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## INFLUENCE OF CLIMATE CHANGE TO CONCRETE BUILDINGS – PRELIMINARY STUDY



# Influence of climate change to concrete buildings – preliminary study

## Contents:

- Finnish building stock
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- Climate change predictions
- Durability properties and deterioration of concrete buildings
- Conclusions

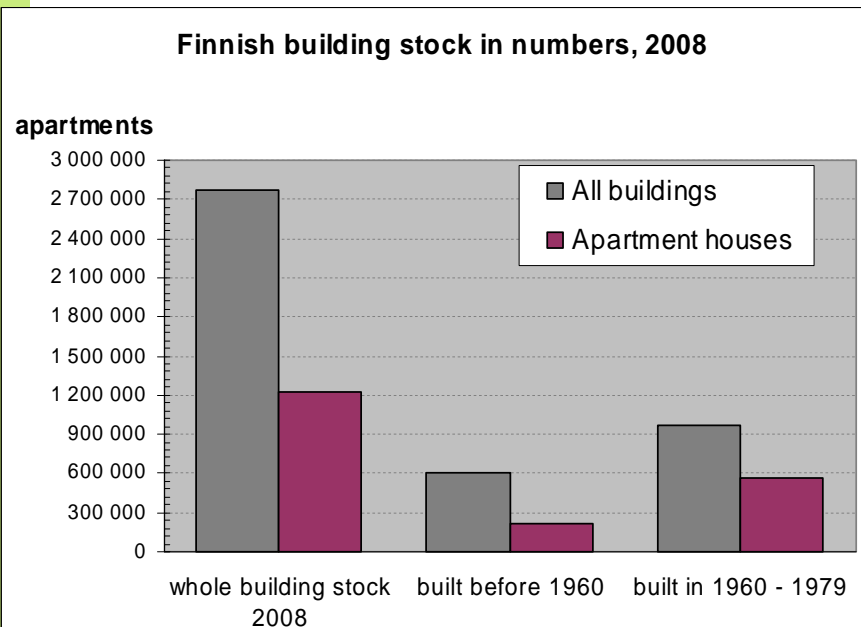


# FINNISH BUILDING STOCK

Half of Finnish apartment buildings has been built between 1960 and 1979  
→ precast concrete buildings.

Totally app. 44 Mm<sup>2</sup> concrete facades, 975 000 concrete balconies until 2005 (and 5,2 million inhabitants).

Remarkable repair need after short service life.



