FLOOD RISK IN CASE OF YESA'S DAM BREAK

Lorenzo Gracia Llinares

CIMNE / Universidad Politécnica de Cataluña

November 11, 2015

Motivation

Tous (1982) and Vajont (1963)

Index

1. Introduction and Matemathical Foundations

- Incompressible Navier Stokes 3D for Isotropic Newtonian fluids

$$\partial_t \mathbf{u} + (\mathbf{u} \cdot \nabla)\mathbf{u} - \nu \Delta \mathbf{u} + \nabla p = \mathbf{f}$$

$$\nabla \cdot \mathbf{u} = 0$$

- Kolmogorov Theory (1941)
  - It allows to obtain estimations of the scales necessary for the discretization of the problem

1. Introduction and Matemathical Foundations

- Example of Kolmogorov Theory (1941)

$$\nu = \frac{l_0}{Re^{3/4}} \qquad \tau = \frac{\tau_0}{Re^{1/2}}$$

  where l_0 is the characteristhic length, ν is the smallest space scale, Re is the Reynolds Number, τ_0 is the charactheristic time and, τ is the smallest time scale

  - Using l_0=1 m and τ_0=1 seg, finally we obtain;

$$N = Re^{11/4}$$

  For a hydraulic problem, an usual value for the Reynolds number can be of order to 10^6 then the needed number of nodes would be 10^{16}

1. Introduction and Matemathical Foundations

- Simplifications of Navier Stokes Equations
  - Study of turbulent flux $\Rightarrow$ Application of Reynold's Theory

$$u = \overline{u} + u'$$

where $\overline{u}$ is the average variable and u' is the turbulent fluctuation.

$$\overline{u} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} u dt$$

  - Depth integration

$$u = \frac{1}{h} \int_{z_0}^{z_0+h} \overline{u} dz$$

1. Introduction and Matemathical Foundations

- Saint Venant 2D
  - Neglecting Coriolis effect (not important in rivers)
  - Applying Leibnitz rule derivation under the integral sign
  - Finally we obtain

$$\frac{\partial h}{\partial t} + \frac{\partial (hu)}{\partial x} + \frac{\partial (hv)}{\partial y} = 0$$

$$\frac{\partial (hu)}{\partial t} + \frac{\partial}{\partial x}(hu^2 + g\frac{h^2}{2}) + \frac{\partial (huv)}{\partial y} = gh(S_{0x} - S_{fx})$$

$$\frac{\partial (hv)}{\partial t} + \frac{\partial (huv)}{\partial y} + \frac{\partial}{\partial y}(hv^2 + g\frac{h^2}{2}) = gh(S_{0y} - S_{fy})$$

2. Software IBER

- 2D Dimensinal Analysis through Saint Venant 2D
- Finite Volumes in 2D
- GID Interface
- Non-linear Hyperbolic System $\Rightarrow$ Roe Scheme

3. Case of Analysis

Yesa's Dam

Source: Jose Miguel Marco (Heraldo de Aragón)

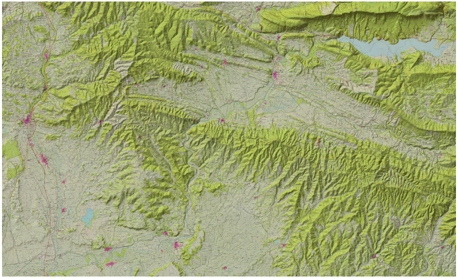
3. Case of Analysis

- Yesa's Dam and Reservoir
  - Gravity dam (480.000 m^3 of concrete)
  - Crest length: 398 m
  - Capacity: 446.90 hm^3
  - Area: 2098 ha
  - Area of basin: 2170 Km^2

Ubication of Yesa's Dam

3. Case of Analysis

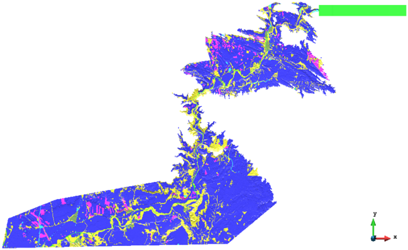
- Input Data
  - MDT 25x25 (ASCII format)
  - A file of land use (SIOSE 2005)
  - Characteristhic curve of the reservoir



