

# INITIAL DEVELOPMENT OF A COMBINED PCM AND TABS SOLUTION FOR HEAT STORAGE AND COOLING

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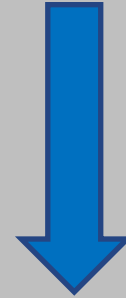
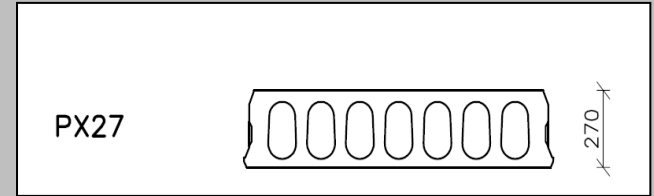
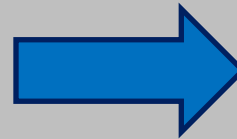
Department of Civil Engineering

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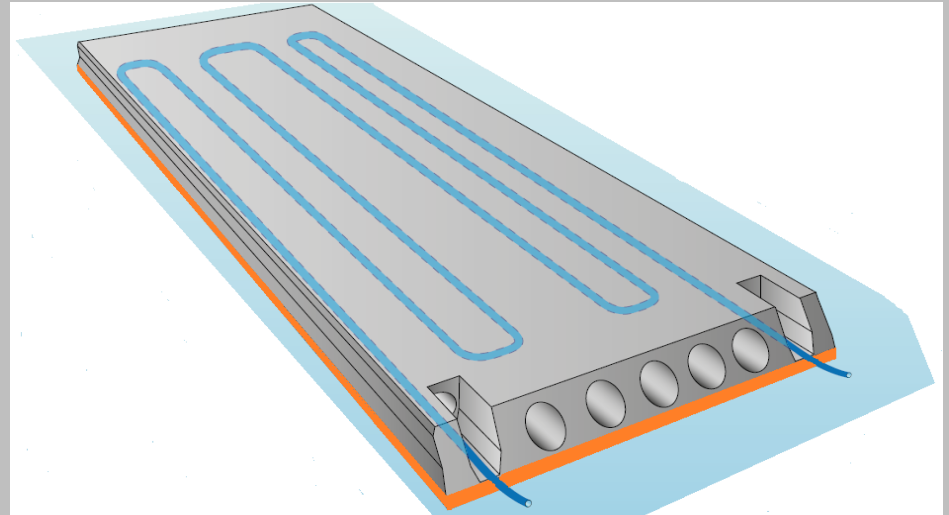
# TABLE OF CONTENT

- Development of combined PCM and TABS concrete element
- Assumption to modeling of combined PCM concrete deck element
- Results
- Conclusion

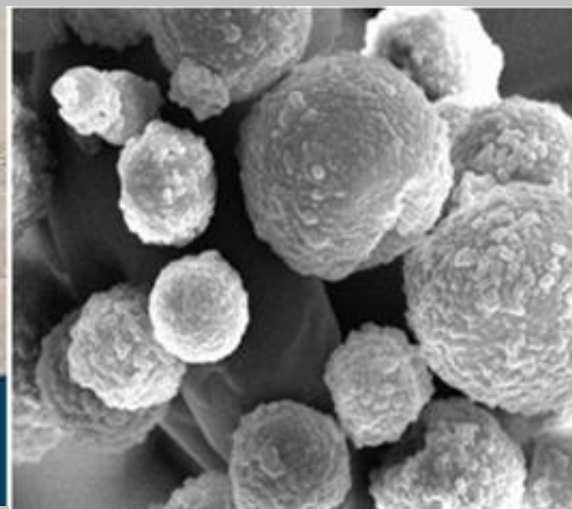
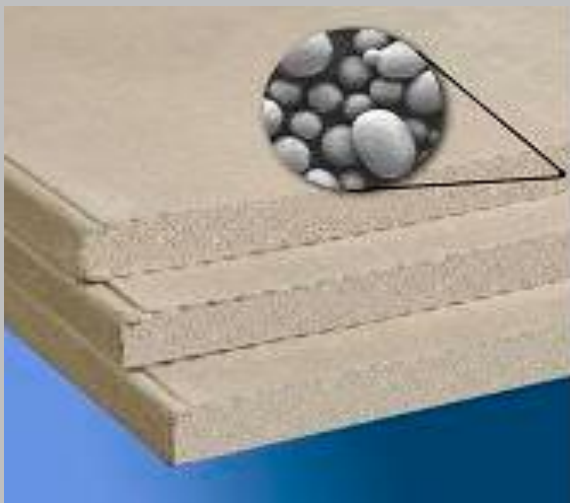
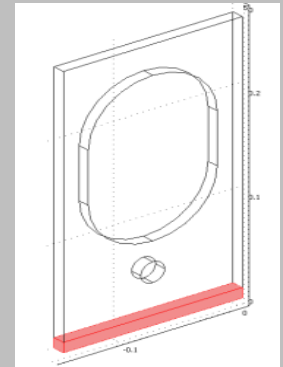
# CONCRETE DECK DESIGN