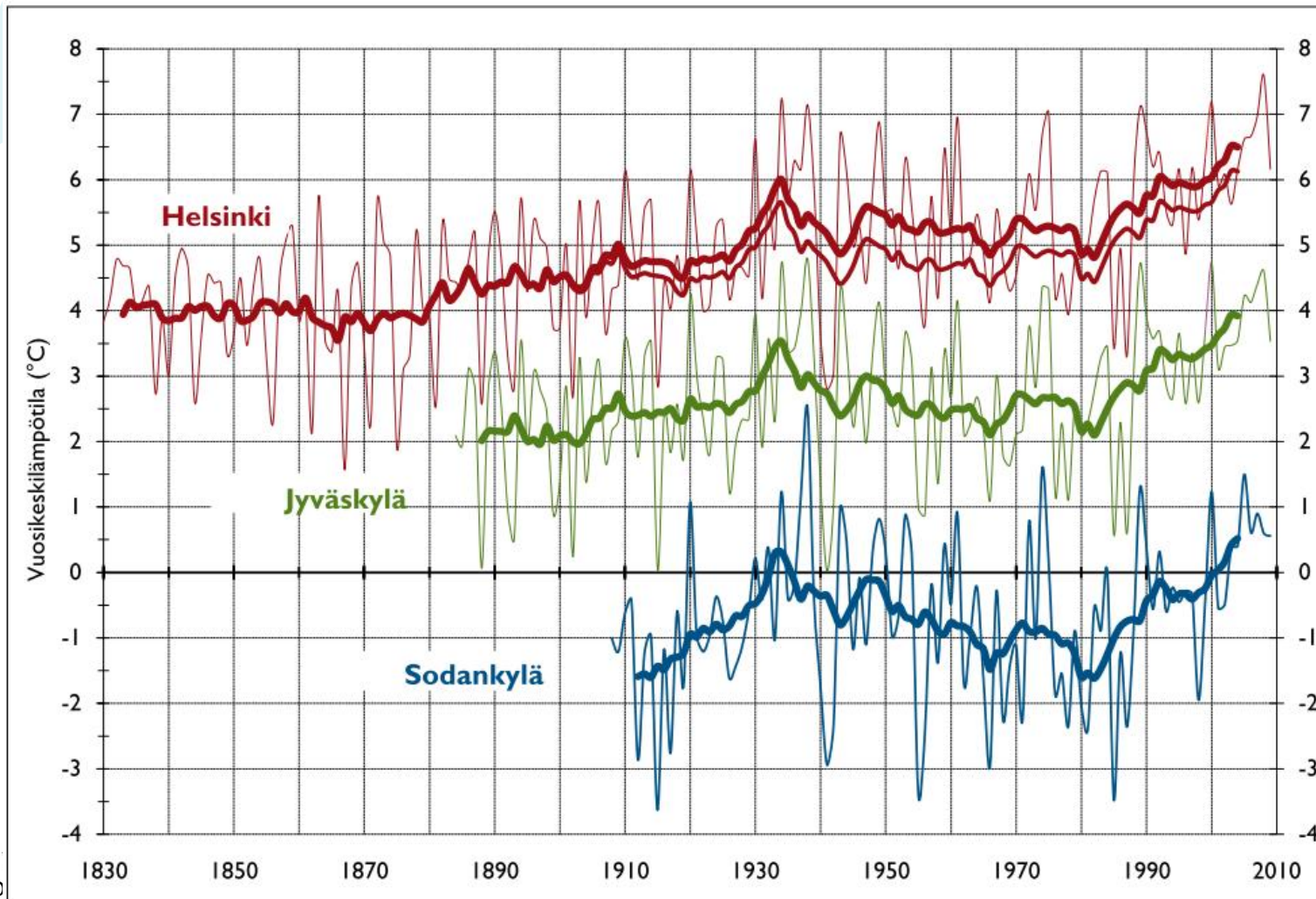
# OBJECTIVES AND RESEARCH MATERIAL

- Estimate the effects of climate change to existing concrete buildings based on present knowledge.
- Estimate usability of today's repair methods in the future climate.
- Research material consist of previous studies
  - ACCLIM (FMI)
  - Repair strategies of concrete facades and balconies (TUT), measured weather data (1961-2009) and researchers experience related to deterioration of facades and repair methods.



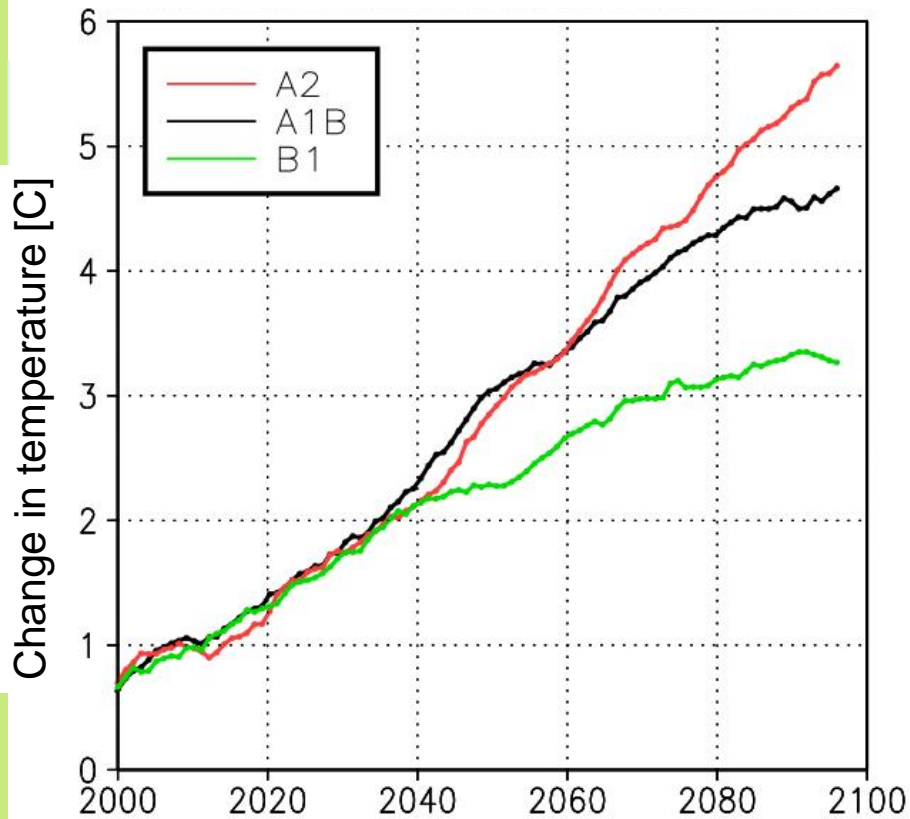
# CLIMATE CHANGE PREDICTIONS, present climate

