

Ascending evacuation in long stairways: Physical exertion, walking speed and behaviour

ENRICO RONCHI, Ph.D.

**Department of Fire Safety Engineering
Lund University, Sweden**

enrico.ronchi@brand.lth.se



Agenda

From 13.00-15.00:

- General project overview
- Field experiments in stairwells
- Field experiments in stopped escalator
- Physiological results
- EMG results
- Questions and Discussion



Agenda

After 15.00..

Optional visit to the Thermal Environment Laboratory at the Department of Design Sciences at Lund University...



Stair machine demonstration



LUND
UNIVERSITY

Project partners

Dr Enrico Ronchi - *Lund University, Department of Fire Safety Engineering*

Johan Norén - *Briab*

Mattias Delin - *DeBrand*

Silvia Arias - *Lund University, Department of Fire Safety Engineering*

Dr Kalev Kuklane - *Lund University, Department of Design Sciences*

Amitava Halder - *Lund University, Department of Design Sciences*



Acknowledgements

Sponsors



Research collaborators

Karl Fridolf - *(former project leader)*

Karin Lundgren - *(research collaborator)*

Sofia Månsson - *(research collaborator)*

Caroline Ericsson Lantz - *(research collaborator)*

... and many more!

Chuansi Gao, Michael Miller

Reference group members

SLL, MTR



LUND
UNIVERSITY

Motivation

Deeper underground facilities

*Metro station in Stockholm
95 m below ground*

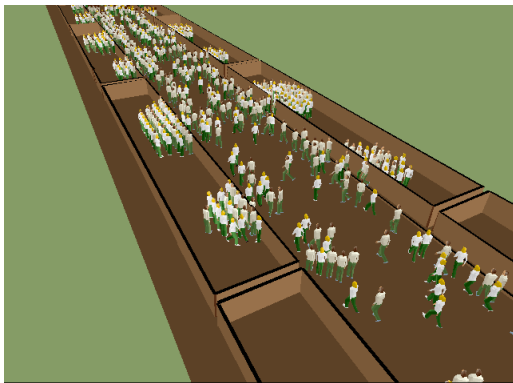
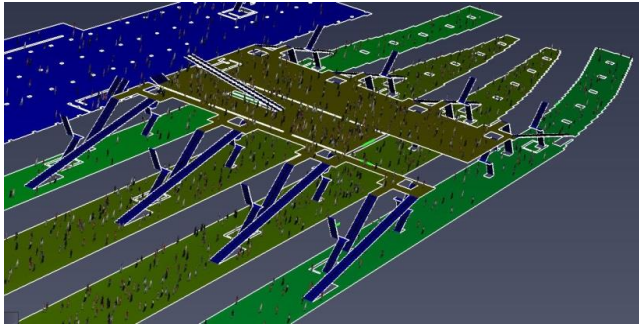


*Bus station in Stockholm 24 m
below ground*



Motivation

Are today evacuation models valid?



<https://fseg.gre.ac.uk>

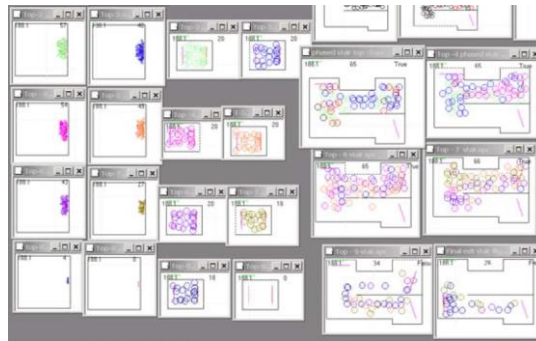
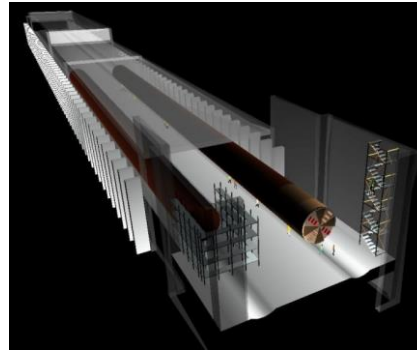
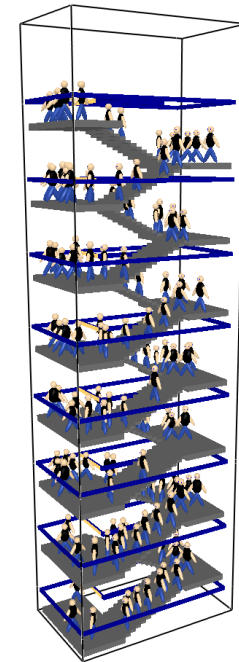


Image by D. Purser



Time: 155.5



LUND
UNIVERSITY

THANK YOU FOR COMING!

