DIANA Users Association

Annual report 2011

18-05-2012

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

DIANA
Users Association

Annual Report 2011

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 fulfils 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 2011

During this reporting year, the Executive Committee consisted of:

Chairman:	dr.ir. A. de Boer, Centre for Infrastructures, Ministry of Infrastructures and the Environment, Utrecht
Secretary/ Treasurer:	ir. N. Vollema, Royal Haskoning, Nijmegen
Committee member:	ir. H.G. Burggraaf, TNO, Delft

The Executive Committee has mainly dealt with the following:

1. Discussion on continuing new research projects on the basis of a national and international user's wish list.
2. Continuing contributing to the set-up a database with publications related to DIANA or FEA.
3. Extending the existing e-mail database with foreign users in the fields of concrete, concrete mechanics, bridges and tunnels.
4. Preparation of general and technical meetings.
5. Association finance.
6. Progress in an international response/discussion forum around developments now and in the future related to Users Wishes.

3 Actitivities

3.1 General

The Association holds a general meeting of members twice a year, followed if possible by a technical meeting (lectures). In 2010 there was held only one technical meeting, a lecture evening.

3.2 Technical lectures June 16th, 2011

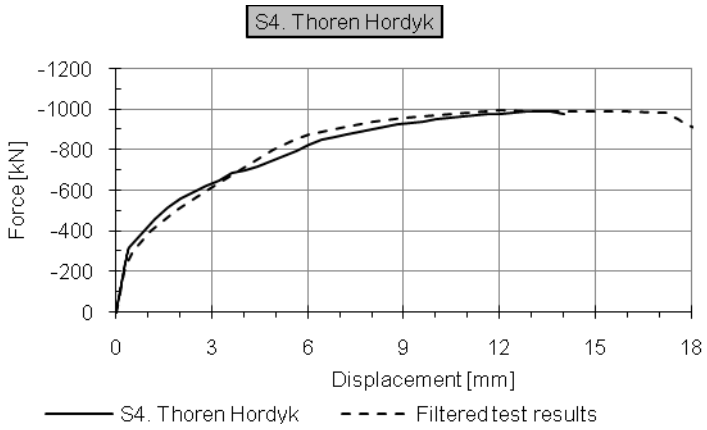
Comparing the load bearing capacity of reinforced beam girders
Bart van Hulten, Delft University of Technology / Corsmit

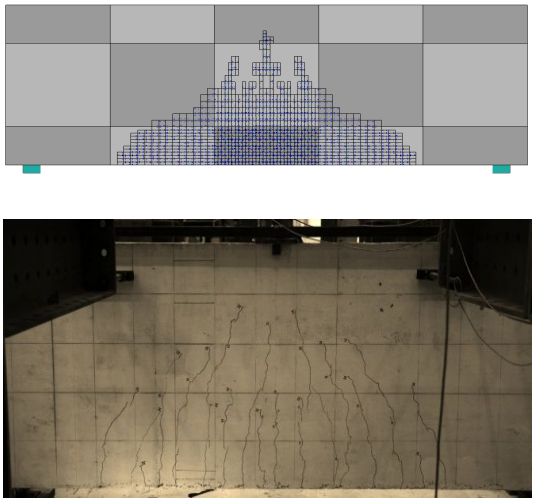
In the report of Romans is stated that the load bearing capacity as determined by ESA PT did not match with the maximum acting load that was found in the Atena finite element modelling (FEM) program. In this report further research is done with Diana, this is another FEM program. Besides theoretical calculations, an experiment in Stevin laboratory is done.
Designing a concrete deep beam ESA PT could be useful design tool. Is this valid and does it
meets the safety requirements?
Theory
Before doing the experiment a calculation of the bearing capacity by hand is done. Furthermore several stress strain that could be modeled in Diana are investigated. This investigation is done with a simple block mesh. In this way the behavior and govern parameters of a certain stress strain relation can be determined. In this study a of a concrete block, a steel bar and a combination of a steel bar in a concrete block is done.
Experiment
After designing and building of the mold, specimen S-2-4 is made. Specimen S-2-4 is 3 m long, 1 meter high and 0,2 m thick. It has no basic reinforcement net, but is designed as precisely as possible according to the outcome results of ESA PT. The specimen is tested 24 days after casting. The beam is tested with an imposed displacement and the next parameters during the test are measured:
- Net displacement of beam, measured with two lasers with an accuracy of 0.025 mm.
- The total force of the jack with an accuracy of 10 N.
- The crack widths, locations and lengths. With an accuracy of 0.05 mm.
- Horizontal elongation (after testing) with an accuracy of 1 mm.