TABS + PCM

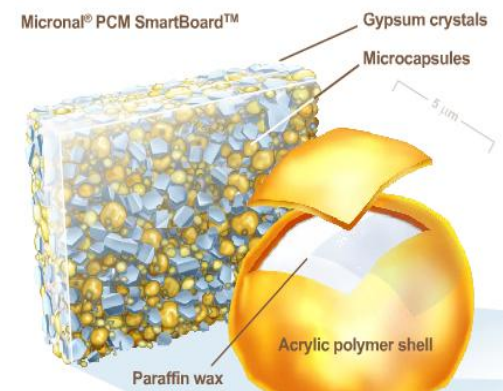


# WHAT IS PCM?



## Micronal<sup>®</sup> PCM – Thermal buffer for hot days

Micronal<sup>®</sup> PCM SmartBoard<sup>™</sup>



# TABLE OF CONTENT

- What is PCM- concrete element
- Assumption to modeling of combined PCM concrete deck element (COMSOL)
- Results
- Conclusion

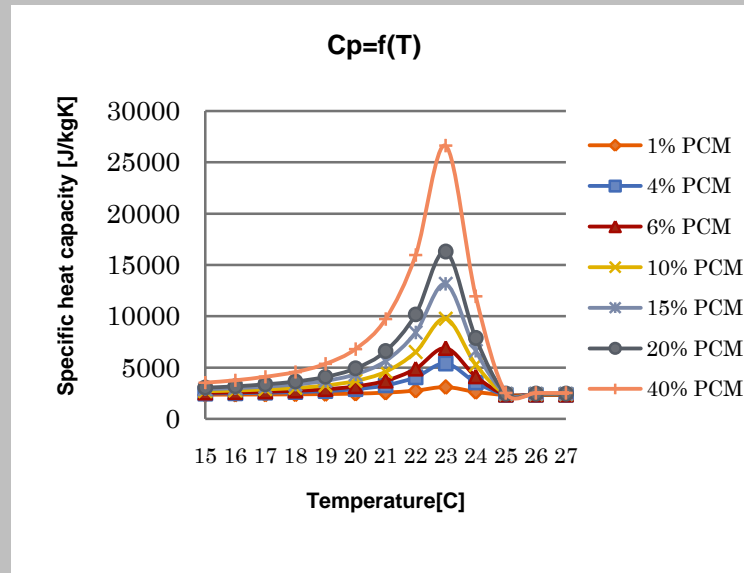
# ASSUMPTION TO COMBINED PCM-CONCRETE MATERIAL

density

PCM [%]	density [kg/m <sup>3</sup> ]
0	2300
1	2287
4	2247
6	2221
10	2168
15	2102
20	2036
40	1772
60	1508
80	1244

\*Calculated as weight average

specific heat capacity



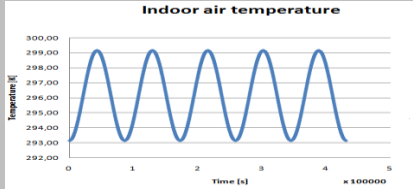
\*Calculated based on enthalpy curves obtained from DSC for pure PCM

thermal conductivity

PCM [%]	$\lambda$ [W/mK]
1	1,78
2	1,77
3	1,75
4	1,73
5	1,72
6	1,7
10	1,63
15	1,55
20	1,47
40	1,14
60	0,8
80	0,47

\*Calculated according to area average equation for inhomogeneous constructions

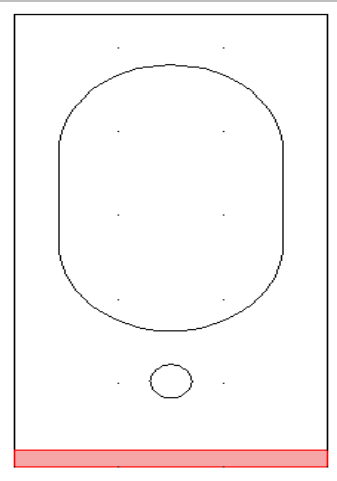
# ASSUMPTION-BOUNDARY CONDITION



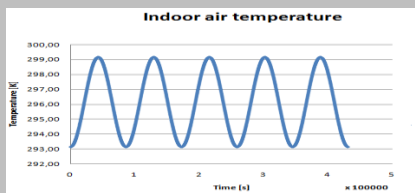
convection + radiation

combined convective and radiative heat transfer coefficient:  
 $h$  [W/m<sup>2</sup>K] (2,4.....30)

Adiabatic



Adiabatic

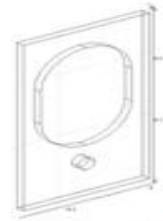


combined convective and radiative heat transfer coefficient:  
 $h$  [W/m<sup>2</sup>K] (2,4.....30)

convection + radiation

# ASSUMPTION-LOCATION OF PCM

Reference:



Only concrete

Geometry 1:



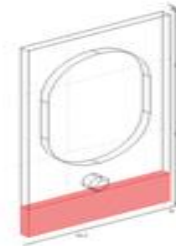
1cm PCM



2cm PCM



3cm PCM

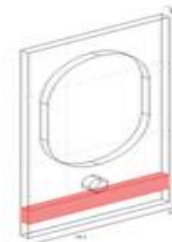


4cm PCM

Geometry 2:



