FLOODSTAND - Short introduction to the EU-project (nr. 218532)

Aalto University
Dipoli Congress Centre, Otakaari 24,
Espoo, 00076 AALTO, Finland
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EU project FLOODSTAND – WP2 Summary of tests etc.

INTEGRATED FLOODING CONTROL AND STANDARD FOR STABILITY AND CRISES MANAGEMENT

Coordinator: Risto Jalonen
Aalto University, School of Engineering
Department of Applied Mechanics
Marine Technology group

Aalto University

WP2

Summary of tests, computations and simulations related to flooding

Aalto University / School of Engineering
Department of Applied Mechanics / Marine Technology
Risto Jalonen

WP2

Summary of tests, computations & simulations:

Contents	Report
Experimental tests with doors etc. in real scale	D2.1b
Numerical tests (with FEM) with doors etc.	D2.2a
Experimental tests with man-holes & cross-ducts	D2.3
Numerical tests (CFD) with man-holes, cross-ducts & air pipes	D2.4a&b
Model tests with compartments	D2.5b
Sensitivity analysis	D2.6

Research topic: WP2 Flooding progression modelling

Different door types
in category A,
see D2.2b:

Table 2: Degrees of watertightness for Category A

Definition	Action/Performance	Description	Conditions of use
Watertight	To withstand constant pressure[2] ($p > p_L$)	Under bulkhead deck	To be kept closed during navigation (special exceptions may be applied)
Light watertight	To withstand constant water pressure[3] ($p < p_L$)	On Bulkhead deck	To be kept closed during navigation (special exceptions may be applied)
Semi Watertight	Weathertight to provide positive residual stability[4]	On bulkhead deck and above	May be kept open during navigation

Fire doors (here hinged, double-leaf)

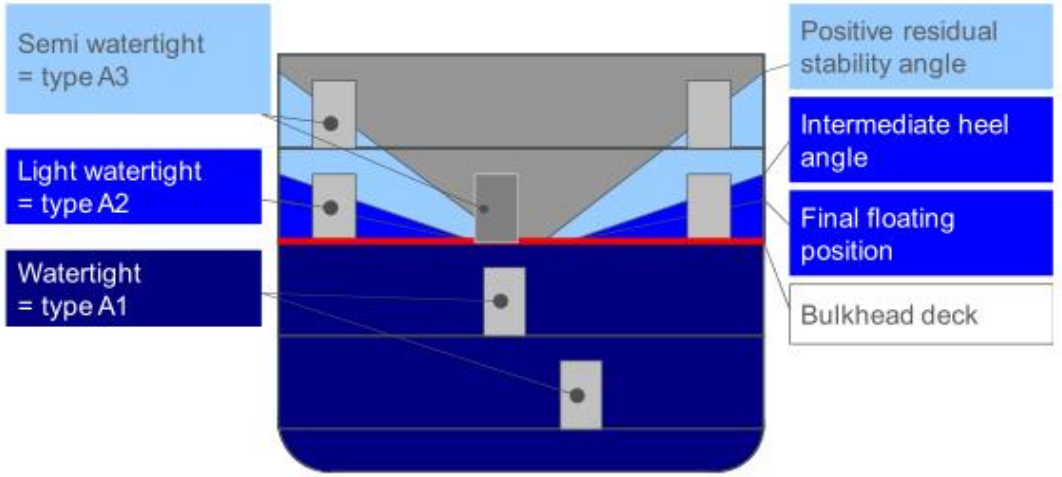


Figure 2: Category A doors in passenger ships (STX Finland)

Research topic: WP2 Flooding progression modelling

Experiments with leaking and collapsing structures => Work completed

Responsible: **CTO S.A.**; Other participants: STX Finland, MEC, MW, AALTO

- Semi-watertight doors, fire doors (sliding and hinged), cabin walls etc.
- Measured: **water pressure** and **flow rate** through the leakages during the structural deformation and collapse

Photographs of doors with the frames sent from the shipyard to the testing facility at CTO in Gdansk, Poland, where these tests with stepwise increased water pressure head were carried out in 2010