Specimen S-2-4 before testing After testing, the total imposed deformation is 18.22 mm

During the test a maximum load of Fu = 992 kN is measured. Yielding of steel occurred before the deciding failure mode of concrete crushing.
Further research
The theoretic models are used for input to compare the output with the test results. It turned out that Thorenfeldt / Hordijk model is the best fit compared to the test results. Further research in the variation of the material parameters is done. After this calibration further research is done with parameters as described in EC1992-1-1 as in EC1992-2. With the test results as guidance, there is made an attempt to determine the nominal load.

With Diana FEM results it is not possible to prove that ESA PT meets the safety requirements.
The results of the FEM models give a lower capacity than the design load. However, the analysis in the Diana model and test results correspond very well. So the Diana model has given good results.
Therefore the Diana results can be used for further research. The lower bearing capacity according to the FEM models, are in accordance with the possible overestimation of the nominal load.





Extension and Verification of Sequentially Linear Analysis tot Solid Elements
Lars Vormeeren, Delft University of Technology

When analyzing three-dimensional problems with nonlinear finite element analysis (NLFEA) often problems are encountered such as bifurcation and divergence of the solution. In particular, cases subjected to tension softening tend to encourage the emergence of multiple equilibrium paths. In order to overcome these problems the alternative Sequentially Linear Analysis (SLA) method has been developed for three-dimensional solid elements. Here, a series of linear analyses are used to model the nonlinear behavior of the structure. By directly specifying a damage increment in each linear analysis, extensive iterations within the load or displacement increment can be avoided. In this research the SLA method first had to be extended to 3D stress-strain states (solid elements) and implemented in finite element program DIANA. Afterwards, the strengths of the SLA method have been demonstrated by verification study on a tested reinforced concrete slab. The results were critically evaluated, interpreted and compared to results from the experiment and the incremental-iterative Newton-Raphson method. It appeared that the Sequentially Linear Analysis is able to properly capture the quasi-brittle behavior of the reinforced concrete slab.

Control of a cracked cross section
Ostar Joostensz, ABT

The finite element method is based on principal stresses, while the classical mechanics bases itself on shear force and moments.
To meet the critical questions of the engineers, ABT is continuously busy to innovate and verify its finite element models. Composed elements have already bridged between both disciplines, but they do not work as well with the varying thicknesses, non-linear behavior and embedded reinforcements.
Based on model RB2 (Beam8), it has been tried to draft a valid cross-sectional check for shear force, based on the shear stresses in the elements. With this, not only reinforcement and flexural cracks played its part, but also convergence behaviour, the crack model and the way of loading. The results are very diverse, but most of all show that not in all cases equilibrium is shown.

3.3 International DIANA Users Meeting 2011

An international meeting was scheduled in Gothenburg, Sweden at the Chalmers University. Unfortunately there were not enough submitted abstracts, so the meeting was delayed. In October Chalmers organised a Nordic FEA meeting for the engineers from Scandinavia. However a combination meeting wasn't preferable, so it was decided to try the next meeting in Gothenburg in October 2012, while a *fib* symposium already is scheduled in June in Stockholm.

