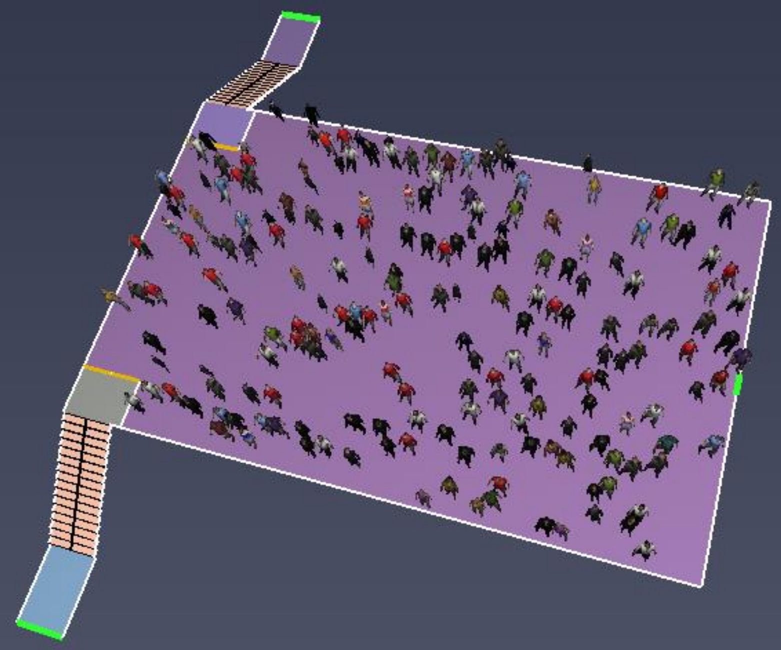
Managing quality in FSD projects involving RSET analyses



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Background

- **Regulations**
  - In the past: FSD of a building relied on prescriptive regulations
    - Little or no room to verify the design
  - Today: Most are still based on prescriptive solutions
    - In many countries, they have been developed to allow for a performance-based design and evaluation of the fire safety
- **Type of evaluation is dictated by the project scope**
  - Qualitative
  - Quantitative
    - Deterministic
    - Probabilistic
- **Occupant scenarios are identified and selected to represent design occupant scenarios if fire safety goal is protection of life safety**
  - These are then evaluated and compared against performance criteria
    - Temperature, visibility, and etcetera

Background

- **In a quantitative approach, computer evacuation models for buildings typically assist the designer in the evaluation of trial designs**
- **Valuable, as they allow for quantification of evacuation processes**
  - Relatively basic engineering tools
  - Simplification of reality (= model)
  - Little understanding of human behaviour
- **Number of models, and their complexity, has increased**
  - Technological developments
  - Higher demand to cope with more complex geometries
- **Both aspects stresses the need for well-developed, effective and operational routines for managing quality when doing RSET analyses**

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Quality management in general

- → **Most companies are certified to quality management systems such as ISO 9000:2015**
- → **Key components**
  - Quality management
    - *[…] establishing quality policies (3.5.9) and quality objectives (3.7.2), and processes (3.4.1) to achieve these quality objectives through quality planning (3.3.5), quality assurance (3.3.6), quality control (3.3.7), and quality improvement (3.3.8).*
  - Traceability
- → **A certified company must define**
  - Quality objectives
  - Operational processes to achieve the objectives
- → **Overall level: Establishing routines/guidelines for ensuring quality**
- → **Typical processes for quality control**
  - Self-inspection: The designer is required to check his/her own work
  - Internal review: Review performed by a qualified colleague who is well-informed about the project, but who is independent of the actual design being reviewed

Development of a QM system for RSET analyses

- **Purpose**
  - Develop an effective and operational routine for managing and ensuring quality in fire safety design projects involving RSET analyses with computer evacuation models
- **Result**
  - A template summary sheet that can be used to summarize an RSET computer evacuation model, and
  - A tool that can be used to facilitate both self-inspection and internal review of that computer evacuation model.
- **Acknowledgements**