Email:

enrico.ronchi@brand.lth.se

Department of Fire Safety Engineering:

www.brand.lth.se



LUND
UNIVERSITY

ASCENDING EVACUATION IN LONG STAIRWAYS: PHYSICAL EXERTION, WALKING SPEED AND BEHAVIOUR

Johan Norén, Briab

A NEW HOLISTIC APPROACH



Study & quantify ascending stair evacuation



Develop a method for laboratory environment to study walking speed and fatigue



Develop a mathematical model including fatigue

A NEW HOLISTIC APPROACH

Literature review

Fysisk ansträngning vid utrymning
uppför trappor –
Kunskapsöversikt

Mattias Delin & Johan Norén

Department of Fire Safety Engineering
Lund University, Sweden

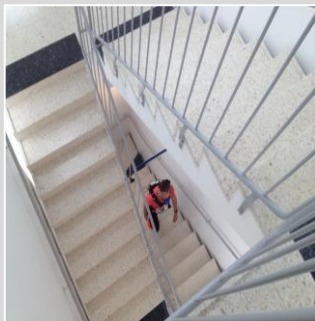
Brandteknik
Lunds tekniska högskola
Lunds universitet

Lund 2014

Laboratory experiments on a stair machine



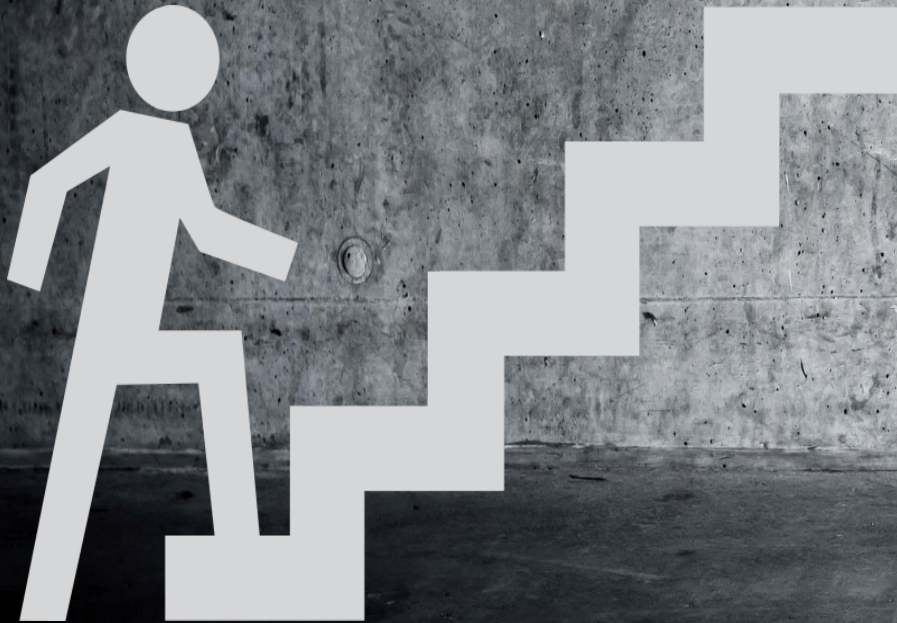
Field experiments in two stairwells



Field experiments in a stopped escalator



LITERATURE REVIEW - FINDINGS



Physical exertion may affect evacuation during long ascending evacuation

Today's design guidelines and building codes are primarily for descending movement