Annual average temperature in Finland according to FMI

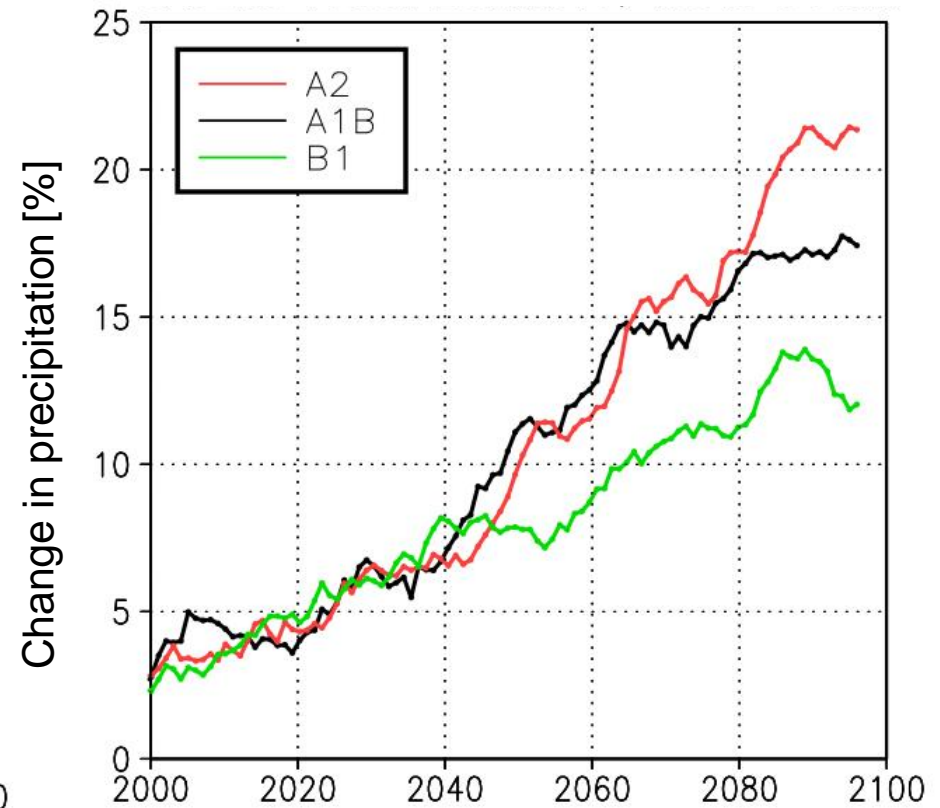


# CLIMATE CHANGE PREDICTIONS

Year average temperature, whole Finland



Year average precipitation, whole Finland



# CLIMATE CHANGE PREDICTIONS

- Average temperature will rise 3 to 9 °C at winter time, and 1 to 5 °C at summer time.
- Precipitation will rise at winter time 10 to 40 % and 0 to 20 % at summer time. The change is more significant in the North than in South. The precipitation will be more in liquid mode also at winter time.
- The rise of temperatures in general will also increase the number of annual freeze-thaw cycles.
- Air humidity will rise in general. The consequence is that drying of structures is slower and the time for good mould growing atmosphere is longer.