  - Mr. Johan Askman, intern at WSP Sverige AB
  - Past initiatives by others, for example
    - Kuligowski
    - Briab Brand & Riskingenjörerna AB

Summary sheet

- **A simple summary sheet to primarily facilitate self-inspection, but also internal-review**
- **Intention to summarize RSET model**
- **Contents (tables)**
  - General information about the project
  - Drawings and other similar references on which the model is based
  - Basic information about the design occupant scenarios
  - Input parameters
- **Filled out before and during analysis**
  - Implicitly forces designer to go through the model and document it thoroughly while model assumptions are made, and he/she still have them fresh in mind
- **Positive effects**
  - Implicitly forces designer to double check model
  - Becomes a transparent presentation of the model
  - Facilitates internal review

Summary sheet

Input parameters – ***Developed for Pathfinder, remove or leave non relevant rows empty when using another model*** *When multiple model ID's are included, insert separate rows only where the parameter differs between the models (see example in 1.02: Time Limit)*				
#	**Parameter**	**Value**	**Unit**	**Comment/Justification**
1.13	*Save Restart Files*		-	
1.14	*Snapshot interval*		s	
1.15	*Curve error*		-	
1.16	*Face error*		-	
2	**Profile: Disabled**			
2.01	*Priority Level*		-	
2.02	*Speed*		m/s	
2.02.01	*Level Terrain: Speed*		m/s	
2.02.02	*Level Terrain: Speed-Density Profile*		-	
2.02.03	*Stairs: Speed Fraction Up*		-	
2.02.04	*Stairs: Speed-Density Profile Up*		-	
2.02.05	*Stairs: Speed Fraction Down*		-	
2.02.06	*Stairs: Speed-Density Profile Down*		-	
2.02.07	*Ramps: Speed Fraction Up*		-	

Complementing tool to facilitate self-inspection and internal review

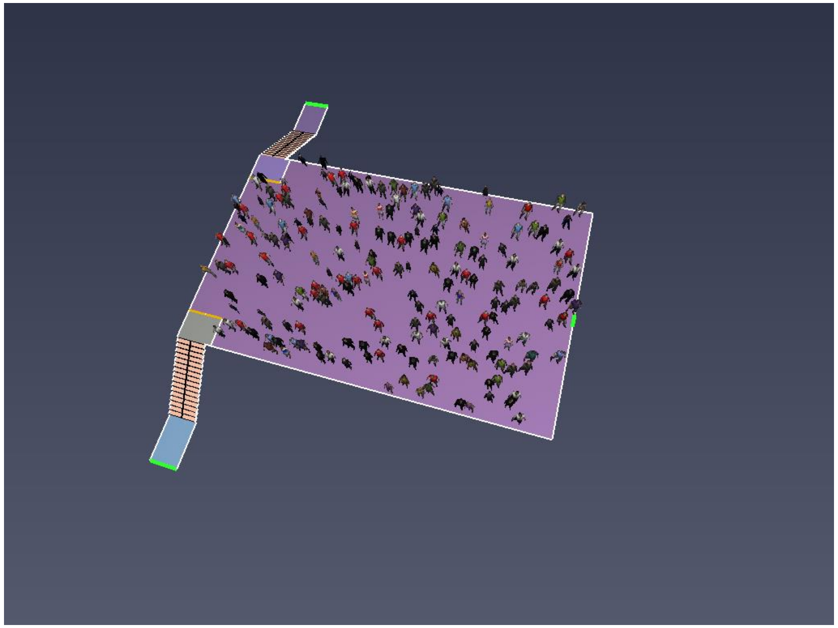
- **Summary sheet particularly good for self-inspection**
- **This tool is particularly helpful in internal review**
- **Simple Excel spreadsheet**
  - Five worksheets
    - General information about the tool
    - Basic model assumptions
    - Verification, model inspection and control
    - Life safety verification, inspection and control
    - Final remarks of inspection and control
- **Fire safety designer answers pre-defined questions, motivates model choices, and etcetera, before handing model and documentation for internal review**
- **Internal reviewer checks answers and motivations, and can provide his/her own**

