Experiences and advances in the use of the Life Safety Model to assist flood evacuation planning

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Introduction

Recent major flood events from around the world have highlighted the importance of an effective emergency response in minimising loss of life. The development of a Life Safety Model (LSM) allows evacuation times from flood zones and the potential number of fatalities to be assessed. This is illustrated by a selection of case studies for different flood hazards.

Overview of the Life Safety Model

The Life Safety Model (LSM) is the only tool that is currently available that allows for a dynamic interaction between people, vehicles, buildings and the flood wave, in order to model risk to people.

The LSM has the following features:

- Was developed more than 10 years ago by BC Hydro, initially to be used in planning the response to major dam failures in Canada
- Uses latest available physical equations
- Includes traffic and pedestrian models
- Can be used to assess the consequences for any flood event (where 2D hydraulic modelling results are available)
- Models the "fate" of a set of receptors (i.e. people, vehicles and buildings)
- Uses a generalised event logic to determine:
  - the location of each receptor
  - whether it is aware of the flood wave
  - whether it is trying to find a safe haven
  - what happens if it encounters the flood
  - whether the receptor survives or not

Recent developments

Since 2006, HR Wallingford has been working with BC Hydro in the use and development of the LSM, and in early 2012 signed an agreement for HR Wallingford to take over the development of the software, with the aim being to support both commercial and academic use of the model.

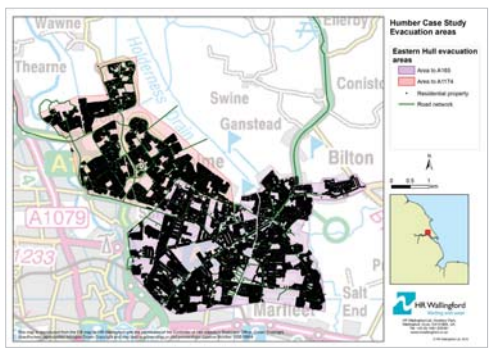
Between 2009 and 2012 HR Wallingford reviewed the model code and with BC Hydro and other users agreed a set of improvements, which were released in version 2 in 2012. These include:

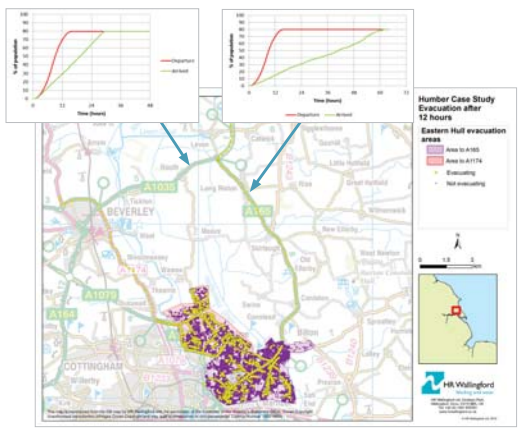
- A consistent data format for input/output based on XDMF
- Outputs that can be displayed using Paraview (a freeware application)
- Retention of ability to display results using the original EnSim software (now freely-available as Blue Kenue)
- Ability to run the model without flood model output (to simulate either an evacuation plan or to understand how much time is needed to evacuate before a flood arrives)
- More realistic modelling of safe havens, allowing for a finite capacity, entry rate limit and vertical evacuation
- New tools to assist in the building of the 'virtual world'
- Inclusion of parameter to set the agent uncertainty in the choice of the 'optimum' route

Case Study

Humber Estuary, UK (sea surge)

The LSM was used as part of a tiered traffic modelling approach to investigate how long it would take for mass evacuation of the area in advance of a major storm surge (such as happened in 1953). This utilised the new feature of 'running in the dry'. The 'micro' modelling carried out by LSM for the east of the City of Hull showed that congestion would take place on the local road network, which had not been modelled in the other two approaches. This has raised the need for further investigation of how the local roads are used. Overall, LSM produced consistent evacuation times to the other models.

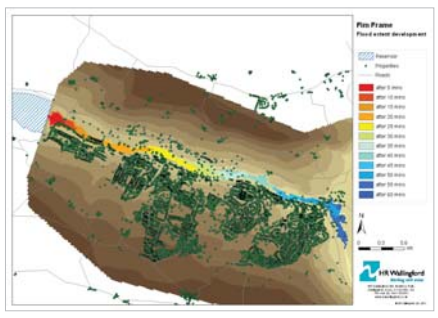




Case Study

Pennines dam, UK (dam failure)

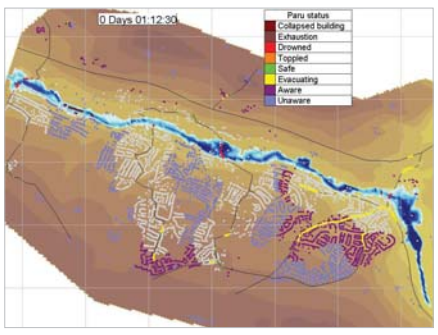
As part of the European-funded research project, FIM FRAME, a range of tools were assessed for the development and use of flood emergency plans. A dam in England formed one of the case studies, which included the issue of lack of warning in the event of potential failure. Although the dam is extremely unlikely to fail, the model application showed that the number of fatalities could be significantly reduced if a warning was provided at the dam site. The application of LSM also raised issues such as omission of evacuation routes and safe havens in the local flood plan.



		Flood Risk to People		Life Safety Model no warning		Life Safety Model with warning	
Population		13,836		13,836		13,836	
Deaths	Total	8.5	0.1%*	240 (153)**	1.73% (1.11%)	35 (35)**	0.25% (0.25%)
	drowning	-	-	150	1.08%	35	0.25%
	exhaustion	-	-	3	0.02%	0	0.00%
	building collapse	-	-	87	0.63%	0	0.00%
	vehicles swept away	-	-	0	0.00%	0	0.00%
Injuries		64.2	0.5%	-	-	-	-

* percentage evaluated on the total population

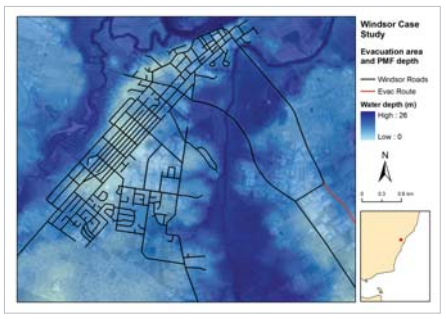
** in brackets, the total deaths and percentage if building collapse is not considered.



Case Study

Windsor, NSW, Australia (river flooding)

A new application of LSM has been commissioned in May 2013 by SES, NSW. This will act as a pilot study to demonstrate the model's capabilities for the community of Windsor. Simulations to date have been 'in the dry', pending receipt of the flood model outputs. This has looked at the time needed for everyone to reach safety (the Olympic Stadium in Sydney) prior to being cut off by rising floodwaters.



Conclusions

- The LSM offers a scientifically robust method of assessing residual risk behind flood defences and downstream of dams in terms of fatalities.
- The LSM model is the only model that has a dynamic interaction between the receptors (e.g. people, vehicles) at risk and the flood hazard.
- The model was validated against historical data from the Canvey Island flood (UK) in 1953 and the failure of Malpasset Dam (France) in 1959.
- The LSM can be used to test emergency plans for a variety of types of floods (river, sea, tsunami, dam) and to develop evacuation and warning strategies.

Further Information

www.lifesafetymodel.net

References

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