, and if the design is changed, all the 2D generated drawings are adapted unambiguously using the 3D model.

In a 3D model the insight is greater and it is easier to come up with alternatives at an early stage for the benefit of the design. Some subjects become more complex through this technology and an integrated design approach may even be necessary.

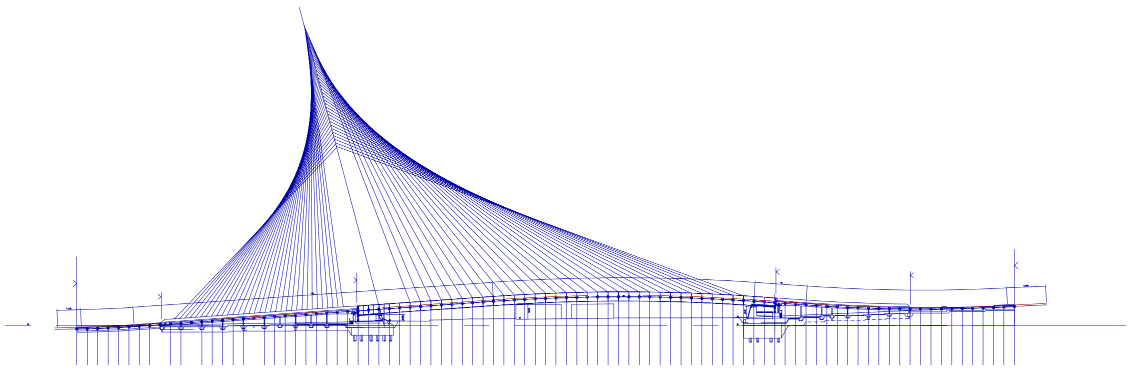
3.3 Technical lectures 31 October 2006

3.3.1 Calatrava bridge, Jerusalem

René Dorleijn RI, Movares, Utrecht

Within the framework of the Jerusalem Transportation Master Plan the Israeli Ministry of Transport and the city of Jerusalem have opted for a light rail link as the backbone for future traffic solutions. In this link a cable stayed bridge designed by the renowned architect Santiago Calatrava will serve as a monumental gateway to Jerusalem. The unconventional structure looks different from every angle and even seems, from one particular perspective, to fly.

A second opinion of the design of this bridge has been given by the engineering consultancy Movares in Utrecht, in terms of the dynamic behaviour of the structure and how this impinges on the comfort of the passengers. With the help of an EEM model the presentation will go into the modal and transient dynamic analyses that were carried out and into the testing of the comfort criteria.



3.3.2 Simulation of the detachment of carbon fibre reinforcement externally bonded to concrete

Reinier Ringers, Delft University of Technology/Bouwdienst RWS

Strengthening concrete structures by means of externally bonded carbon fibre reinforcement is a relatively new and promising reinforcement technique. Despite the extensive research that has been carried out both nationally and internationally, there are still several issues concerning this technique. In most cases, detaching the carbon fibre reinforcement appears to be the cause of its failure. One of these issues, which have not yet been adequately studied, is the effect of temperature on the detachment of externally bonded carbon fibre reinforcement.

Within the framework of doctoral research at the Eindhoven University of Technology a number of experiments were carried out on concrete structures, strengthened with carbon fibre reinforcement, to study in detail the detachment mechanism of transverse cracks. In addition, a numerical research project was set up, carried out by E. Klamer, in which a simulation was made of the detachment mechanism of transverse cracks. This research led to a simulation of a single beam with a single explicit discrete transverse crack.

The current study is looking at the same concrete structure simulation, but now with several discrete transverse cracks. The aim of this simulation is to achieve a better determination of the prospects of reinforcing concrete structures, as proposed by CUR recommendation 91.

3.3.3 Study of the structural aspects of a new flooring system, Dycore's Flexvloer

J. Bruggraaf – Delft University of Technology/ TNO Built Environment and Geosciences

The system was developed by Dycore BV and a study was carried out in the context of Mr Bruggraaf's master thesis project at the Delft University of Technology. FlexVloer is based on IFD (industrial, flexible and demountable building) and involves pre-stressed concrete floor elements with a network of hollow areas and tunnels. Cables and pipes can be installed in this network.