Research topic: WP2 Flooding progression modelling

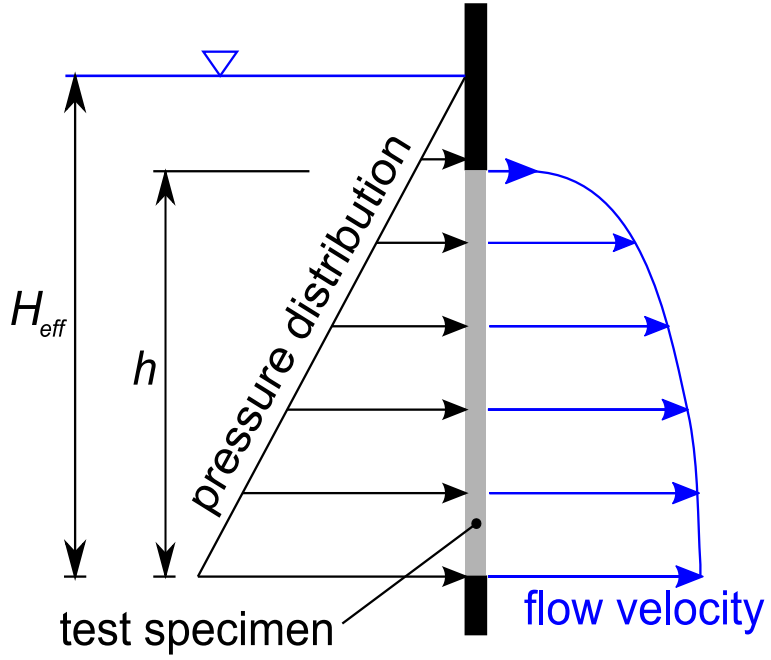


Figure 1: Distributions of pressure and assumed flow velocity for assessment of leakage area ratio

A photograph of experiments in full scale in 2010 at CTO in Gdansk, Poland

Research topic: WP2 Flooding progression modelling

Numerical modeling and **criteria for leaking and collapsing structures** => **Work completed** (see D2.2a & D2.2b)

Responsible: **MEC**; Other Participants: CTO, NAPA, STX

- Focus on **failure mechanisms** for doors and structural components
- Numerical simulations; explicit FEM code

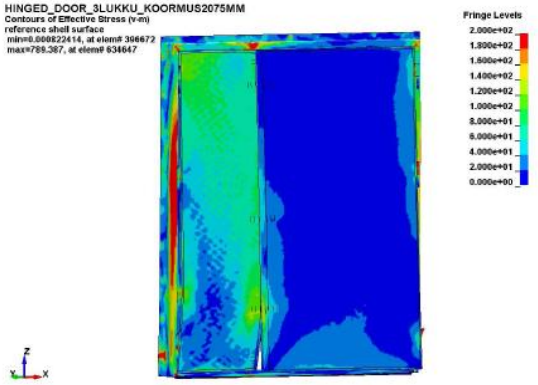
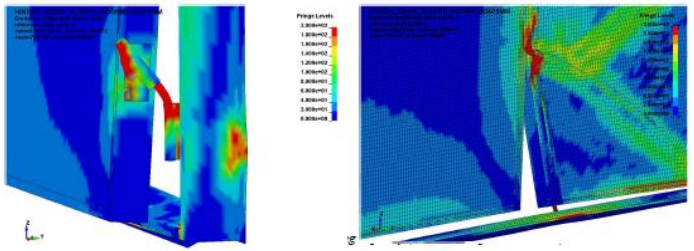


Figure 5.3 Outside of hinged fire-door at failure (von Mises equivalent stress)

- Specific data obtained also on
  - -- **the leakage pressure**, i.e. when the structure looses watertight integrity and
  - -- **the collapse pressure** gets it to collapse.
- Computations will be validated with experiments

=> criteria for leakage and collapse of doors etc.



In real flooding case it might be quite rear to obtain hydrostatic difference more than 2.06 meters as the structure is not watertight.

Research topic: WP2 Flooding progression modelling

Result from WP2 / Task 2.2:

Based on this work rough guidelines for modelling leakage and collapse of various A- and B-class doors etc. for flooding simulations could be given => Report D2.2b

These guidelines have been provided for IMO's use:

⇒ **SLF54/INF.8**/Rev. Modelling of leaking and collapsing of closed non-watertight doors. 28 October 2011. Submitted by Finland.