1cm concrete 2cm PCM

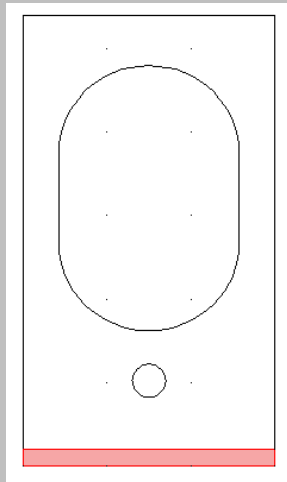


2cm concrete 2cm PCM



# PASSIVE VS. THERMALLY ACTIVATED DECK

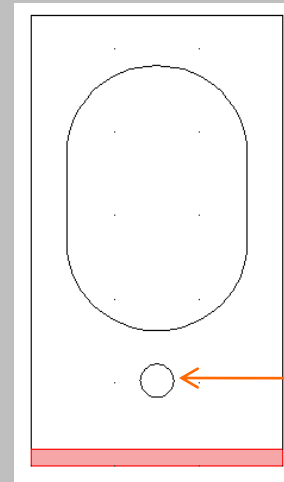
## ○ Passive



## ○ All variables:

rho, Cp, conductivity, combined heat transfer coefficient, geometry

## ○ Active



## ○ All variables:

rho, Cp, conductivity, combined heat transfer coefficient, geometry

Water temperature:  
16°C  
18 °C  
20 °C

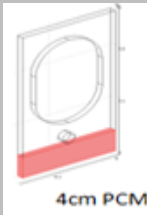
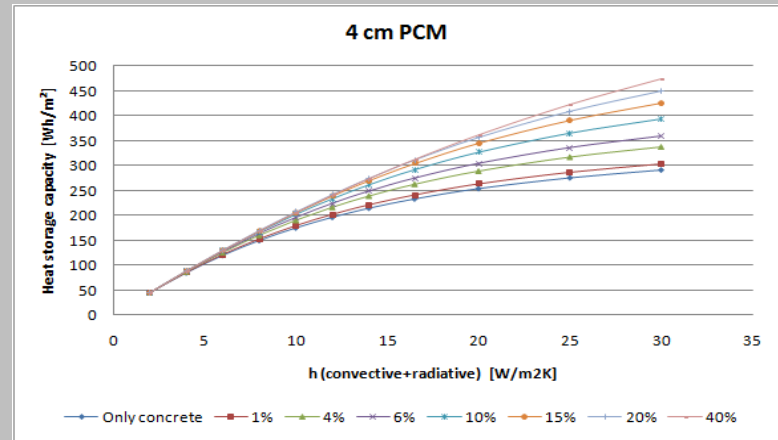
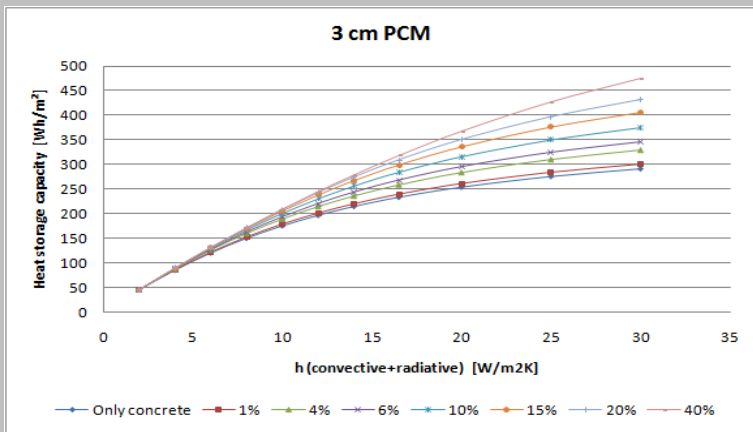
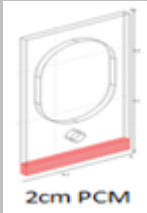
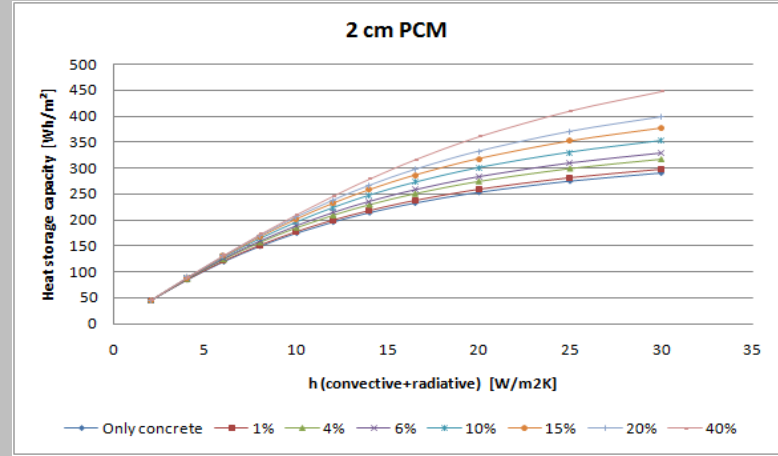
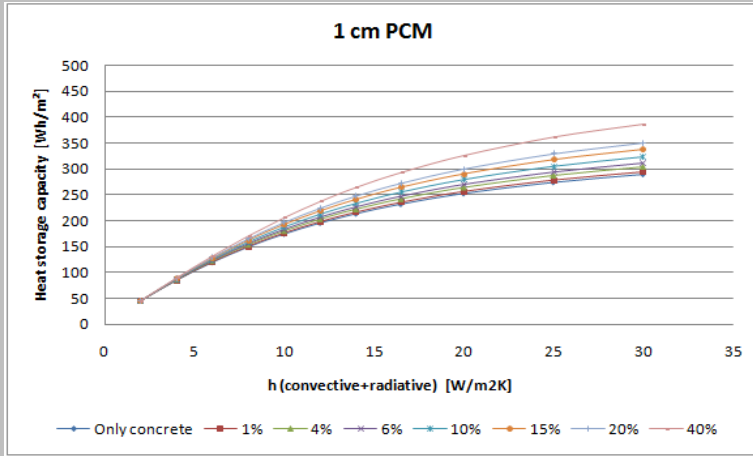
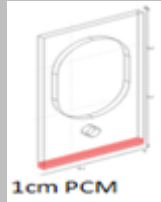
Pipe location