3.4 Technical lectures November 24th, 2011

Damaged basement floors
Ostar Joostensz, ABT

As a damage expert, ABT has been heavily involved with cracking in basement structures. Cracking in basement floors can lead to severe flooding. The user-friendliness and functionality of the underground parking garage has been affected. Many damage cases show that the cracking was taken too little into account during the design phase.
This contribution is a reminder to the current engineer, to take the aspect of cracking into account. General knowledge is that for this goal there are too little calculation clauses in the current recommendation. Besides, calculating based on crack width demands a project specific approach.
This lecture will further explain the basic principles of the design of a basement floor. Some things will be clarified through calculations with the finite element method program DIANA.

Multiscale modelling
Erica Coenen – TNO

The development and application of heterogeneous materials has expanded enormously in the past decennia. The microstructure of 'smart' materials has been

designed as such that the functionality of the final product shows the desired characteristics. For this, the development of the material and product will go hand in hand. Traditional material models, that are used for simulations at production level, often have a phenomena failure character. These models can only stimulate the scaling of the links between aspects with this underlying microstructure a limited amount. Multi-scale models provide an answer to the question how the mechanics can be linked at different length scales. Numeric homogenization provides the possibility to a full transfer of the non-linear constitutive behaviour of the underlying microstructure. This method is essentially based on the formulation of a microstructure boundary condition problem, based upon which the local constitutive material behaviour for the macro scale will be derived.

Stability walls of sandstone

Lex van der Meer, Eindhoven University of Technology

The moment- and shear force of unreinforced sand-lime brick stability walls is due to the relatively low tensile strenght of in particular the wall-floor connections, dependent on the present normal force. From an architecturally point of view it is not always possible to divide the stability walls in the floor-plan in a way that every stability wall gets sufficient normal force. By vertical prestress of the stability wall, the right amount of normal force can be applied for each wall .
For performance technical reasons, the pre-tension without bonding(VZA) has been chosen. For the structural calculation of a single stability wall with VZA, this can be simplified by a stability wall without prestress with extra normal force. In the ultimate limit state, cracking of the stability wall is allowed. The distribution of the horizontal wind load on a building over the stability walls is however typically based on the linear-elastic stiffness ratios of the stability walls.
With cracks and eventual plastic behaviour of the stability walls this is not right. That is why, an attempt has been made with DIANA to model a simple building in which non-linear behavior of sand-lime brick will be charged with help from the anistrope Rankine-Hill model of Paulo Lourenco. Because this is by default only implemented for 2D plane stress in DIANA, a User-supplied Subroutine has been used. The provisional results of the still ongoing research will be presented.
The final goal is to predict the distribution of the wind load over the stability walls in the ultimate limit state well, so that a safe but not conservative approach of the capacity of the entire building can be obtained.

A priori attempts of the crack bandwidth in the smeared crack approach

Arthur Slobbe, Delft University of Technology

Shortly after the introduction of the smeared crack approach, during the end of the sixties, people discovered that the energy dissipation in the numerical crack process was proportional with the crackwidth value of the used finite elements. This dependence of the space discretization of the finite element model on the numeric solution of the non-linear analysis is unwanted. In 1983, the crackbandmodel was introduced with which the problem of mesh-size dependancy could be prevented. With this model, the energy dissipation will be directly linked to a regularised fracture energy G / h of the material. This regularization of the fracture energy takes place through the introduction of a so-called crackband width parameter. While the fracture

energy G itself can be seen as a material characteristic, the crackband width h is a finite element discretization characteristic, of which an estimate should be made in advance. Partly due to the simple concept and the facility it can be implemented in the standard EEM – codes use a lot of EEM – packages this crackband width. The way in which the crackband width h a priori is estimated, can differ. It is evident that a good estimation is necessary for a correct energy consumption of the numeric model. From results of non-linear analysis, it has been shown that the highness of the value for G / h can be of influence on the highness of the failure load and even the failure mode of the finite element model.
In DIANA, the default-value for h is dependent on the type of element and on the surface / volume and interpolation function of the element. In this lecture, an improved a priori estimation of the crackband parameter h will be proposed, of which among other things the direction of the crack relative to element edges will be taken.

