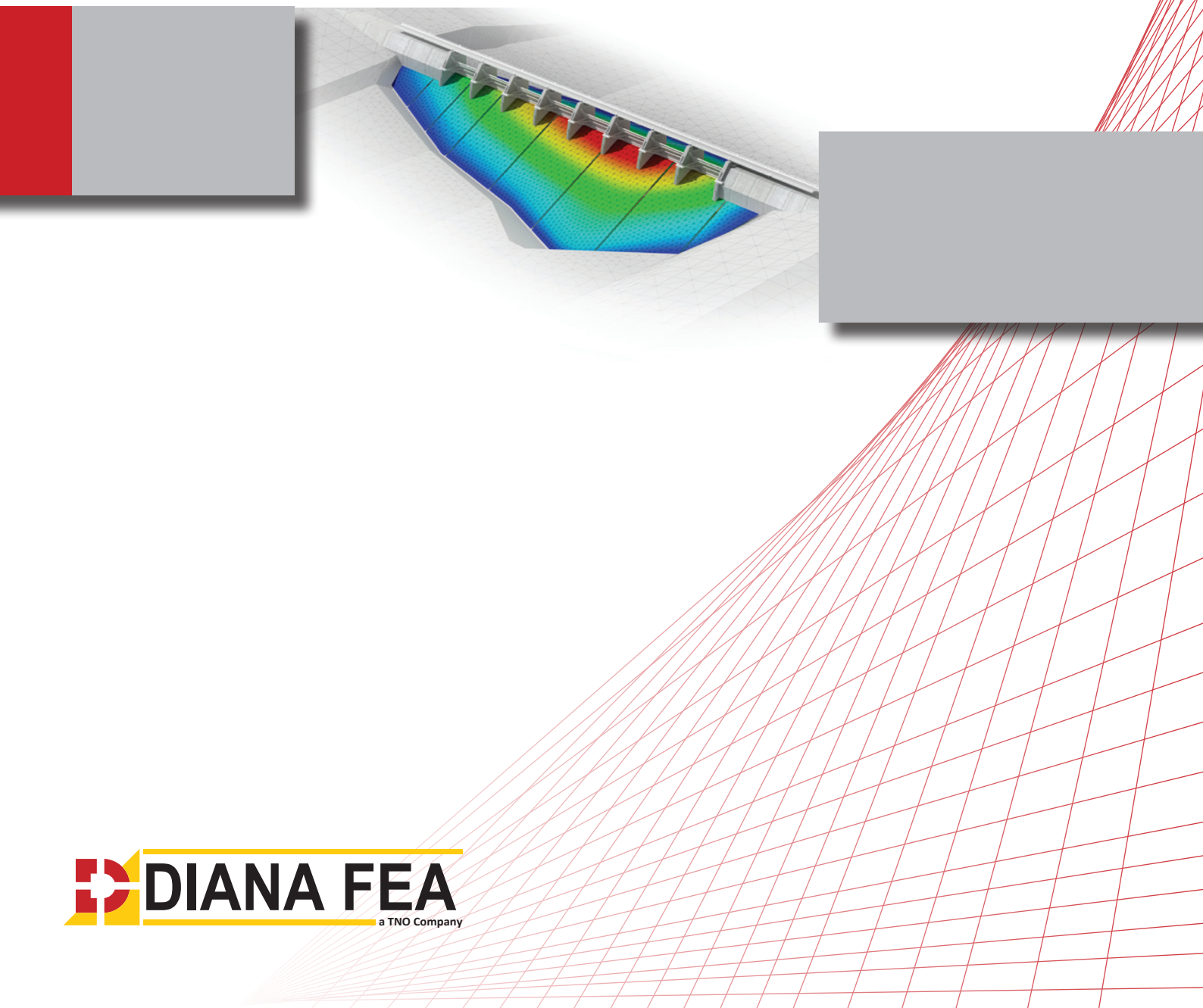


DIANA

SOLUTIONS FOR DAMS & DIKES



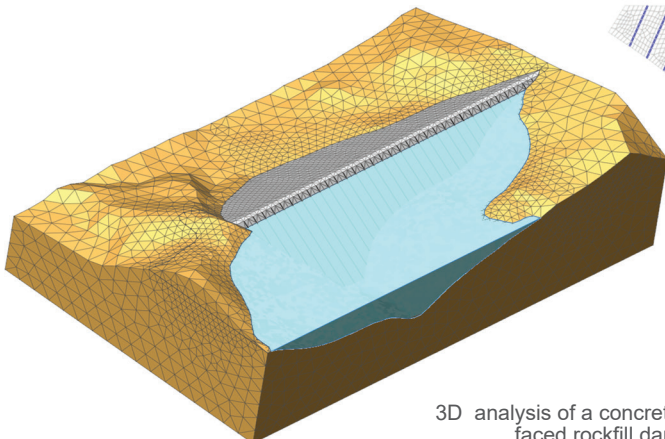
DIANA (Displacement ANALyzer) is an extensive multi-purpose finite element software package that is dedicated, but not exclusive, to analysis of a wide range of problems arising in civil and oil & gas engineering including structural, geotechnical, tunnelling, and earthquake engineering disciplines.