# DURABILITY PROPERTIES, frost resistant of concrete

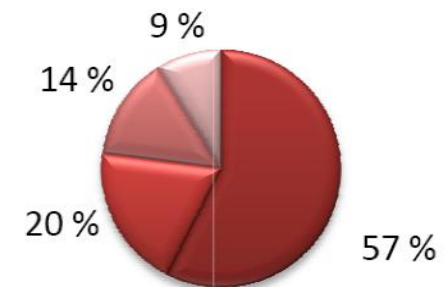
Protective pore ratio should be  $p_r \geq 0,20$

If  $p_r < 0,10$ , concrete has no frost resistant in outdoor climate

Deterioration speed is highest in coastal areas.

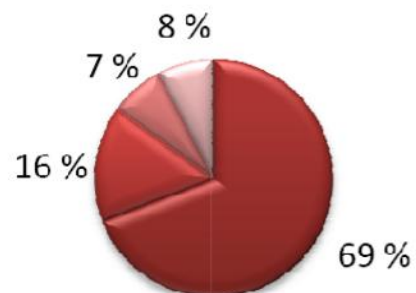
Balcony slab, n= 707

■ < 0,10 ■ 0,10-0,14 ■ 0,15-0,19 ■ ≥ 0,20



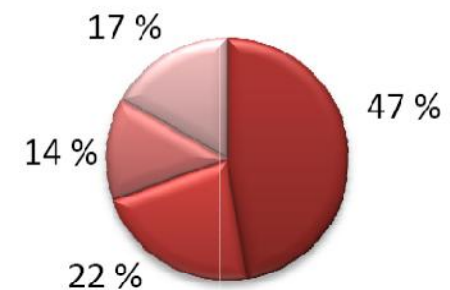
Balcony side wall, n= 718

■ < 0,10 ■ 0,10-0,14 ■ 0,15-0,19 ■ ≥ 0,20



Balcony parapet, n= 483

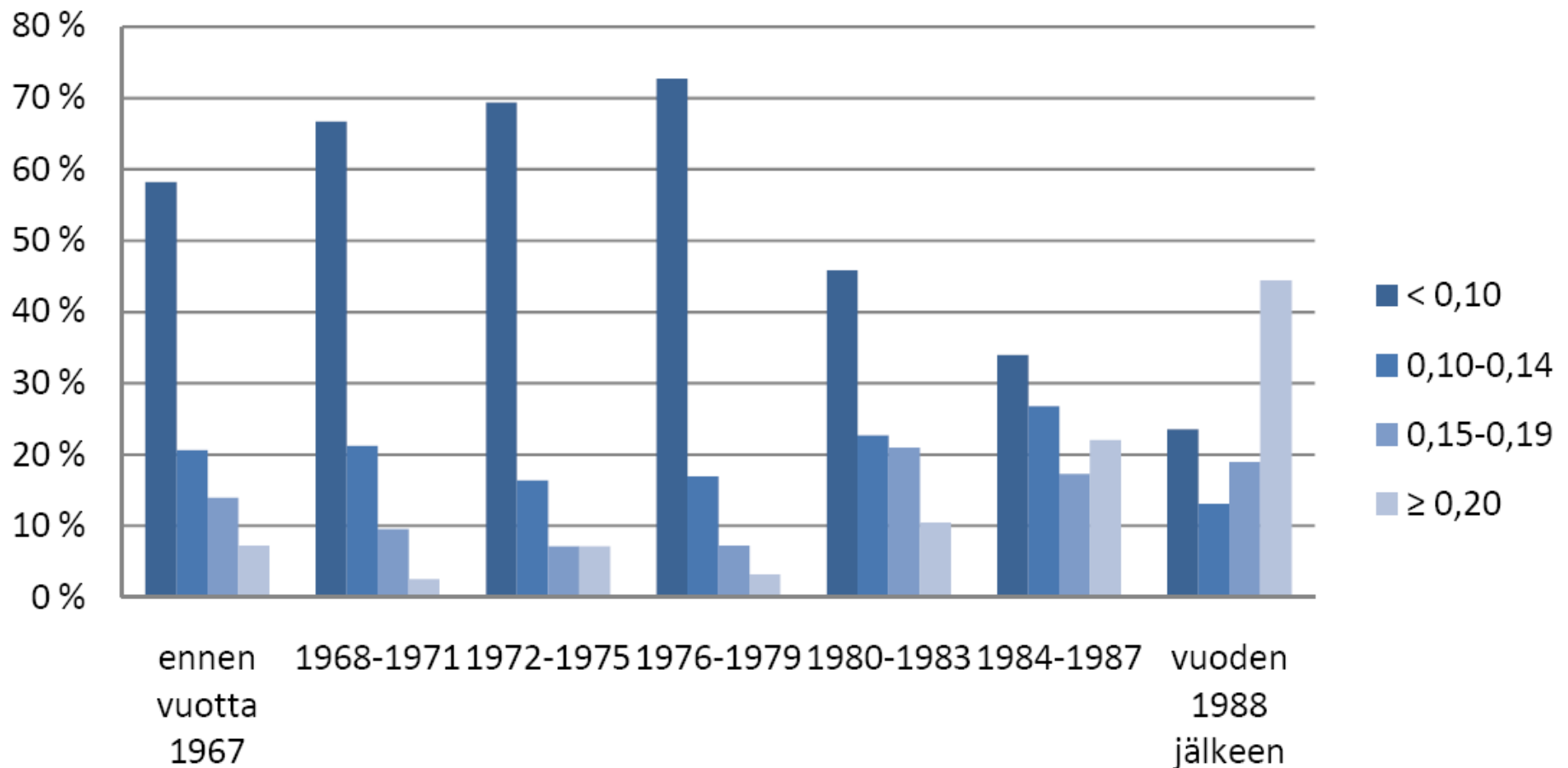
■ < 0,10 ■ 0,10-0,14 ■ 0,15-0,19 ■ ≥ 0,20





# DURABILITY PROPERTIES, frost resistant of concrete

Protective pore coefficient according to competition year, n = 1905