4. Financial aspects 2011

DIANA Ontwikkelingsvereniging

Balans behorend bij financiëel jaarverslag 2011

	31 december 2011		31 december 2010	
ACTIVA				
VASTE ACTIVA	€ 0		€ 0	
		€ 0		€ 0
VLOTTENDE ACTIVA				
Vorderingen (debiteuren)	€ 272		€ 284	
Liquide middelen	€ 36.780		€ 35.431	
Transitoria	€ 0		€ 0	
		€ 37.052		€ 35.715
TOTAAL ACTIVA		€ 37.052		€ 35.715
PASSIVA				
EIGEN VERMOGEN	€ 36.045		€ 35.043	
		€ 36.045		€ 35.043
KORTLOPENDE SCHULDEN				
Transitoria (crediteuren)	€ 1.007		€ 672	
		€ 1.007		€ 672
TOTAAL PASSIVA		€ 37.052		€ 35.715

Winst- en verliesrekening behorend bij financiëel jaarverslag 2011

	2011	
Netto omzet	€ 4.913 +	
Kostprijs van de omzet	€ 1.852 –	
BRUTO OMZETRESULTAAT		€ 3.061
Personeelskosten	€ 2.070 –	
Algemene beheerskosten	€ 686 –	
Financiële baten	€ 698 +	
Financiële lasten	€ 0 –	
RESULTAAT UIT GEWONE BEDRIJFSVOERING		€ 1.001
Buitengewone baten en lasten	€ 0 +	
RESULTAAT		€ 1.001

Penningmeester DOV:	Accordering kascommissie:	
	handtekening:	handtekening:
	naam: Sander Meijers	naam: Oslar Joostensz
Nynke Vollema opgemaakt 19 mei 2012	datum: 6 juni 2012	datum: 05 juli 2012

5. Publication list 2011

TNO Earth, Environmental and Life Sciences

Orlic B., ter Heege J., Wassing B.B.T. (2011). Assessing the short-term and long-term integrity of top seals in feasibility studies of geological CO2 storage. Proc. of the 45th US Rock Mechanics / Geomechanics Symposium (ARMA), San Francisco. Paper no ARMA 11-375.

Giger S.B., Clennell M.B., Harbers C., Clark P., Ricchetti M., Ter Heege J.H., Wassing B.B.T, Orlic B. (2011). Design, operation and validation of a new fluid-sealed direct shear apparatus capable of monitoring fault-related fluid flow to large displacements. International Journal of Rock Mechanics & Mining Sciences. Vol. 48, 1160-1172.

Wassing B.B.T., Orlic B., Leeuwenburgh O., Geel C.R. (2011). 3D geomechanical modelling of fault stability in the Bergermeer field during undergound gas storage operations. TNO report TNO-060-UT-2011-01388/C (confidential report).

Orlic B., Ter Heege J. (2011). Reservoir-caprock-overburden deformation and effects on caprock integrity. CATO-2 Deliverable WP3.03-D10 (confidential report).

TNO

Van Overbeek A.B.M., Noordijk L., Burggraaf H.G., Stadsbrug Nijmegen - Eenvoudige berekening van temperatuursverdeling in vork en tuien bij 100 MW vrachtwagenbrand, TNO-060-DTM-2010-03799, TNO, Delft, January 2011 (Confidential report).

Borsje H., Burggraaf H.G., Hartog J., Onderzoek naar de oorzaak van het ongeval op de B-toren te Rotterdam - Deelrapport D: Constructieve beoordeling van de ondersteuningsconstructie, TNO-060-DTM-2011-01870, TNO, Delft, June 2011.

Burggraaf H.G., Gijsbers F.B.J., Vervuurt A.H.J.M., Van der Veen C., Controle tussendwarsdrager Brug over de Oude Weg (KW 10H-101) op basis van een 3D-eindige elementenanalyse in DIANA, TNO-060-DTM-2011-02358, TNO, Delft, July 2011.