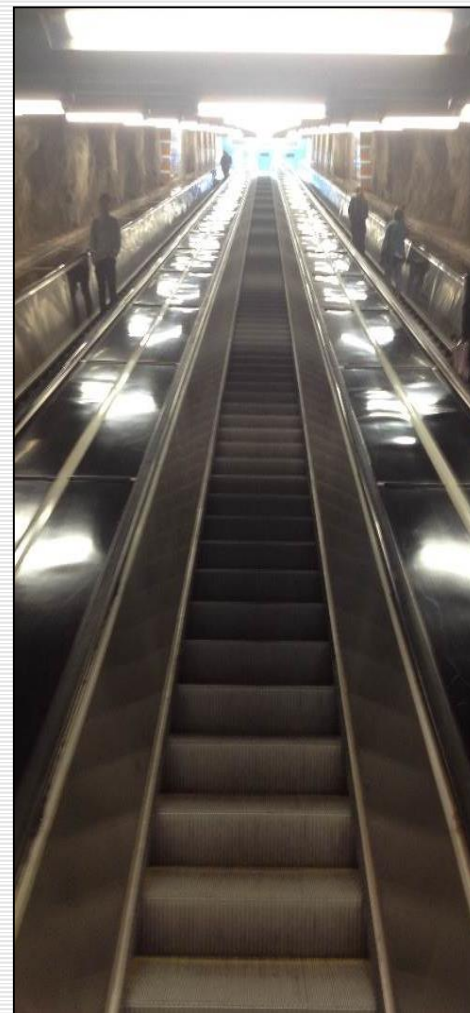
FIELD EXPERIMENTS



**Ideon Gateway -
height 48 m**



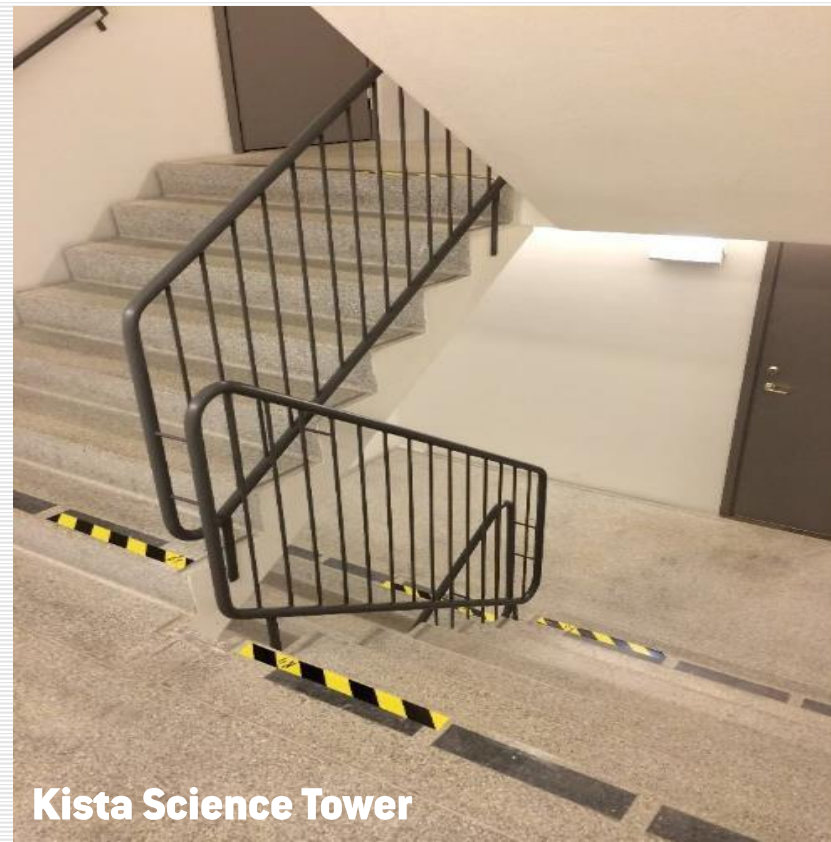
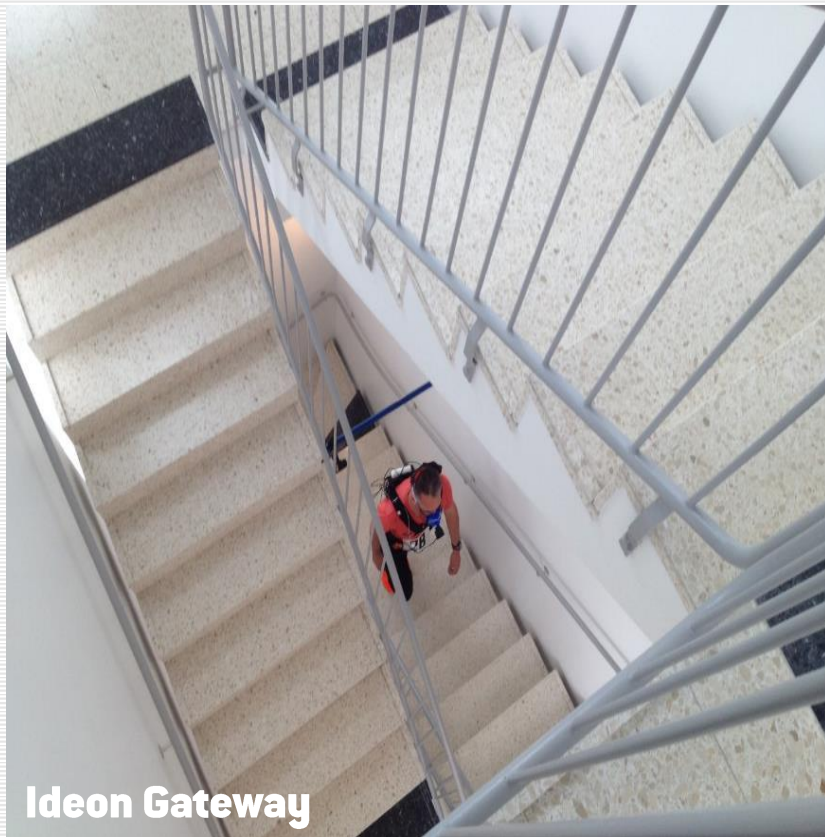
**Kista Science Tower -
height 109m**