DIANA development started in 1973 at the Department of Computational Mechanics of TNO (Netherlands Organisation for Applied Research). In the 1980s, DIANA was made commercially available and since then is distributed worldwide among universities, research organisations and engineering companies. In 2003, the department of computational mechanics of TNO became a wholly owned subsidiary of TNO, with the name TNO DIANA BV and in 2016 this, in turn became DIANA FEA BV.

Analysis of Dams is one of the specialties of DIANA for its extensive library of material models and analysis capabilities that are suited for this purpose, e.g. phased (staged) construction, soil-structure and fluid-structure interaction, user supplied material models, large range of interface models, large displacement and large strain analyses, material non-linearity, time and ambient dependency effects, and nonlinear dynamic analysis. Furthermore, the program is structured such that all different analyses can be performed in one analysis command sequence. For this reason we are very proud to say that DIANA offers an **“all in one solution”** for the analysis of dams.

Dynamic Analysis of Dams

- Direct frequency analysis, modal response analysis, and spectral response analysis, with fluid-structure interaction
- Linear and nonlinear time domain analysis with a wide choice of time integration schemes
- Hybrid frequency-time domain analysis, with possibility to include compressibility of the fluid and bottom absorption
- Multi-directional acceleration loads
- Viscous, structural and continuous damping
- Specified or calculated initial conditions



3D analysis of a concrete faced rockfill dam

Analysis of Earth and Rockfill Dams

Material models

- Mohr-Coulomb and Drucker-Prager
- Tresca and Von Mises
- Modified Mohr-Coulomb (double-hardening)
- Hoek-Brown and Jointed-rock
- Modified Cam-Clay
- Jardine (London Clay)
- Nonlinear elasticity (Duncan-Chang)
- Discrete cracking with interface elements (inc. Janssen model)
- Smeared crack models with fixed and rotating cracks
- Material aging
- Liquefaction

Analysis features

- Fully coupled consolidation
- Saturated and partially saturated soils
- Steady-state and transient ground-water flow
- Drained/undrained soil
- Phased analysis
- Nonlinear analysis

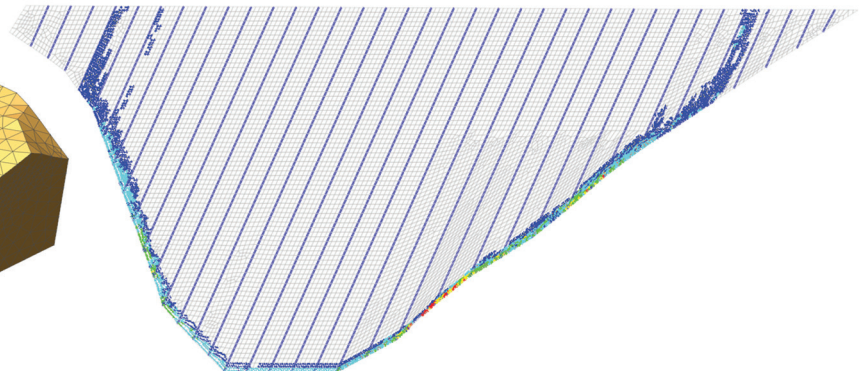
Analysis of Concrete Dams

Material models

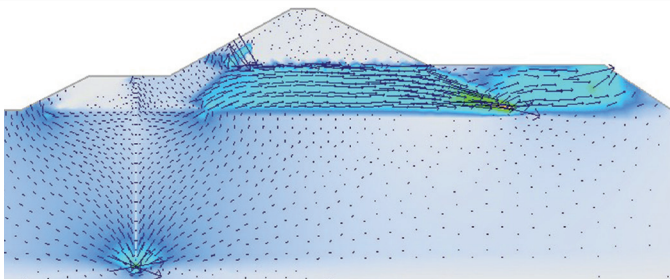
- Linear, nonlinear and hyper elasticity
- Mohr-Coulomb and Drucker-Prager
- Multi-directional fixed crack model
- Total strain crack models
- Several models for joints
- Viscoelasticity
- Shrinkage
- Linear elastic and plastic reinforcements
- User-supplied materials