Complementing tool to facilitate self-inspection and internal review

Geometry
Is the correct scale used during import of drawing and are model openings replaced by exits?
Is the correct height used between the floor plans?
Are doors, stairs and other connections widths correctly defined?
Door and other connections (excl. stairs)
Has the effective door width been taken into account?
Has the correct capacity been defined?
Has a sensitivity analysis been executed with half/full blockage of some doors?
Has capacity been defined differently for known/unknown exits?
Stairs
Has the effective stair width been taken into account?
Has the correct capacity been defined at each top/bottom door to the stair?
Is the walking speed adjusted in stairs compared to horizontal areas?

Case study: Background

- **Demonstration of tools**
- **Two-storey building with two main entrances/exits (2 m wide)**
  - Floor area 400 sqm
  - Two main entrances/exits
  - A third emergency exit required by building regulation
    - Spiral stair (lower flow rate)? Does not meet D2S solution.
    - Straight stair (more space)?
- **Verification of whether spiral stair provides same level of safety**
- **Four scenarios**
  1. All evacuation routes are accessible, the third evacuation route is a spiral stair
  2. As #1, but one main entrance blocked
  3. All evacuation routes are accessible, the third evacuation route is a straight 1.2 m wide stair
  4. As #3, but one main entrance blocked



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Case study: Summary sheet

General information	
Project name:	FEMTC 2016 paper
Project number:	-
Study:	Case study for paper
Date started:	2016-10-10
Personnel	
Lead engineer(s):	Karl Fridolf
Evacuation modeller(s):	Daniel Rosberg
Reviewer(s):	Karl Fridolf
General project description:	Reconstruction of building to accomodate restaurant
Model description:	Life safety verification assuming evacuation through a spiral stair
Model purpose:	To verify if evacuation is satisfactory
Model file location:	-
Checking summary:	Checked by reviewer

Case study: Summary sheet

Drawings	
ID	**Drawing** ***Import drawings over the relevant model areas***
-	All made up • 16x25 sq m • 200 people • 2 main stairs, 2 m wide • 1 spiral stair

Tabell 3

Basic model information		
Model ID	**Scenario description**	**Time line** ***Highlight the most important times in the scenario (as an example, t = 60 s: Evacuation is initiated.)***
1	All stairs available for evacuation	Only movement time modeled
2	One of the main stairs is blocked for egress	Only movement time modeled
3	As #1, but spiral stair is replaced by a 1.2 m straight stair	Only movement time modeled
4	As #2 (one of the main stairs blocked by fire), but spiral stair is replaced by a 1.2 m straight stair	Only movement time modeled

Case study: Summary sheet

Input parameters – *Developed for Pathfinder, remove or leave non relevant rows empty when using another model* *When multiple model ID's are included, insert separate rows only where the parameter differs between the models (see example in 1.02: Time Limit)*				
#	**Parameter**	**Value**	**Unit**	**Comment/Justification**
5	**Key geometry connections (doors etc.)**			
5.01	*Door to third exit*			
5.01.01	*Model ID 1: Spiral stair*	*0.8*	m	Standard door width
5.01.02	*Model ID 2: Spiral stair*	*0.8*	m	Standard door width
5.01.03	*Model ID 3: Straight stair*	*1.20*	m	Standard door width
5.01.04	*Model ID 4: Straight stair*	*1.20*	m	Standard door width
5.02	*Doors to main stair #1*	2 x 1.2	m	According to architectural drawings
5.03	*Doors to main stair #2*	2 x 1.2	m	According to architectural drawings
5.04	*Main stair #1*	2.0	m	According to architectural drawings
5.05	*Main stair #2*	2.0	m	According to architectural drawings
5.06	*Exit doors at level +0 m @Main stairs #1*			
5.06.01	*Model ID 1: Available*	2.0	M	Same as stair width. Will not restrict flows.
5.06.02	*Model ID 2: Unavailable*	-	M	Blocked for egress (Disabled in model)
5.06.03	*Model ID 3: Available*	2.0	M	Same as stair width. Will not restrict flows.