The production method is as follows:

- phase 1 = B65 concrete with steel fibres is cast in a flexible mould (with removable cassettes, to provide openings). After loosening from the mould, the top plate is pre-stressed.
- phase 2 = the upper side of the top plate is inverted and placed on a bottom plate, which is then pre-stressed.

There are no rules for calculating these different sections. The shear resistance was tested on the basis of NEN 6720, using the principle of equivalence. These calculations were made on a test strip fitted with a longitudinal rib and several cross ribs. Reinforcement with dowels was used on the joints. Manual calculations and 3D FEM calculations were made. These showed the favourable effect of steel fibres on force transmission on cracks at the joint of top plate and bottom plate. A test in the compression bench showed that shearing occurs through crack development in the tunnel corner (underside of top plate), which confirmed the calculated results.

3.3.4 Calculation of the likelihood of cracks in hardened concrete elements

Herbert van der Ham, Delft University of Technology

The durability of (reinforced) concrete structures depends both on the design of the concrete elements and on the presence of cracks that may occur when the concrete is hardened. In the context of making durability forecasts it is necessary to predict as reliably as possible the likelihood of cracks. There are three different levels in calculating the likelihood of cracks:

Level I	Partial safety factors;
Level II	Linearisation of the reliability function
Level III	The probability of failure is calculated, including examining the probability density functions of all the load and strength variables.

Current probability calculations for hardened concrete are usually based on Level II calculations, with the likelihood of cracks being calculated on the basis of the relationship between the average values of the current tensile stress and the current tensile strength. Manual parameter studies are carried out to examine the influence of different parameters. Each study examines the influence of changing a single parameter.

By introducing Monte Carlo simulations (Level III calculation) it is possible to study the influence of changing a single parameter while all the other parameters are variable too. A comparison is made between the different levels of calculating the likelihood of cracks in a hardened concrete structure and an overview is given of the accuracy of the three calculation levels in relation to the reliability of the likelihood of cracks.

3.4 International DIANA Users Meeting 2006, 16-17 March 2006, Essen, Germany

Lectures:

Computer supported knowledge based cooperative work
M. Schnellenbach-Held & M. Hartmann, Institute of Concrete Structures and Materials, University of Duisburg-Essen, Essen, Germany

Micro-mechanical Analysis of Fiber Reinforced Cementitious Composites using Cohesive Crack Modeling
H. Stang, Department of Civil Engineering, Technical University of Denmark, Lyngby, Denmark

Composed beam elements – in plane loading
A. van den Bos, ABT, Velp, The Netherlands

Finite element modelling of steel fibre or synthetic fibre reinforced concrete structures
T. Kanstad and Å.L. Døssland, Norwegian University of Science and Technology, Trondheim, Norway

Can engineers take up the challenge of digital architecture ?
A. Borgart, Delft University of Technology, The Netherlands

Analysis of masonry shear walls and non-load-bearing inner walls with the aid of the finite element method (FEM)
B.G. Kang e.o., Institut of Building Materials Research Aachen University, Aachen, Germany

Instrumentation, Monitoring and Execution Control of the New Footbridge over Mondego River in Coimbra
Mario Pimentel, University of Oporto, Porto, Portugal

Numerical simulation of volumetric expansion of stone in historical buildings
K. Hoiseth and K.L.K. Chuen, Norwegian University of Science and Technology, Trondheim, Norway

Steel fibers as reinforcement for precast tunnel segments
G. Tiberti, Department of Civil Engineering, University of Brescia, Italy

DIANA and ESPI: use the best of two worlds for masonry research
A. Vermeltfoort, University of Eindhoven, Eindhoven, The Netherlands

Shear capacity and compression strut failure of biaxial hollow slabs
M. AldeJohann, Institute of Concrete Structures and Materials, University of Essen, Essen, Germany