



**PFC<sup>2D</sup>** (Particle Flow Code in 2 Dimensions) and **PFC<sup>3D</sup>** (Particle Flow Code in 3 Dimensions) are discontinuum codes used in analysis, testing, and research in any field where the interaction of **many discrete objects** exhibiting **large-strain and/or fracturing** is required.

**PFC version 4.0 includes** a version (in addition to the 32-bit version) that is operable on a 64-bit processor computer running the Windows XP X64 operating system. The **64-bit version** will allow a virtually unlimited model size.. The **improved FishTank library** produces a synthetic material consisting of grains and cement. Arbitrarily shaped grains are produced by creating **clumps**, and distinct material and refinement regions can be specified with their own sets of micro properties and grain-size parameters. The **new smooth-joint contact model** can be used to simulate the behaviour of an interface regardless the particle contact orientations along the interface allowing jointed material to be modelled, as done in *UDECI/3DEC software*. A **new fluids modelling** capability is available by coupling **PFC3D** to the **CCFD** (Coupled Computational Fluid Dynamics) code that computes fluid flow through arbitrarily-shaped volumes. Last but not least, a **compiled help file** is now available on the "Help" menu in *PFC2D/PFC3D*.

## ■ FIELDS OF APPLICATIONS

**PFC** can be used to perform complex studies in a broad range of problems in **Civil Engineering, Material Science, Process Engineering, Food and Chemical Industries.**

- Analysis of damage and failure of rocks and cohesive materials subjected to mechanical, thermal or hydraulic loadings.
- Modelling of flow of granular materials in the contexts of landslides, material transport ... Study of particle trajectories with respect to mechanical and geometrical properties
- Analysis of cyclic and static fatigue, in the short and long terms (creep)
- Design of appropriate tools for mixing and separation of granular materials
- Optimization of powder compaction processes and of the ejection of the final product
- Study of phenomena that lead to crushing and disintegration of materials

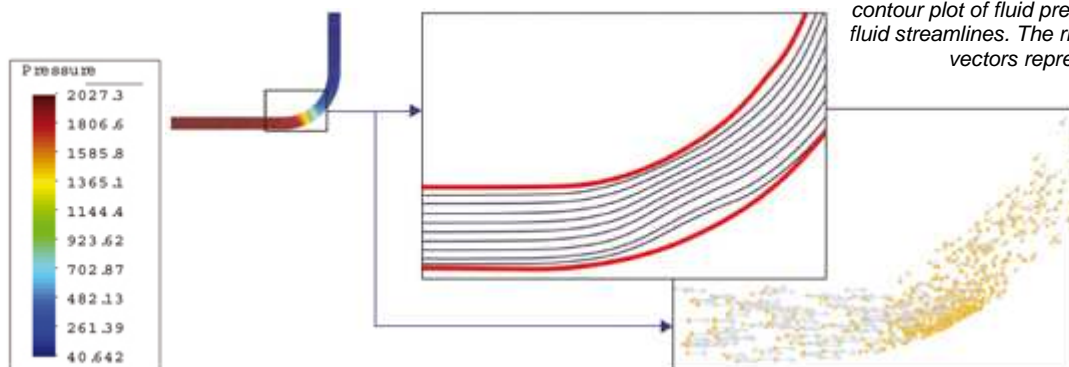
## ■ GENERAL FEATURES

### METHODOLOGY

**PFC models the dynamic motion and the interaction** of a system of **rigid balls** that can deform locally at contact points. Independent particles can be defined to model granular materials (sand and gravels). Besides, particles may be **linked to one another in clumps** to simulate solid materials (concrete, rock) in which fractures develop when the adhesion or the cementation between particles progressively disappear.

### CONSTITUTIVE ELEMENTS

- **Particle** : arbitrarily sized disk or sphere.
- « **Clump** » : unbreakable assembly of particles, with any non-uniform shape.
- « **Cluster** » : assembly of bonded particles with a non-uniform shape. In contrast with clumps, clusters are breakable.
- **Wall** : planes or curves (2D) ; planar, cylindrical, conic or spiral forms (3D) that allow the modelling of complex geometries or the application of boundary conditions.
- **Joints** : elements used to automatically generate fractures in a rock mass.
- « **Pbrick** » : from v3.1, PFC allows continuum and discontinuum models (AC/DC : Adaptive Continuum/Discontinuum Code).to be coupled directly, by using « Periodic Brick ».



*Particles conveyed along a pipe with a 90° bend. The leftmost figure shows the pipe geometry along with a contour plot of fluid pressure. The centre figure shows the fluid streamlines. The right a shows the PFC particles with vectors representing particle velocity.*

## CONTACT MODELS

Several contact models are built-in *PFC*. They can be used **on all contacts or on part of them**.

- **Contact-stiffness** models (linear and Hertz-Mindlin)
- **Slip** model
- **Viscous damping** contact model
- **Bonding** models
- **Alternative** models
  - **Simple viscous** model
  - **Simple ductile** model
  - Displacement-**Softening** model
  - **Hysteretic** damping model

Possibility to **develop one's own constitutive models in C++** (*available as an option*). This significantly **reduces computation times** when compared to a classical Fish programming. The user can also access constitutive models developed by other PFC users ; they are available on our web site <http://www.itasca-udm.com/>.

## INITIAL AND BOUNDARY CONDITIONS

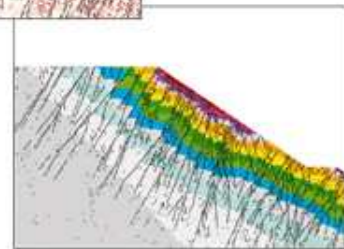
**Velocities, forces and stresses** can be applied to part or all of the model by means of *PFC* commands or pre-defined Fish functions.

## LOADING

- **Mechanical**: simulation of an excavation, a displacement or a stress field, a surface load ...
- **Dynamic**: simulation of an earthquake or an explosion.
- **Creep**: simulation of the fatigue of materials (contacts) subjected to static loading by means of changes in micro-mechanical properties.
- **Thermal** (*option*): simulation of transient heat conduction in materials and the development of thermally-induced displacements and forces that may result in damage or failure of the material.
- **Hydraulic** (*option*): simulation of particle-incompressible fluid interaction by means of a two-way coupling: flow forces controlled by the pressure gradient are applied to particles and the variation of porosity induced by the displacement of particles modifies the pressure gradient.



*Rock stability analysis: Joints which have undergone normal (red) and shear (black) strain and the resulting horizontal particle displacement (depicted as distinct colors) display a clearer image of the toppling failure mechanism*



## FISH MACRO-LANGAGE

All ITASCA codes possess the built-in programming language *FISH* that allows users to customize their analyses to suit their needs. Loading patterns, servo-control of test conditions and model generation sequences may be defined using *FISH*.

## INTERNATIONAL RECOGNITION

ITASCA Consultants, an expert in numerical modelling, offers a new vision of numerical solutions thanks to its know-how and its software solutions. At the crossroads of consulting and Research & Development, Itasca Consultants provides computer modelling solutions for both the public sector and consulting firms.

## ASSISTANCE

Installation and general codes operations are provided for free by phone, fax or email. Web site support ([www.hcitasca.com](http://www.hcitasca.com)) includes free codes updates and a « Frequently Asked Questions » (FAQ) page.

Training courses, general or tailored to users' needs, are regularly organized by ITASCA. Do not hesitate to contact us.

As provider of consulting services, ITASCA provides tailored help to solve technical problems and write specific procedures.



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