## Annual freeze-thaw cycles (Jyväskylä 1960-2009)

0 °C Freeze-thaw cycles 62 – 138/year (51 – 150/year in Helsinki)

-5 °C Freeze-thaw cycles 15 – 52/year (13 – 34/year in Helsinki)

-10 °C Freeze-thaw cycles 5 – 26/year (2 – 17/year in Helsinki)

Frost damage will occur in porous material only if the pore structure is fulfilled with water over the individual critical point (Fagerlund 1977).

Freezing of concrete structure during 3 days after rain or wet snow

0 °C Freeze-thaw cycles 18 – 37/year (11 – 36/year in Helsinki)

-5 °C Freeze-thaw cycles 8 – 25/year (4 – 20/year in Helsinki)

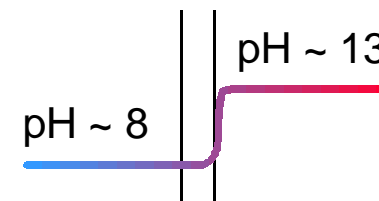
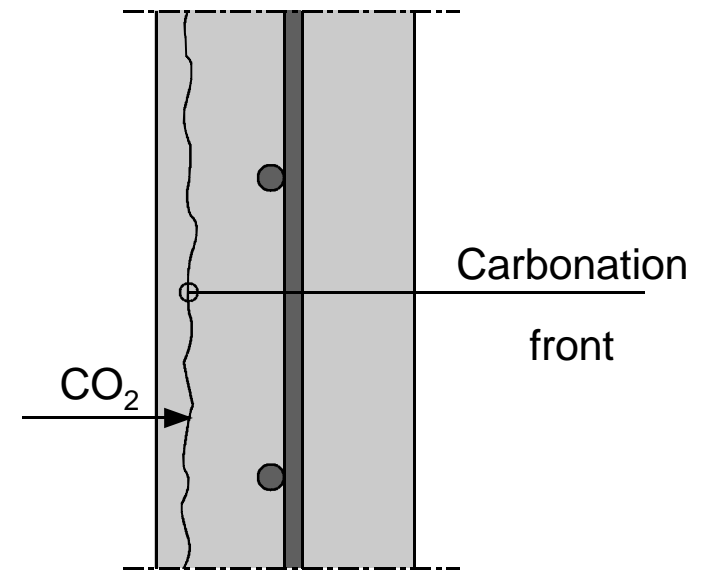
-10 °C Freeze-thaw cycles 2 – 15/year (2 – 12/year in Helsinki)