=>

Table 1: Rough guidelines for modelling doors and boundaries for flooding simulation, the values marked with an asterix (*) are estimations that are not based on experimental or FEM results *(Ruponen and Routi, 2011)*

Type	direction	H_{leak} (m)	A_{ratio}	H_{coll} (m)	Notes
Light watertight door	into	–	–	8.0*	minimal leaking at lower pressures, full collapse likely for $H > 8$ m; note that only direction "out" was tested
	out	–	–	8.0	
A-class sliding	into	0.0	0.025	1.0	almost constant leakage area ratio
	out	0.0	0.025	1.0	
A-class hinged	into	0.0	$0.02 \cdot H_{eff}$	2.5	A_{ratio} depends on the gap size
	out	0.0	$0.03 \cdot H_{eff}$	2.5	A_{ratio} depends on the gap size
A-class double leaf	into	0.0*	0.025*	2.0*	**Not tested!** Assumed to be independent on direction
	out	0.0	0.025	2.0	Collapsing could not be tested due to high leaking, value based on FEM
Cold room sliding door	into	0.0	$0.01 \cdot H_{eff}$	3.5	Only one direction tested; collapsing pressure height assessed with numerical methods
	out	0.0*	$0.01 \cdot H_{eff}$*	3.5*	
B-class joiner door	into	0.0	$0.03 \cdot H_{eff}$	1.5	panels around the door will fail first, A_{ratio} expression is very approximate
	out	0.0	0.03	1.5	door is distorted, A_{ratio} increases slowly
Windows	–	–	–	> 18	can be excluded in simulations

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Research topic: WP2 Flooding progression modelling / T2.3

Results:

Figure 16, in annex 2 to document SLF 53/INF.2, is replaced by the following:

"

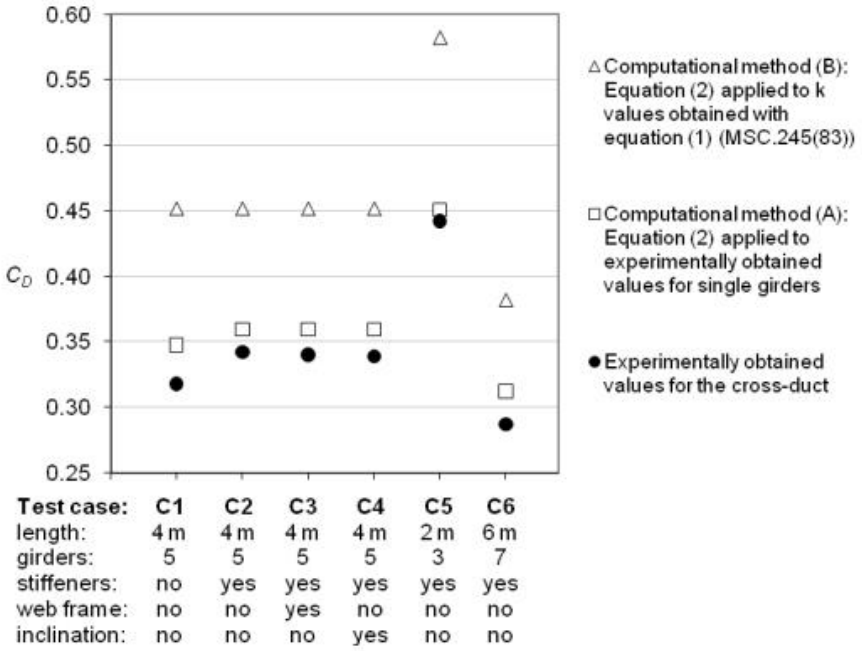

Figure 16: Comparison of experimental results and formulae in resolution MSC.245(83)"

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Research topic: WP2 Flooding progression modelling / T2.3&T2.4a

An example of results: **Flow in a cross-duct**

Sub-Task 2.4.1
Responsible: **CNRS** (& CTO)
Status: **Completed**

Case	Theoretical discharge (m^3/s)	Computed discharge (m^3/s)	Computed discharge coefficient
Model scale	*0.126*	*0.042*	*0.333*
Full scale, 5m	1.960	0.638	0.325
Full scale, 10m	3.140	1.051	0.335

Table 4 Discharge and discharge coefficient for the two inlet water heights

For more details,
see D2.4a

Research topic: WP2 Flooding progression modelling/ T2.3 & T2.4a

Results: The method of successive openings (with C_d = 0.6 for each manhole) results in slightly smaller effective discharge coefficient for the whole duct than the model tests or CFD results.

So it can be deduced that the method of successive openings is slightly conservative.

The regression equation (that is currently recommended in the Resolution) gives notably higher (about +30%) values for the discharge coefficient.

Thus the use of the regression equations may cause a significant under-estimation of the cross-flooding time.