Control strategy:  
24 h active  
12h active  
8h active

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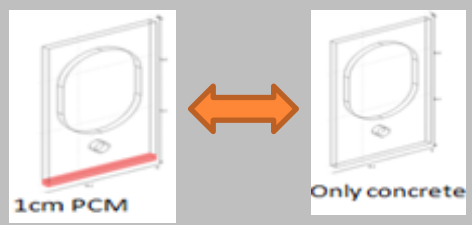
- What is PCM- concrete element
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# PASSIVE – RESULTS (GEOMETRY1)

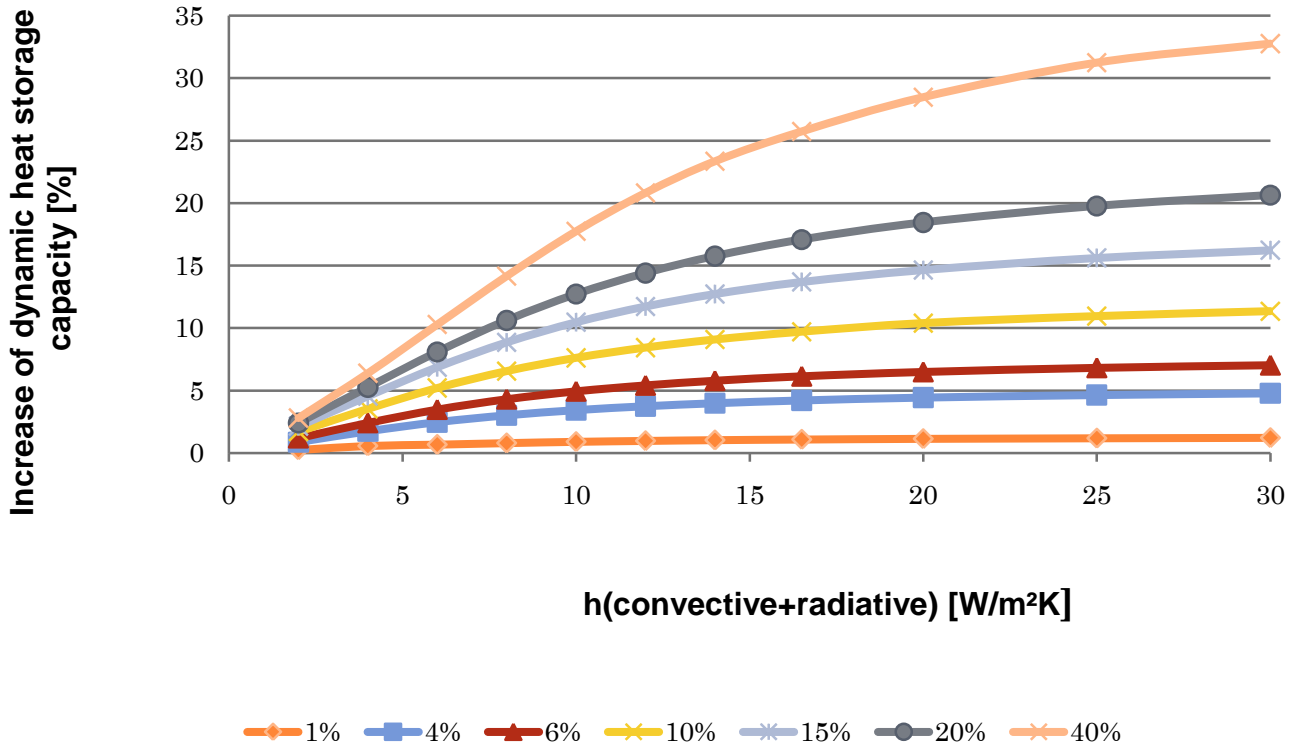


◆ Only concrete 
 ■ 1% 
 ▲ 4% 
 ✖ 6% 
 ✱ 10% 
 ● 15% 
 + 20% 
 — 40%

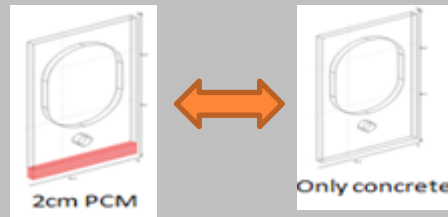
# IMPROVEMENT OF DYNAMIC HEAT STORAGE



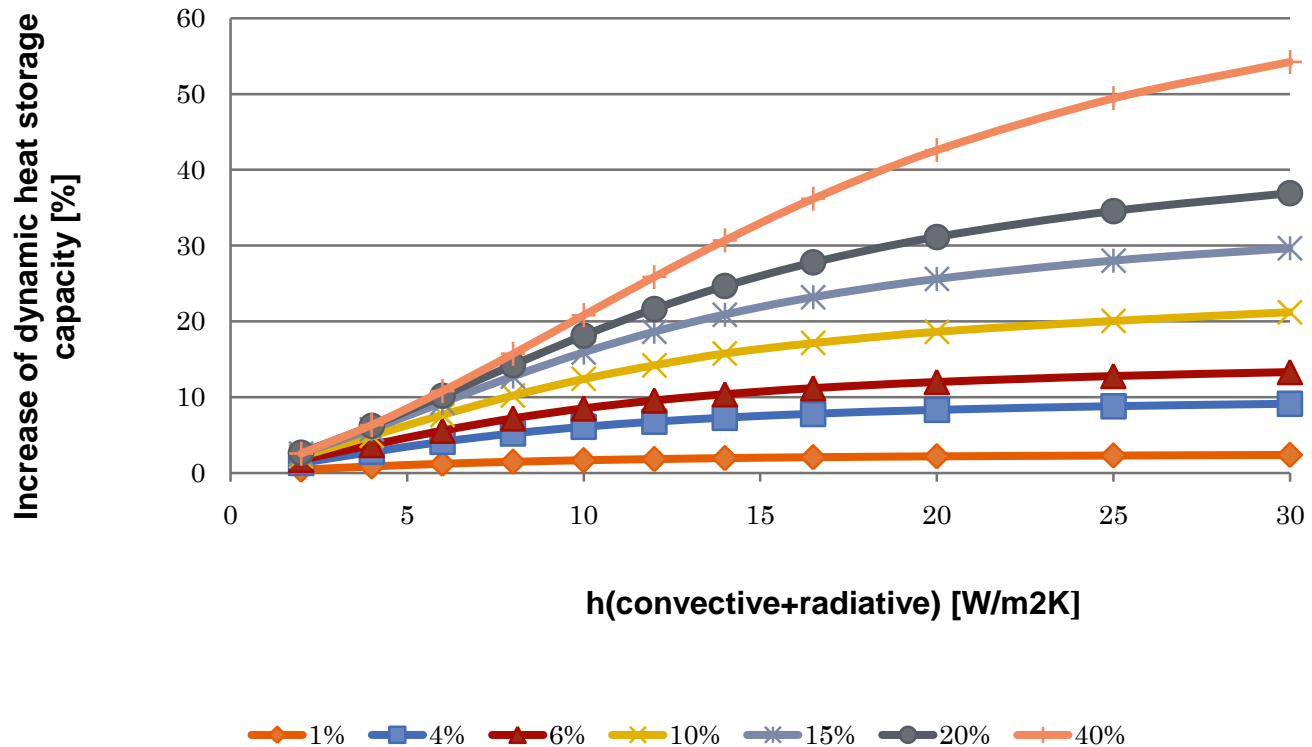
## 1 cm PCM vs Only concrete



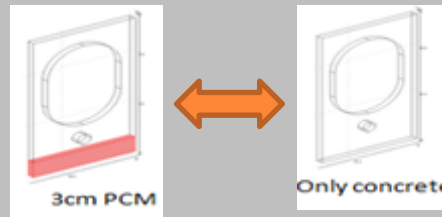