# DURABILITY PROPERTIES, carbonation of concrete and cover depth of reinforcement

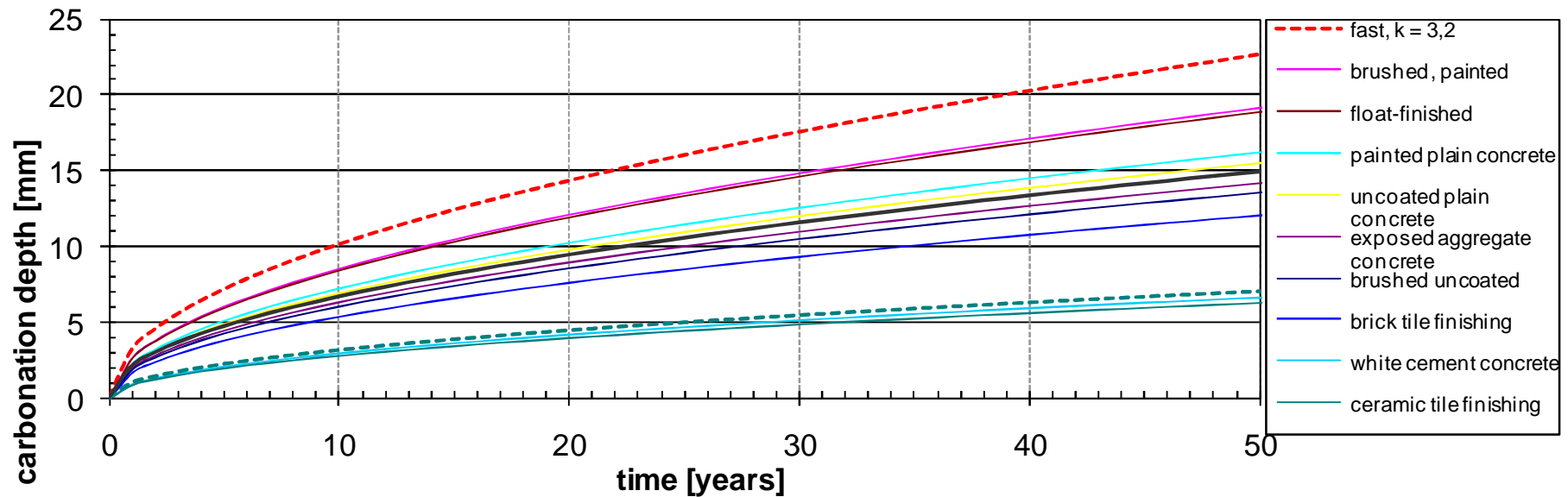
- Cover depths of reinforcement are generally small
- Carbonation of concrete proceed slowly during time.



# DURABILITY PROPERTIES, carbonation of concrete and cover depth of reinforcement

Cover depths of steelbars, Balcony frame  
Single measurements 32 676 piece from 653