Burggraaf H.G., Steenbergen H.M.G.M., Structural appraisal of ceiling substructures, TNO-060-DTM-2011-03240, TNO, Delft, September 2011 (Confidential report).

Abspoel-Bukman L.M., Burggraaf H.G., Maljaars J., Sterkte berekeningen aan Flare Stack 1 en 2, TNO-060-DTM-2011-04042, TNO, Delft, December 2011 (Confidential report).

Koopman A., Galanti F.M.B, Burggraaf H.G., Spoor door Goes: studie naar effectiviteit van een betonnen spoorbak op maaiveld als trillingsreducerende maatregel, TNO-060-DTM-2011-02597, TNO, Delft, December 2011.

TNO DIANA BV

Rahman T., Jansen E. and Gürdal Z. Dynamic buckling analysis of composite cylindrical shells using a finite element based perturbation method. Nonlinear Dynamics, 66(3), 389-401. (2011).

Rahman T., Jansen E.L., Tiso P. A Finite element-based perturbation method for nonlinear free vibration analysis of composite cylindrical shells. International Journal of Structural Stability and Dynamics, Vol. 11, No. 3 (2011) 1_18.

Rahman T., IJsselmuiden S.T., Abdalla M.M., Jansen E.L. Post buckling analysis of variable stiffness composite plates using a finite element-based perturbation method. International Journal of Structural Stability and Dynamics, Vol. 11, No. 3 (2011) 1_19.

Schreppers G.J. and Lilliu, G. Prediction of swelling due to Aar in Kariba Dam XI ICOLD Benchmark workshop on numerical analysis of dams. Valencia, October 20-21, 2011.

El-Kadi O., Elkadi A.S.K. Constructing Load Transfer Q-z and T-z Curves from Pile Loading Test for 3D FE Analysis. International Conference on Advances in Geotechnical Engineering, 7th - 9th November, 2011 - Perth, Australia.

Lilliu G., Meda, A. Fire Analysis of RC precast segmental tunnels. Application of Structural Fire Design, 29 April 2011, Prague, Czech Republic.

Ucci M., Camata G., Spacone E., Lilliu G., Manie J., Schreppers G.J. Nonlinear soil-structure interaction of a curved bridge on the Italian Tollway A25. Proceedings of the 8th International Conference on Structural Dynamics, EURODYN 2011. Leuven, Belgium, 4-6 July 2011.

Chalmers University

Zandi Hanjari K., Kettil P., Lundgren K. Analysis of Mechanical Behavior of Corroded Reinforced Concrete Structures, ACI Structural Journal, 108 (5), 2011, p. 532-541.

Zandi Hanjari K., Coronelli D., Lundgren K. Bond capacity of severely corroded bars with corroded stirrups, Magazine of Concrete Research, 63 (12), 2011, p. 953-968.

Zandi Hanjari K., Kettil P., Lundgren K. Modelling the structural behaviour of frost-damaged reinforced concrete structures, Structure and Infrastructure Engineering, DOI: 10.1080/15732479.2011.552916, Available online: 07 Mar 2011.

Zandi Hanjari K., Lundgren K., Plos M., Coronelli D. Three-dimensional modelling of structural effects of corroding steel reinforcement in concrete, Structure and Infrastructure Engineering, DOI:10.1080/15732479.2011.607830, Available online: 24 Aug 2011.

Zandi Hanjari, K., Lundgren, K., Plos, M., Gylltoft, K. Corroded reinforced concrete structures: effects of high corrosion and corroded stirrups, Proceeding of XXI Nordic Concrete Research Symposium, ISBN/ISSN:
978-82-8208-025-5 / 0800-6377, number 43, 2011, p. 179-182.

Delft University of Technology

Cecilia Damoni, Joop A. den Uijl, Max A.N. Hendriks, Beatrice Belletti, "Optimization of NLFE settings for evaluation of shear compression resistance", in proceedings of fib Symposium PRAGUE 2011, pp 147-150.