Table 1: Comparison of discharge coefficients

Cross-duct design:	*Model test or CFD*	*Successive openings*	*Regression equation*
FLOODSTAND: L_{duct} = 6 m	0.442	0.397 ⟷	0.582
FLOODSTAND: L_{duct} = 12 m	0.342	0.318 ⟷	0.451
FLOODSTAND: L_{duct} = 18 m	0.287	0.273 ⟷	0.382
Case Study 2 (CFD)	0.308	0.296 ⟷	0.37 .. 0.39

=> A related document has been now submitted to IMO: SLF54/4

Research topic: WP2 Flooding progression modelling / T2.6

An example of results of Task 2.6:

Sensitivity analysis

Task 2.6
Responsible: **AALTO & NAPA**
Status: **Completed**

For more details, see D2.6

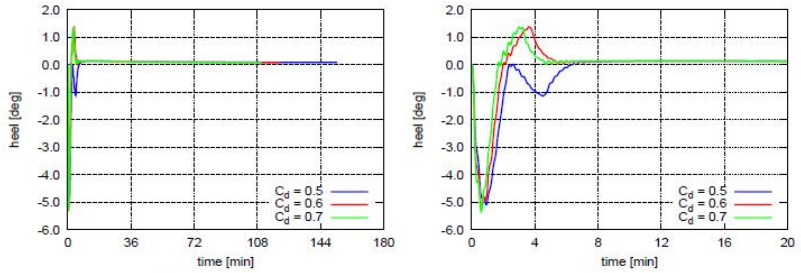
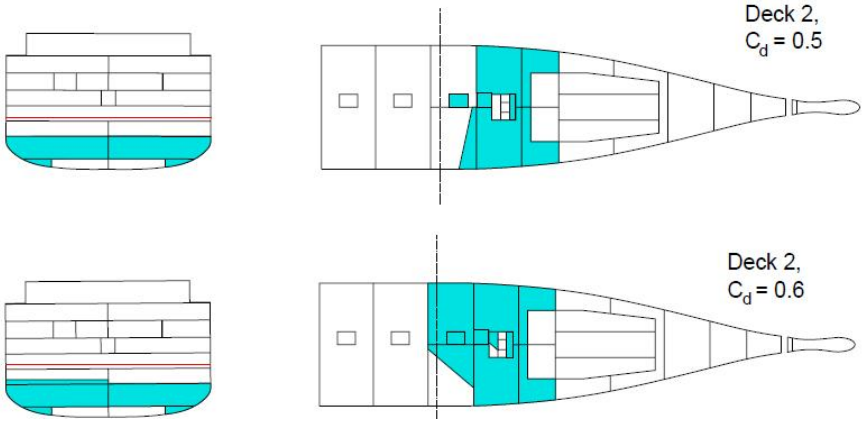


Figure 15: Time history of heel with different discharge coefficients

- This result indicates that in some cases, the discharge coefficient may have significant impact on the behaviour of the ship. The dependency of the heeling direction on the water accumulation is illustrated in Figure 16 with two different C_d values, at t = 2.5 min.



Research topic: WP2 Flooding progression modelling / T2.6

Sensitivity analysis

Systematic variations of input parameters (discharge coefficient, collapsing pressure head, leakage modeling) related to the door tests were carried out for simulation of progressive flooding in a damaged passenger ship (Design A with some minor modifications.

In the presented studies, no parameter variation whatsoever seemed to have any significant effect on the maximum transient heel. No change to this conclusion was justified even with the extensive and asymmetric flooding in the Case C. On the other hand, the applied parameters had notable effects on the time-to-flood and on the progress of flooding and the heeling after the transient phase. For example, variation of discharge coefficient affected directly the flooding time and indirectly the collapses of doors. An interesting result in the light of heel was in Case A when the heeling after the transient peak took a different direction with a lower discharge coefficient, Cd = 0.5 (in comparison to the reference value 0.6).

Research topic: WP2 Flooding progression modelling / T2.6

Sensitivity analysis

Variation of critical pressure head for collapse had the most apparent effect on the way the flooding progressed. In this way it affected the nature of the heeling behaviour, but it also had an effect on the flooding rate and thus on the time-to-flood.

Leakage area modelling had a clear effect on the time-to-flood. This effect became apparent after the early flooding phases when most of the flooding was based on leaking through closed doors. If the variation of Aratio did not have an effect on the collapse of doors, the consequent effects especially on heel were almost non-existent.

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Research topic: WP2

For additional information related to WP2,

see e.g. the following 9 public reports (deliverables) of project FLOODSTAND:

- D2.1a, D2.1b, D2.2a, D2.2b, D2.3, D2.4a, D2.4b, D2.5b, D2.6,

the following two journal articles:

More publications from WP2 are in our plans as well as joint publications with links between other Tasks of the project.