Analysis features

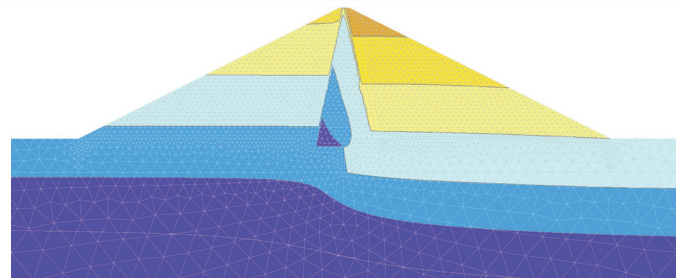
- Coupled thermo-stress analysis
- Young hardening concrete behaviour also with cooling
- Time, temperature and maturity dependency
- Discrete and smeared crack analysis
- Dedicated post-processing of crack patterns



Crack pattern in the slab of a CFRD



Seepage analysis of an earth filled dam during service



Seepage analysis of a clay core dam during rapid drawdown

General Product Functionality

Element types

- Truss
- Timoshenko, Bernoulli, and Mindlin beam
- Plane stress and plane strain
- Complete/general plane strain
- Axisymmetric
- Plate bending
- Flat, curved and layered shells
- Solid
- Composited (line/surface)
- Interface
- Contact
- Discrete spring/dashpot
- Base spring
- Bounding
- Point mass/damping
- Embedded reinforcements
- Flow
- Embedded pile
- Boundary surface
- Perfectly matched layers (PML)

Preprocessing

- CAD like geometry modelling functionality
- Parasolid built-in tools
- Import CAD/Revit file formats
- Python scripting
- Advanced selection methods
- Advanced geometry modelling
- Boolean operation for solid modelling
- Auto clash detection
- Geometry check and repair tools
- Practical mouse snapping
- Auto-, map- and protrude-mesh methods
- Hybrid mesher
- Mesh manipulation and check functionality
- Loads and boundary conditions applicable both on geometry or mesh
- Function based definition of loads and boundary conditions
- MS-Excel compatible tables

Postprocessing

- Contour and vector plots
- Iso-surface, slice, clipping and partition plot
- Diagram and vector plot
- Results extraction to MS-Excel compatible table
- Screen-shots in different picture formats
- Result animation
- Automatic report generation

Solution procedures

- Automatic solver selection
- Out-of-core direct equation solvers
- Nonlinear equation solvers
- Automatic substructuring
- Eigenvalue analysis
- Newton-Raphson, Quasi-Newton, Linear and Constant stiffness iterative procedures
- Load and displacement control incremental procedures
- Arc length control incremental procedure
- Adaptive load and time increments
- Automatic incremental loading
- Direct, iterative and eigen solvers with parallel processing
- Updated and total Lagrange geometrical nonlinear formulation

Services

Support & training

Successful finite element modelling requires sound understanding of the background theory with good engineering judgment. We at DIANA FEA BV, together with our partners, are dedicated to provide the highest level of service for DIANA:

- Personalised hotline and Email support by highly qualified staff
- Customised training solutions
- Regular training courses
- Extensive technical and theoretical manuals
- Online training sessions

Analysis consultancy

DIANA FEA BV offers to carry out analysis consultancy projects on behalf of their clients which includes the analysis with DIANA and the interpretation of results

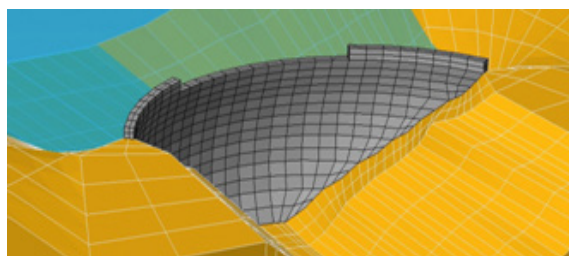
Software services

DIANA FEA BV Consultants and software development team can provide customised solutions for your engineering problems:

- Specialised software with dedicated GUI
- New modelling capabilities development and implementation
- Integration with customer software



3D Dynamic analysis of a concrete arch dam



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DIANA FEA BV

Delftechpark 19a

2628 XJ Delft

The Netherlands

+ 31 (0) 88 34262 00 (T)

+ 31 (0) 88 34262 99 (F)

(Headquarters)

WWW.DIANAFEA.COM