Topographic map of study area

3. Case of Analysis

- Mesh and Roughness
  - A structured triangular mesh
  - Size element: 200
  - Number of elements: about 1.000.000



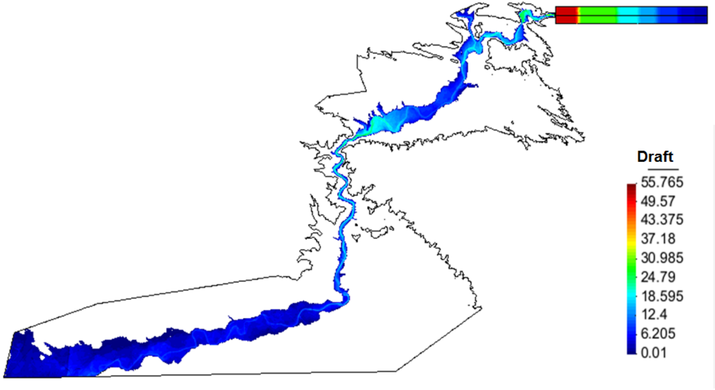
Manning map

3. Case of Analysis

- Break according ICOLD
  - Duration: 24 hours
  - Partially breach, 1/3 of the whole body
  - Time of breakage: 900 seg

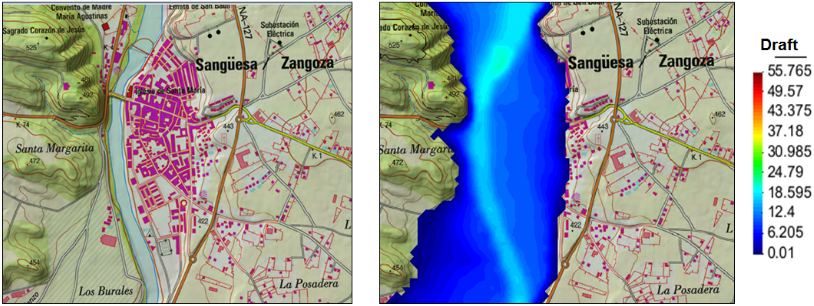
4. Results

- Maximum drafts



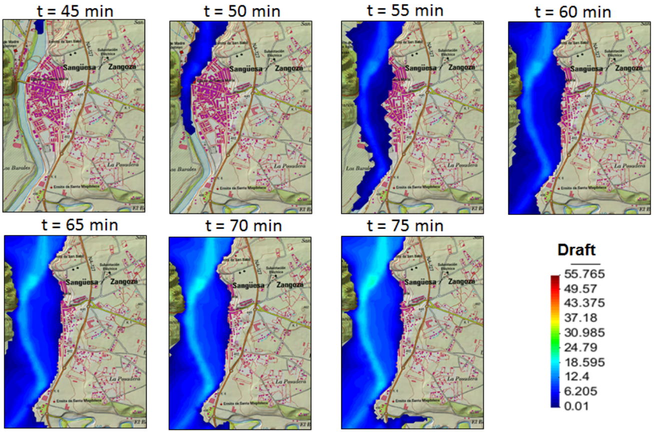
4. Results

- Sangüesa's drafts



4. Results

- Evolution in time of Sangüesa's drafts



5. Conclusions

- Critical situation for Sangüesa's village in case of break, necessity of an evacuation plan for the population
- Some phenomena are not taken into account since we are using Saint Venant 2D, but in the case of this study, for instance, turbulence can be neglected
- Related with the simulation, this software provides accurate results but the computational cost for large areas of study are extremly high
- The obtained results are in consonance with the developed studies some years ago by Dr. Antonio Casas (*University of Zaragoza*)

THANK YOU FOR YOUR ATTENTION!