- Stening, M., Järvelä, J., Ruponen, P. & Jalonen, R.: Determination of discharge coefficients for a cross-flooding duct. Ocean Engineering 38 (2011), 570-578. (doi.org/10.1016/j.oceaneng.2010.12.004)
- Ruponen, P., Queutey, P., Kraskowski, M., Jalonen, R. & Guilmineau, E.: On the calculation of cross-flooding time. Ocean Engineering 40 (2012), 27-39. (doi.org/10.1016/j.oceaneng.2011.12.008),

and the annexes of the following SLF-documents submitted to IMO:

SLF 54/4, Sub-Committee on Stability and Load Lines and on Fishing Vessels Safety, 54th session, Agenda item 4, Development of Guidelines on safe return to port for passenger ships. SLF 54/4 An analysis of the recommendation on a standard method for evaluation of cross-flooding arrangements as presented in resolution MSC.245(83). 14 October, 2011. Submitted by Finland. and

SLF 54/INF.8/Rev.1, Sub-Committee on Stability and Load Lines and on Fishing Vessels Safety, 54rd session, Agenda item 4, Development of Guidelines on safe return to port for passenger ships. SLF54/INF.8/Rev.1 Modelling of leaking and collapsing of closed non-watertight doors. 28 October 2011. Submitted by Finland.

Thank you!

If there is time ... any questions?

Note! Questions can also be asked during the "Discussion"

Good to know (1): DIPOLI

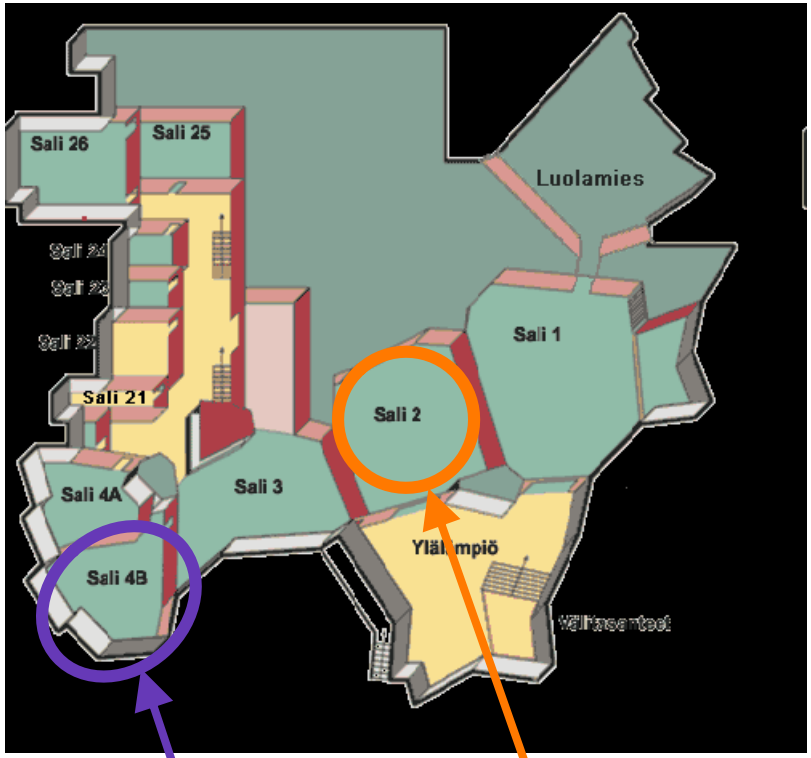
Ground floor

Toilets

Cone Entrance

Stairs to upper floor

1st floor



Hall 4B
We are here

Our lunch-room, Hall 2

Good to know (2):

DIPOLI

Dipoli (Finnish for dipole) is a conference center located in Otaniemi, Espoo, Finland as a part of the Otaniemi campus of the Aalto University (AALTO).

When the TKK moved from Helsinki to Espoo in the early 1960s, a design contest was held for what would become the new building for the Student Union of Helsinki University of Technology. The contest was won by Reima and Raili Pietilä, and their 1961 design was used as the blueprint for the Dipoli building. Work began in 1965, and the building was ready for use in the fall of 1966. The name is a pun; it can mean dipole, but also "the second Poli", the second building of the polytechnic students.

In 1993 the building was transformed into a training centre of the university due to high maintenance costs. Besides its primary role, Dipoli is still regularly used for conventions, congresses and student parties. The building houses over 20 conference rooms and auditoriums. Source: fi.wikipedia...