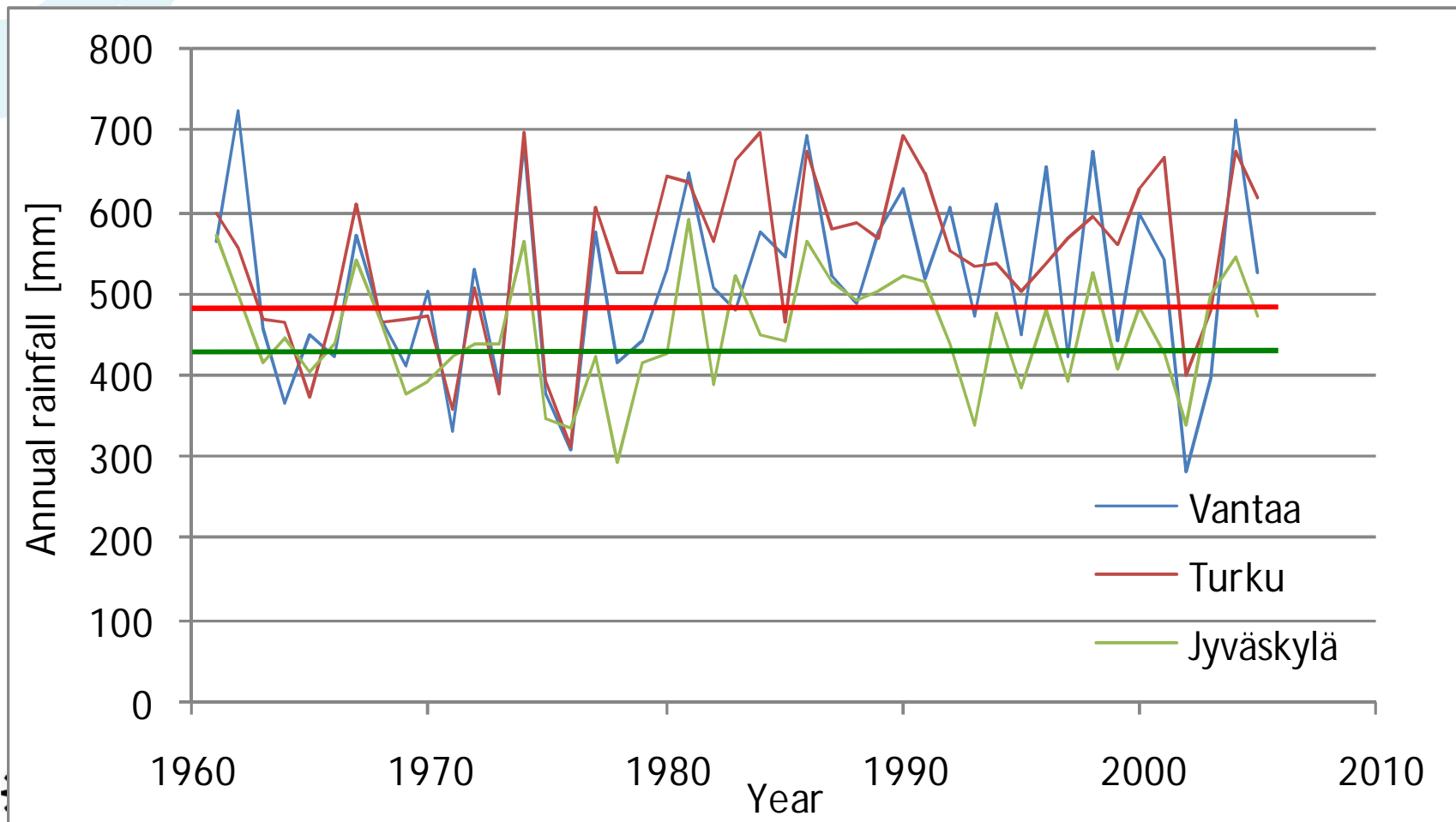
Corbonation of concrete according to surface finishing



Cover depth [mm]

# Weather stress

Corrosion speed depends strongly on the amount of rain.



# CONCLUSIONS

Durability properties of concrete are poor in most of the facade finishing and especially balcony frames. Far advanced and wide spread visually seen damages occurs widely on coastal areas mostly in Finnish concrete facades made 1970's or earlier.

The deterioration speed of concrete buildings has strong relationship with the amount of rain and prevailing wind directions. Deterioration occurs mostly on southern and western facades and is more general in the upper parts of facades than first floors.

The climate change has only harmful effects to existing concrete facades and balconies. The climate will be more severe during next 20-30 years especially inland.



TUT campus



Hervanta suburban area in Tampere  
28 000 inhabitants

Thank You.

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