Input parameters – *Developed for Pathfinder, remove or leave non relevant rows empty when using another model* *When multiple model ID's are included, insert separate rows only where the parameter differs between the models (see example in 1.02: Time Limit)*				
#	**Parameter**	**Value**	**Unit**	**Comment/Justification**
6	**Flow rates**			
6.01	*Door to third exit*			
6.01.01	*Model ID 1: Spiral stair*	*0.5*	p/s	Door flow restrictions are equal to flow restrictions in stairs (spiral) for easier modelling (no need to model the actual spiral stairs)
6.01.02	*Model ID 2: Spiral stair*	*0.5*	p/s	Door flow restrictions are equal to flow restrictions in stairs (spiral) for easier modelling (no need to model the actual spiral stairs)
6.01.03	*Model ID 3: Straight stair*	*0.9*	p/s	Door flow restrictions are equal to flow restrictions in stairs (spiral) for easier modelling (no need to model the actual spiral stairs)
6.01.04	*Model ID 4: Straight stair*	*0.9*	p/s	Door flow restrictions are equal to flow restrictions in stairs (spiral) for easier modelling (no need to model the actual spiral stairs)
6.02	*Doors to main stair #1*	2.31	p/s	Door flow restrictions according to BBRAD3
6.03	*Doors to main stair #2*	2.31	p/s	Door flow restrictions according to BBRAD3
6.04	*Main stair #1*	1.7	p/s	Stair flow restrictions according to BBRAD3
6.05	*Main stair #2*	1.7	p/s	Stair flow restrictions according to BBRAD3

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Case study: Self-inspection and internal review

Door and other connections (excl. stairs)	Designer answer	Designer comment	Reviewer answer	Reviewer comment
Has the effective door width been taken into account?	Yes	Modelled per default.	Yes	
Has the correct capacity been defined?	Yes	Implicitly delimited by other bottlenecks. Not explicitly defined, but based on Steering mode defaults.	No	Flow rates have been limited in bottlenecks (stairs), and unlimited in other connections/doors. However, there's a discrepancy between the description of the model input in the summary sheet, and in the models. In addition, calculation of flow rate capacities in summary sheet does not correspond to BBRAD3 recommendations. See, for example, 6.02-6.03. Please double check.
Has a sensitivity analysis been executed with half/full blockage of some doors?	Yes	Scenarios with one blocked main exit is studied.	Yes	
Has capacity been defined differently for known/unknown exits?	Yes	Third stair accounts for less people than main exits.	Yes	In terms of number of people using different exits, however, not in terms of flow rate restrictions. Deemed not necessary for this analysis.

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Case study: Self-inspection and internal review

Output	Designer answer	Designer comment	Reviewer answer	Reviewer comment
Have pre-movement times been correctly represented in the model?		Not modelled		
Have flow rates in doors and other connections been correctly represented in the model?	Yes	Checked against flow restrictions.	Yes	Seems about right. Flow rates are typically lower than normal design values, but this is due to the queueing situation which is a result of the stair bottleneck.
Have flow rates in stairs been correctly represented in the model?	Yes	Checked against flow restrictions.	No	Stair flow rates in main stairs are lower than defined values in the summary sheet and in the model input. Please double check.
Have population densities been checked in areas where queuing arises?	No	High population densities not expected.	Yes	Checked for case 1. Corresponds to defined maximum value.

Thank you!

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