Arthur T. Slobbe, Max A.N. Hendriks, Jan G. Rots, "Sequentially Linear Analysis of Shear Critical Reinforced Concrete Beams", in proceedings of fib Symposium PRAGUE 2011, pp 215-218.

R. Esposito, M.A.N. Hendriks, G. Lilliu, G.M.A. Schreppers, "Numerical Simulation of Concrete Structure Affected by AAR: The Case Study of Kariba Dam", XI ICOLD Benchmark Workshop on Numerical Analysis of Dams, Valencia, Spain, 20-21 October 2011.

J.G. Rots and M.A.N. Hendriks, "Current and Future Issues in Sequentially Linear Analysis of Brittle Structural Behaviour", Proceedings of the II international conference on computational modeling of fracture and failure of materials and structures, CFRAC 2011, J. Oliver, M. Jirasek, O.Allix, N. Moës (Eds), Barcelona, June 6-8, 2011, 262.

A.T. Slobbe, M.A.N. Hendriks and J.G. Rots, "Analyzing Shear Critical RC Beams with Sequentially Linear Analysis Including a Spatial and Orientation Dependent Crack Band Model", Proceedings of the II international conference on computational modeling of fracture and failure of materials and structures, CFRAC 2011, J. Oliver, M. Jirasek, O.Allix, N. Moës (Eds), Barcelona, June 6-8, 2011, 259.

Jan G. Rots, Max A.N. Hendriks, "Sequentially linear versus nonlinear analysis of rc structures", Proceedings of the International Conference on Recent Advances in Nonlinear Models - Structural Concrete Applications CoRAN 2011, H. Barros, R. Faria, C. Pina and C. Ferreira (Eds), Coimbra,24-25 November 2011, pp 91-100.

Beatrice Belletti, Cecilia Damoni, Max A.N. Hendriks ,"Linee guida olandesi per l'analisi non lineare ad elementi finiti di strutture in c.a.e c.a.p.: alcune indicazioni per la verifica agli stati limite di elementi inflessi", Structural Modeling (magazine di ingegneria strutturale), 3, 2011, 10-12.

Beatrice Belletti, Cecilia Damoni, Max A.N. Hendriks ,"Linee guida olandesi per l'analisi non lineare ad elementi finiti di strutture in c.a.e c.a.p. caratterizzate da rottura per taglio-compressione", Structural Modeling (magazine di ingegneria strutturale), 4, 2011, 9-11.

E. Verstrynge, L. Schueremans, D. Van Gemert, M.A.N. Hendriks, "Modelling and analysis of time-dependent behaviour of historical masonry under high stress levels", Engineering Structures, 33, 2011, 210-217.

S. Invernizzi, D. Trovato, M.A.N. Hendriks, A.V. van de Graaf, "Sequentially linear modelling of local snap-back in extremely brittle structures", Engineering Structures, 33, 2011, 1617-1625.

B. Belletti, M. Hendriks, C. Damoni, "Development of guidelines for nonlinear finite element analyses of existing reinforced and pre-stressed beams", European Journal of Environmental and Civil Engineering, 15, 2011, 1361-1384.

Eindhoven University

L.J. van der Meer, D.R.W. Martens, A.T. Vermeltfoort (2011). Finite element modelling of unreinforced and post-tensioned shear wall assemblies. In: Proceedings of the 9th Australasian Masonry Conference, Queenstown, New Zealand, 15-18 February 2011, ISBN 978-0-473-18069-0, pp 135-144.

