

UK Hazard Mapping with MIKE FLOOD ECOLAB: Solving the Debris Factor Problem in 2D Hydraulic Modelling

Introduction

In the United Kingdom, there are currently two main sources for information on the Flood Hazard Ratings used to derive Flood Hazard Maps:

FD2320/TR2 – ‘Framework and Guidance for Assessing and Managing Flood Risk for New Development’ (Defra / Environment Agency, October 2005)

FD2321/TR1 – ‘Flood Risks to People Methodology’ (Defra / Environment Agency, March 2006)

The approaches in the two reports differ but the final Flood Hazard Rating formula is identical in both FD2320/TR2 and FD2321/TR1 reports. The Hazard Rating formula, based upon consideration of the direct risks to people exposed to floodwaters, is given as:

$$HR = d \times (v + n) + DF$$

where HR = Hazard Rating
d = depth of flooding (m)
v = velocity of floodwaters (m/s)
DF = Debris Factor
n = 0.5 (constant)

Both technical reports strongly recommend the use of an appropriate Debris Factor (see below).

The Environment Agency’s ‘Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1’ (May 2008) reconciles the information provided in the two technical reports. The document emphasises that the approach of FD2320/TR2 with regard to flood hazard mapping should be used, rather than the approach in FD2321/TR1.

Thresholds

Table 2 of the ‘Supplementary Note’ compares the thresholds for flood hazard rating from FD2320/TR2 and FD2321/TR1:

Thresholds for Flood Hazard Rating [HR = d x (v + n) + DF]		Degree of Flood Hazard	Description
FD2321/TR1	FD2320/TR2		
< 0.75	< 0.75	Low	Caution – “Flood zone with shallow flowing water or deep standing water”
0.75 – 1.25	0.75 – 1.25	Moderate	Dangerous for some – “Danger: Flood zone with deep or fast flowing water”
1.25 – 2.5	1.25 – 2.0	Significant	Dangerous for most – “Danger: Flood zone with deep fast flowing water”
> 2.5	> 2.0	Extreme	Dangerous for all – “Extreme danger: Flood zone with deep fast flowing water”

Table 01: Hazard to People (Ref: Table 2 of ‘Supplementary Note’)

Debris Factors

Table 3.1 of FD2321/TR1 suggests appropriate debris factors for varying depths, velocities and the dominant land use (see Table 02 below):

Depths, d (m)	Debris Factor (DF)		
	Pasture/Arable	Woodland	Urban
0 – 0.25	0	0	0
0.25 – 0.75	0	0.5	1.0
> 0.75 and/or $v > 2.0\text{m/s}$	0.5	1.0	1.0

Table 02: Guidance on debris factors for different flood depths, velocities and dominant land uses (Ref: Table 3.1 of FD2321/TR1)

Possibly due to some concern over the partial implementation of the recommended debris factors in FD2321/TR1, leading to the use of a debris factor equal to 0 in certain key outputs (specifically the Hazard to People Classifications presented in Figure 3.2 of FD2321/TR1), the approach presented in FD2321/TR1 is not currently recommended for general use.

To simplify the process, whatever the land use, FD2320/TR2 proposes a different debris factor as a function of floodwater depth only:

Depths, d (m)	Debris Factor (DF)
0 – 0.25	0.5
> 0.25	1.0

Table 03: Debris factors for different depths (Ref: Table 13.1 of FD2320/TR2)

This debris factor has been used in Table 13.1 of FD2320/TR2 to determine the currently accepted Hazard to People Classification.

Implementation of Debris Factors in Other 2D Hydraulic Models

Many 2D Hydraulic Modelling software packages employ simplified, but not necessarily conservative, methods in the production of Flood Hazard Maps. Although the general Hazard Rating formula is often used the Debris Factor can be set at zero, and ignored, or set at 1; either ignoring the reduction in debris factor to 0.5 for floodwater depths less than or equal to 0.25m required by FD2320/TR2, or considering the entire 2D model domain as 'Urban' if the full approach in FD2321/TR1 is being followed.

To fully implement the recommendations of either FD2320/TR2 or FD2321/TR1 with regard to Flood Hazard mapping, it is necessary to post-process the results of the above models in an appropriate GIS system.

Implementation of Debris Factors Using MIKE FLOOD ECOLAB

Using MIKE FLOOD ECOLAB it is possible to implement the full requirements of both FD2320/TR2 and FD2321/TR1 as part of a normal 2D overland flow simulation. No additional model runs are necessary, and little or no post processing in a GIS system is needed.

Depending upon the approach adopted ECOLAB will utilise the floodwater depths, velocities (from MIKE FLOOD), and external dominant land use data to calculate the debris factor in each grid cell /

element and at each time step in the simulation. ECOLAB will then use the debris factor to seamlessly calculate the appropriate flood hazard rating at each and every time step in the simulation.

[SECTION REMOVED]

Future Guidance

The use of MIKE FLOOD and ECOLAB for Flood Hazard Mapping is potentially future proof. Changes need only be made to the ECOLAB template to reflect the requirements of new guidance; there is no need to amend the code of the models themselves.

Conclusions

Using MIKE FLOOD ECOLAB it is possible to implement the full requirements of both FD2320/TR2 and FD2321/TR1 as part of a normal 2D overland flow simulation. No additional model runs are necessary, and little or no post processing in a GIS system is needed.

Depending upon the approach adopted ECOLAB will utilise the floodwater depths, velocities (from MIKE FLOOD), and external dominant land use data to seamlessly calculate both the debris factor and the appropriate flood hazard rating in each grid cell / element and at each time step in a simulation.

As such, the combination of ECOLAB to MIKE FLOOD, already recognised as the fastest 1D / 2D hydrodynamic engine for flood modelling, will dramatically improve the efficiency of flood hazard mapping. Furthermore, any physical changes made to the flood models are immediately reflected in the hazard mapping output. It is therefore faster to optimise flood defences for 'Hazards to People' and to run hazard mapping scenarios (based upon robust hydraulic modelling), as well as improve evacuation planning (referencing the available hazard rating versus time output).

As any gridded data can be interrogated and used in an ECOLAB simulation, it may be possible to consider the complete 'Flood Risks to People Methodology' of FD2321/TR1 within a MIKE FLOOD ECOLAB analysis, thereby automatically creating 'Flood Risk to People' maps:

$$N_{inj} = N_z \times \text{Flood Hazard Rating} \times \text{Area Vulnerability} \times \text{People Vulnerability}$$

where N_{inj} = number of injuries within a particular hazard 'zone'
 N_z = number of people within the hazard zone (at ground/basement level)
Flood Hazard Rating = function of flood depth / velocity (within the hazard zone being considered) and debris factor
Area Vulnerability = function of effectiveness of flood warning, speed of onset of flooding and nature of area (including types of buildings)
People Vulnerability = function of presence of people who are very old and/or infirm/disabled/long-term sick

This will require further study.