**Västra skogen metro station
- height 33 m**

FIELD EXPERIMENTS IN TWO STAIRWELLS

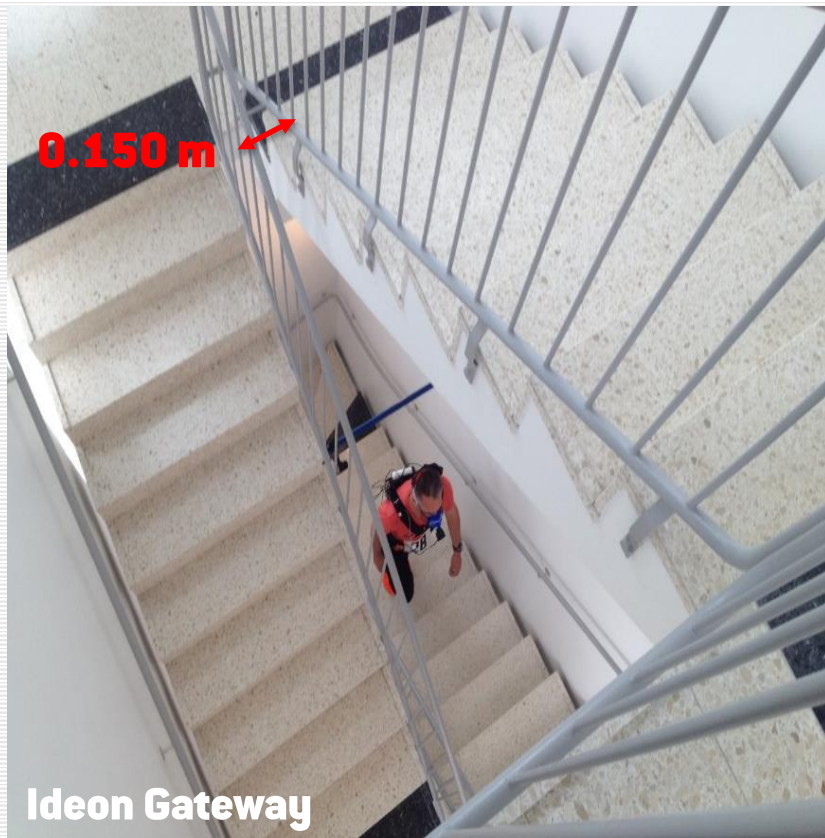
Stairwell	Width	Step height	Step depth	Landings/floor
Ideon Gateway	1,0 m	0,18 m	0,26 m	2
Kista Science Tower	1,6 m	0,17 m	0,27 m	3



