Open Channel Hydraulics Analysis Tool

Overview

This is HYDRAULICS_CODE.m, a MATLAB/GNU Octave script built to handle the heavy lifting of Open Channel Hydraulics analysis.

Instead of solving complex flow problems by hand, this tool uses iterative numerical methods (like fsolve and fzero) to crunch the numbers for you. Whether you are looking for flow depths, velocities, or energy states, this script covers a wide range of flow regimes and channel geometries.

It runs entirely in the **Command Line Interface (CLI)**. Think of it as a guided calculator: it asks you for inputs step-by-step, helping you model everything from simple normal flows to complex, rapidly varying structures like hydraulic jumps or bridge constrictions.

Key Features

The program is divided into three primary calculation modules:

1. Gradually Varying Flow (GVF)

Calculates water surface profiles over distance using the step method.

- **Regime Detection:** Automatically determines if flow is Subcritical (Mild Slope), Supercritical (Steep Slope), or Critical.
- **Profile Calculation:** Computes the distance required to reach a target depth from an initial depth.
- **Iterative Solving:** Uses step-wise integration of the dynamic equation of gradually varying flow.

2. Normal Flow (Uniform Flow)

Solves for normal depth (y_n), critical depth (y_c), and Froude number (Fr) for various channel cross-sections.

- **Supported Geometries:**
  - Rectangular
  - Triangular
  - Trapezoidal (Chezy or Manning input)
  - Circular
  - Composite Shapes (Triangle, Semicircle)
- **Outputs:** Normal depth, Critical depth, Critical Slope (S_c), Specific Energy (E_c).

3. Rapidly Varying Flow (RVF) & Hydraulic Structures

Analyzes local phenomena where flow characteristics change rapidly. This module utilizes the **Momentum Equation** and **Specific Energy** principles to solve for:

- **Weirs:** Broad-crested weir analysis, calculating upstream/downstream depths and checking for modular limits.
- **Channel Constrictions:** Analyzes choking conditions and critical depth transitions.
- **Expansions:** Calculates downstream depth after sudden channel expansion.
- **Sluice Gates:** Computes force on the gate, energy dissipation, and locations of hydraulic jumps.
- **Bridges:** Analyzes flow through bridge piers and checks for choking/backwater effects.
- **Energy Dissipators (Blocks):** Calculates drag forces and depth changes due to baffle blocks.
- **Spillways:** Analyzes flow over spillways and subsequent downstream conditions.

Prerequisites

- **Software:** MATLAB or GNU Octave.
- **Toolboxes:**
    - If using **GNU Octave**, the `optim` package is required (for `fsolve` and `fzero`).
    - If using **MATLAB**, the Optimization Toolbox is standard.

Installation & Usage

1. **Download:** Ensure `HYDRAULICS_CODE.m` is in your working directory.
2. **Run:** Open MATLAB/Octave and execute the script: HYDRAULICS_CODE
3. **Navigation:** Follow the command prompt instructions. The menu system uses numerical inputs to select options.
    - *Example:* Enter `1` for GVF, `2` for Normal Flow, etc.

Input Parameters Guide

Ensure all inputs are in **SI Units** (Meters, Seconds, Cubic Meters).

Parameter	Symbol	Unit	Description
Discharge	Q	m^3/s	Total volumetric flow rate.

Manning's n	n	-	Roughness coefficient of the channel.
Slope	S	m/m	Longitudinal bed slope of the channel.
Width	b	m	Channel bottom width.
Depth	y or h	m	Flow depth.
Gravity	g	m/s^2	Hardcoded as 9.81.

Technical Implementation

Numerical Solvers

The script relies heavily on root-finding algorithms to solve implicit hydraulic equations (such as the Manning's equation for unknown depth):

- fzero: Used for single-variable non-linear equations.
- fsolve: Used for more complex non-linear systems or when initial guesses are required.

Mathematical Models

- **Manning's Equation:** For uniform flow calculations.
- **Froude Number (Fr):** Used to classify flow as Subcritical (Fr < 1), Critical (Fr = 1), or Supercritical (Fr > 1).
- **Specific Energy Equation:** E = y + (V^2)/(2g) used for transitions (humps, constrictions).
- **Momentum Equation:** M = Q^2/gA + z*A used for hydraulic jumps and external forces (drag).

Disclaimer

This code is intended for educational and analysis purposes. While it uses standard hydraulic engineering formulas, users should verify results against hand calculations or established hydraulic modeling software (e.g., HEC-RAS) for critical engineering designs.

Project developed for independent research into Computational Hydraulics.