Rijkswaterstaat, Delft University of Technology and TNO

Raphael D.J.M. Steenbergen, Ane de Boer, Cornelis van der Veen, “Safety assessment of existing concrete slab bridges for shear capacity”, ICASP 2011, Zurich, Zwitserland

Rijkswaterstaat, Delft University of Technology, University of Parma

Ane de Boer, Beatrice Belletti, Max Hendriks, "NL-FEA Guideline for concrete girder analysis", NAFEMS World Congress 2011, Boston, USA, 2011

Rijkswaterstaat, Delft University of Technology

Ane de Boer, Joop den Uijl, Max Hendriks, "NL-FEA Guideline for concrete girder analysis", Nordic Seminar Gothenborg Sweden Nov 2011

ir. Joost Kooiman, dr.ir. C. van der Veen, dr.ir. Ane de Boer, “Herberekening voorgespannen massieve plaatbrug”, Cement 2011/3

Rijkswaterstaat

Ane de Boer, ”Strengthening large concrete box-girder bridge on shear”, Friedberg, Hessen, Germany

Ane de Boer, “Method CRIAM”, Concrete Repair event, Assen Nov 2011

6. Memberslist

Ingenieursburo Zonneveld BV
t.a.v. J.P. van der Windt
Max Euwelaan 23
3062 MA Rotterdam
windt@zonneveld-rotterdam.nl

Deltares
t.a.v. J.A.M. Teunissen
Postbus 177
2600 MH Delft
j.a.m.teunissen@deltares.nl

Rijkswaterstaat Dienst Infrastructuur
t.a.v. A. de Boer
Postbus 20.000
3502 LA Utrecht
ane.de.boer@rws.nl

TU Delft
Faculteit CITG
t.a.v. C. van der Veen
Postbus 5048
2600 GA Delft
c.vanderveen@tudelft.nl

TU Eindhoven
Faculteit Bouwkunde
t.a.v. L. van der Meer
Postbus 513
5600 MB Eindhoven
L.J.v.d.Meer@tue.nl
Royal HaskoningDHV
t.a.v. S. Meijers
Postbus 93059
2509 AB Den Haag
Sander.meijers@rhdv.com

Shell Int. Exp. and Prod. B.V.
t.a.v. P. Fokker
(RIJ-KES ZA015B)
Postbus 60
2280 AB Rijswijk
Peter.Fokker@shell.com

ABT
t.a.v. ing. A.A. van den Bos
Postbus 82

6800 AB Arnhem
a.vd.bos@abt.eu

Royal HaskoningDHV
t.a.v. D.J. Peters
Postbus 8520
3009 AM Rotterdam
dirk.jan.peters@rhdhv.com

Witteveen+Bos
t.a.v. F. Kaalberg
Postbus 233
7400 AE Deventer
frank.kaalberg@nzlijn.nl

TNO
t.a.v. H. Burggraaf
Postbus 49
2600 AA Delft
Henco.burggraaf@tno.nl

TNO Earth, Environmental and Life Sciences
Sustainable Geo Energy
t.a.v. B. Orlic
Postbus 80015
3508 TA Utrecht
Bogdan.Orlic@tno.nl

TU Delft
Faculteit Bouwkunde
t.a.v. A. Borgart
Berlageweg 1
2628 CR Delft
a.borgart@tudelft.nl
Montan University Leoben
Attn. Prof. H. Harmuth
Franz-Josef Strasse 18
A-8700 Leoben, Austria
Harald.harmuth@unileoben.ac.at

TU Delft
Faculteit CITG
t.a.v. J.G. Rots
Postbus 5048
2600 GA Delft
j.g.rots@tudelft.nl

NTNU Faculty of Engineering Science and Technology
Attn. K.V.Høiseth
Department of Structural Engineering

7491 Trondheim, Norway
Karl.hoiseth@ntnu.no

Arcadis BV
t.a.v. C. van der Vliet
Postbus 220
3800 AE Amersfoort
Coen.vandervliet@arcadis.nl

Corresponderende leden:

TNO DIANA BV
t.a.v. G.J. Schreppers
Schoemakerstraat 97
2628 VK Delft

TNO DIANA BV
t.a.v. G. Lilliu
Schoemakerstraat 97
2628 VK Delft

TNO DIANA BV
t.a.v. W.P Kikstra
Schoemakerstraat 97
2628 VK Delft

ABT
t.a.v. O. Joostensz
Postbus 82
6800 AB Arnhem
O.Joostensz@abt.eu