# IMPROVEMENT OF DYNAMIC HEAT STORAGE



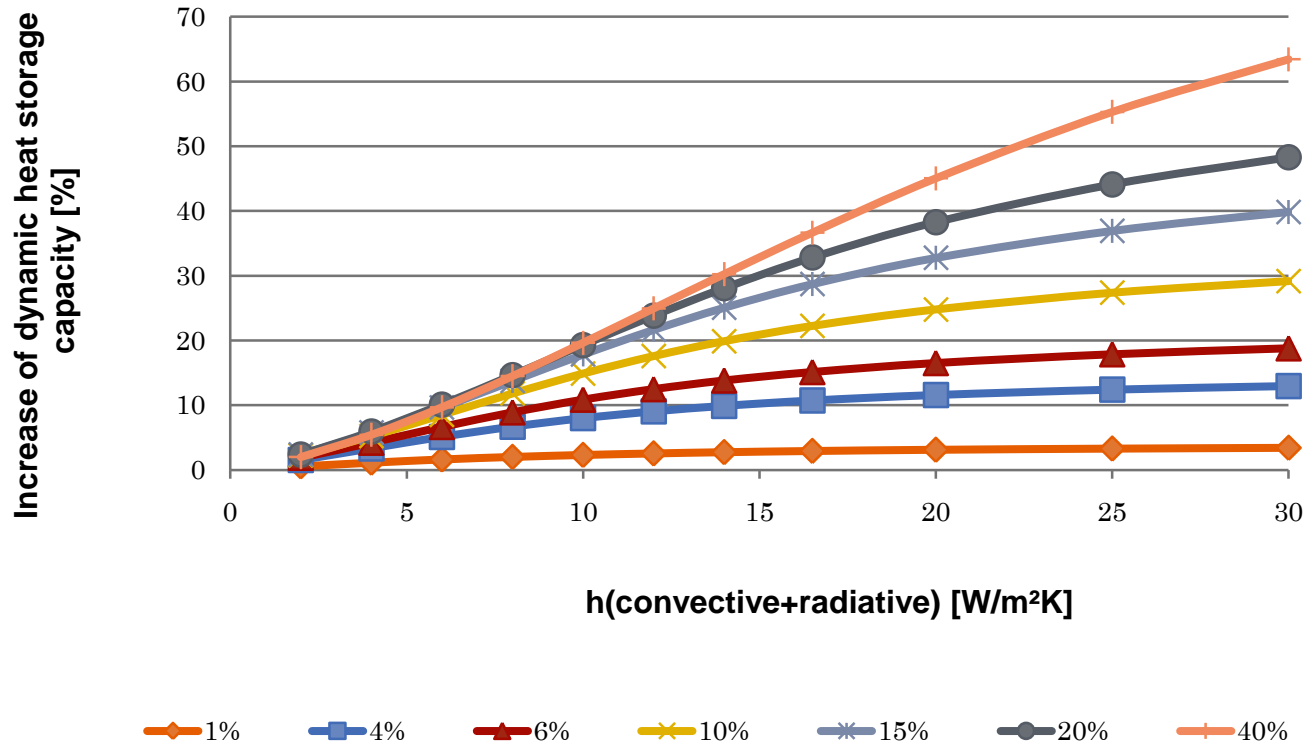
## 2 cm PCM vs Only concrete



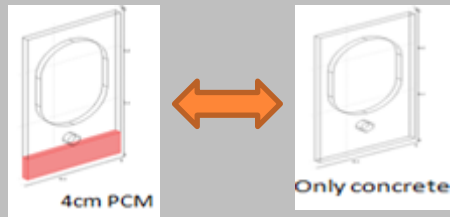
# IMPROVEMENT OF DYNAMIC HEAT STORAGE



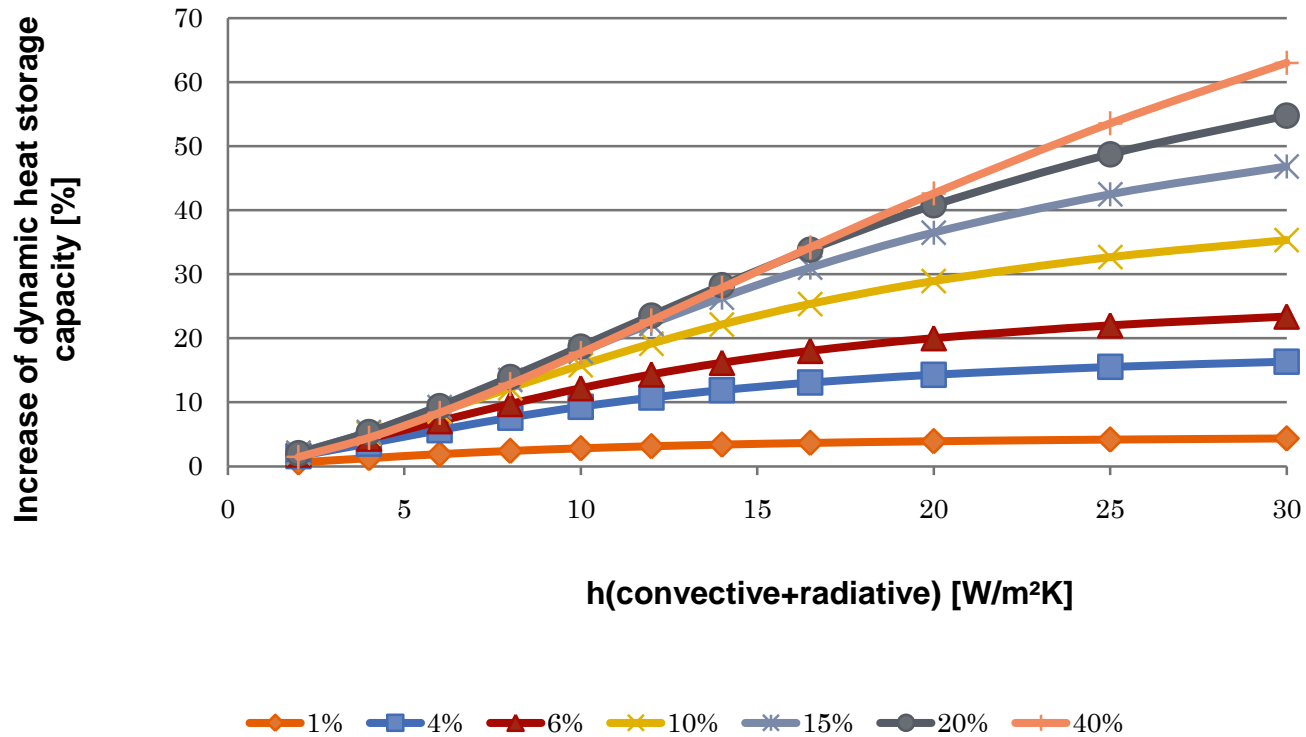
## 3 cm PCM vs Only concrete



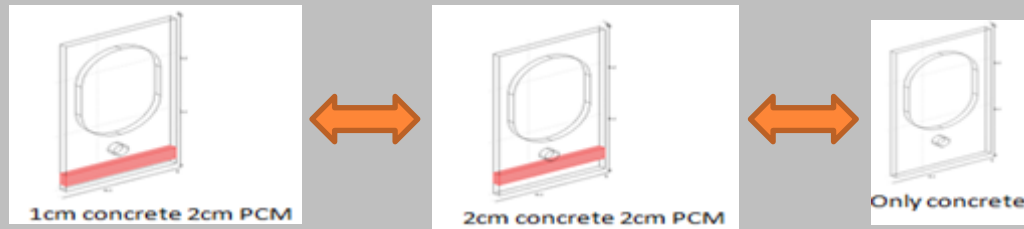