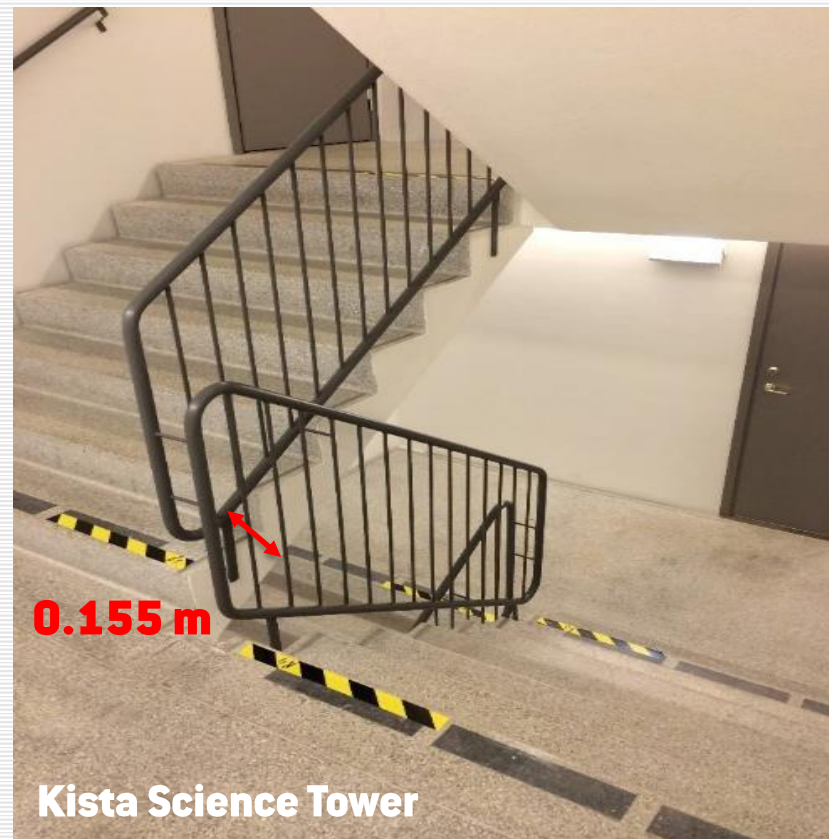
FIELD EXPERIMENTS IN TWO STAIRWELLS

Odd/even number of steps

Radius ~ 0.45 m

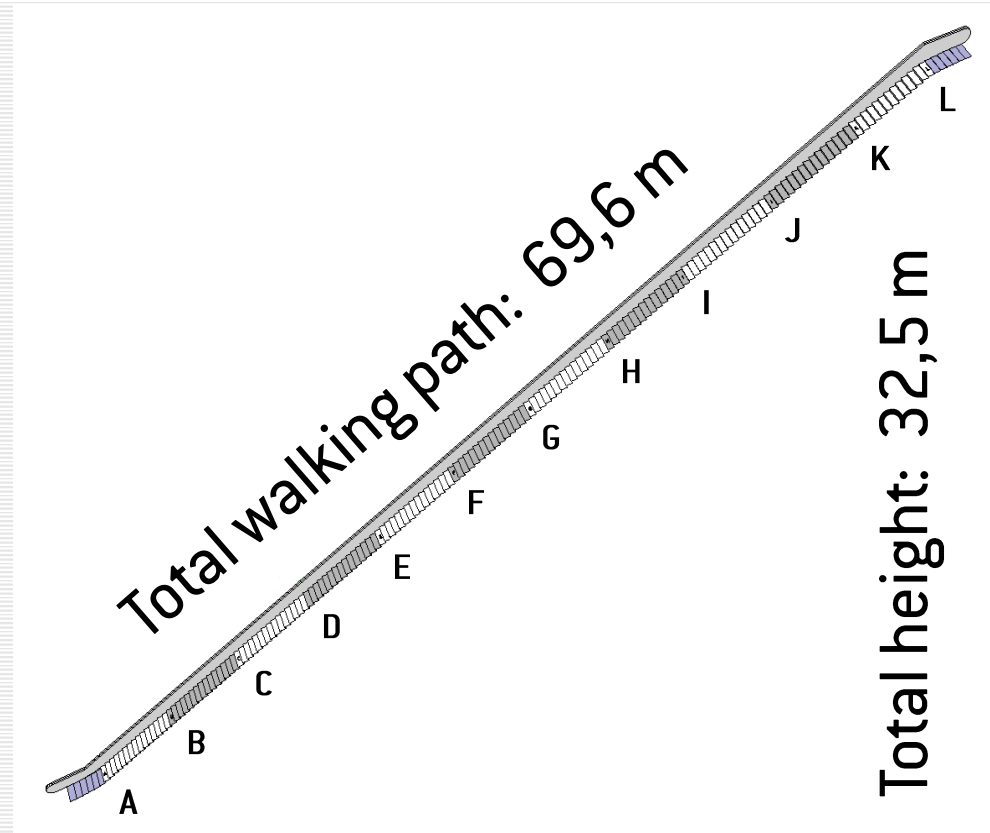


Radius ~ 0.55 m



FIEDL EXPERIMENT IN A STOPPED ESCALATOR

Escalator	Width	Step height	Step depth	Nosing
Västra skogen metro station	1,0 m	0,20 m	0,35 m	0,05 m



FIELD EXPERIMENTS



Individual experiment	Nr. of persons	Men	Women	Age [year]		
				Min	Average	Max
Ideon Gateway	47	27	20	19	33	51
Kista Science Tower	29	16	13	20	32	46
Västra skogen metro station	34	21	13	22	38	64



Group experiment	Nr. of persons	Men	Women	Age [year]		