# IMPROVEMENT OF DYNAMIC HEAT STORAGE



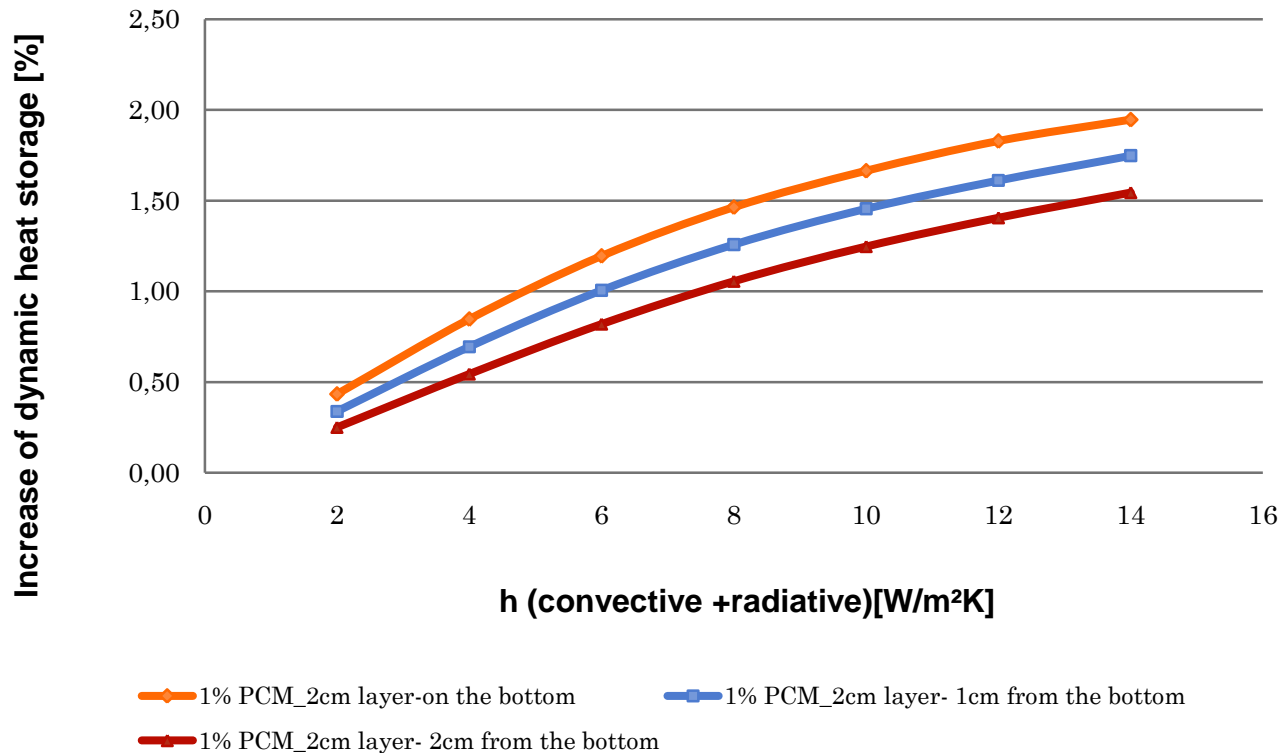
## 4 cm PCM vs Only concrete



# PASSIVE – RESULTS (GEOMETRY 2)



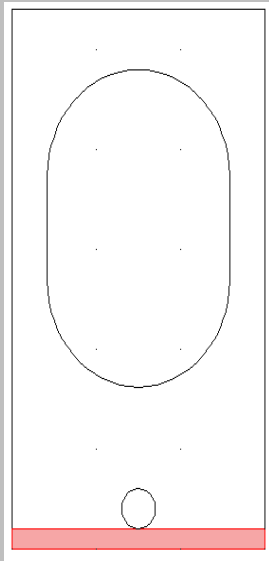
**2cm PCM layer relocated to the inside of the deck vs Only concrete**



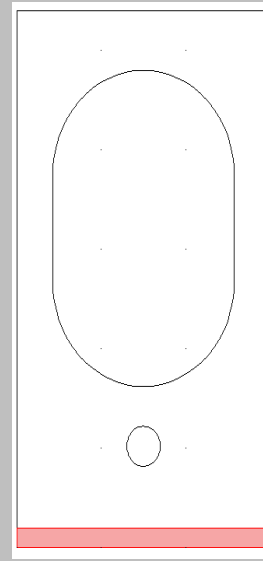


# ACTIVE – MODELING ASSUMPTION

- Water flow is **turned on (24h, 12h, 8h)**.
- Geometry 1: 1 cm with PCM on the bottom of the deck
- Location of center of the pipe from the bottom is:



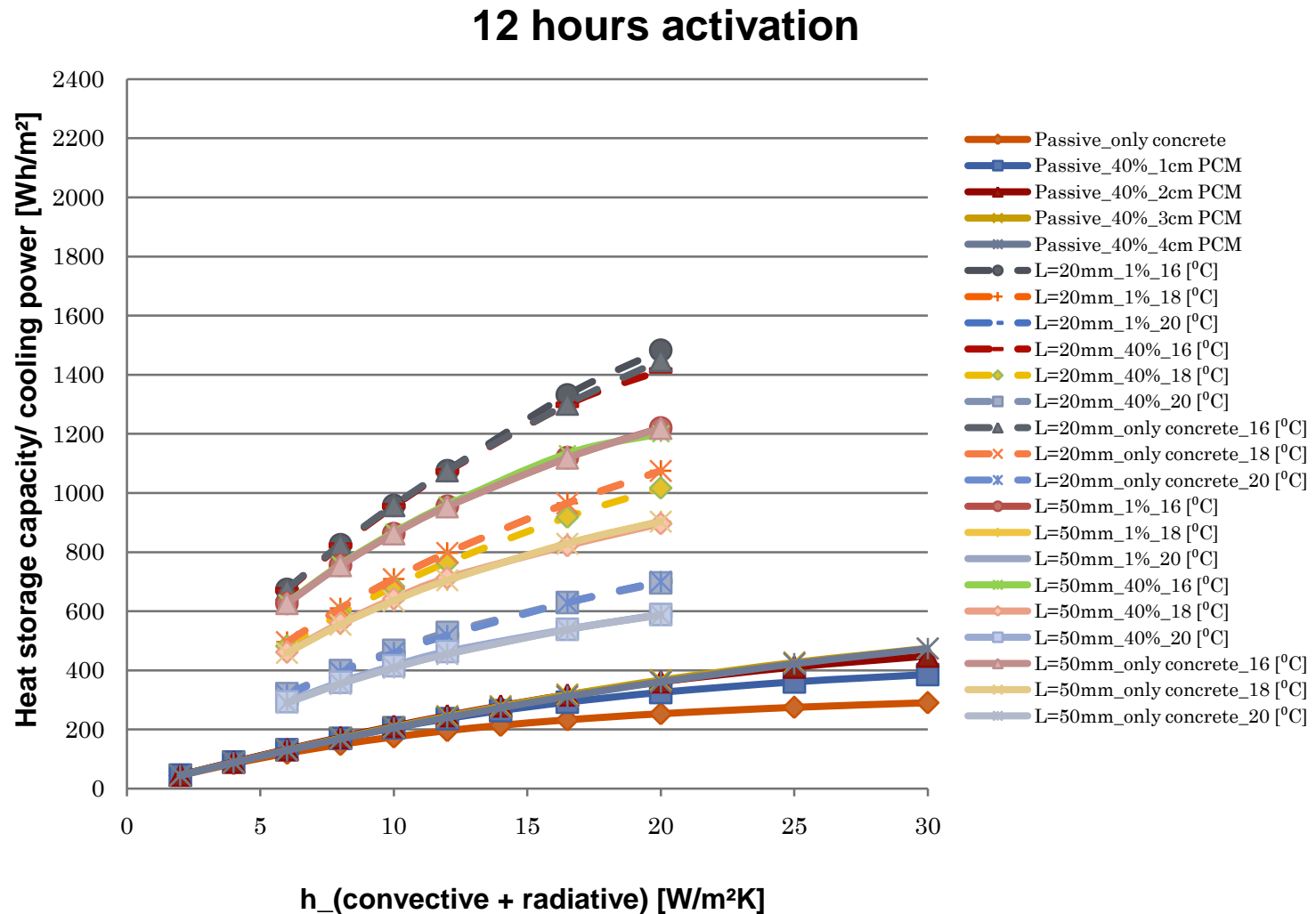
20 mm



51 mm



# 12 HOURS ACTIVATION





# CONCLUSIONS

- ❑ If PCM shall be implemented in concrete deck element then the best location seems to be closest to its surface.
- ❑ To improve dynamic heat storage capacity of already heavy element it is necessary to make sure that heat transfer coefficient on the surface is possibly highest (high convection or high radiation or both convection and radiation must be high).
- ❑ Implamentation of PCM in the concrete deck might be not enough to guaranty good indoor climat.
- ❑ In order to achieve sufficient cooling effect it is necessary to activate heavy construction by for example providing hydronic technology.
- ❑ PCM can damp effect from thermaly acivated system TABS.
- ❑ If thermaly activated system together with PCM can have sufficient cooling effect then further optimization shall be focused on control of TABS.

THE  
END

Thank you for attention