				Min	Average	Max
Ideon Gateway	15	9	6	21	32	56
Kista Science Tower	26	15	11	19	34	59
Västra skogen metro station	21	11	10	20	29	45

MEASURING

OXYGEN CONSUMPTION

**WALKING SPEED
CHANGE IN
BEHAVIOUR
PERCEIVED
EXERTION**

HEART RATE

**LEG MUSCLE
FATIGUE (EMG)**



VIDEO RECORDING & PERCEIVED EXERTION

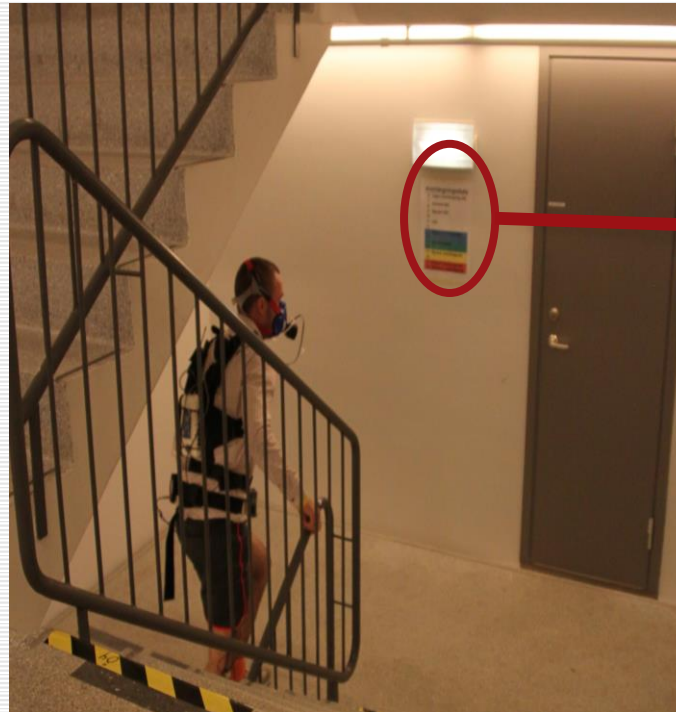
Wall-mounted cameras



Action cameras



Borg scale



Exertion scale

6	No exertion at all
7	
8	Extremely light
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

LABORATORY EXPERIMENT

Measuring

- Heart rate
- Oxygen consumption
- Muscle fatigue (EMG)

