

Valuation of the effects of the natural convection for reducing condensation of Igloo type magazine

Lee Jong chan¹ and Kim Yun jin² and Park Yong ho and Kim Byung seon

¹Department of Architectural Engineering, Yonsei University, Seoul, Korea
statesman@hanmail.net

²Department of Architectural Engineering, Yonsei University, Seoul, Korea
kimyj0320@yonsei.ac.kr, sean@yonsei.ac.kr

ABSTRACT : A Igloo type magazine is the structure that after building the structure on the ground, covered on an upper slab. Exactly as covering with earth on the upper slab, even if it is the ground building, have character of heat environment like underground environment. A indoor temperature is less than the air and keeps a low temperature, but with the air, surface condensation is easy to be generated in the rainy season. This study is to analyze the natural convection to have an effect on condensation in the covered with earth magazines then present to the solution for reducing condensation from increasing the natural convections.

Keywords: Igloo, Ammunition, Condensation, CFD

1. INTRODUCTION

The development of a modern society is on the increase to use underground space as an overpopulated phase of city and a shortage of useful site. An underground space has various uses such as a subway, an underground passage and a store, a warehouse, a parking lot and a shelter. However, there are a natural lighting, the regulation of the quality and humidity of the air to solve an environmental problem for the development of the underground space.

The underground spaces deteriorate the air more than the ground. Because convection and ventilation of the air are short, increase humidity and happen mold. The Igloo magazine is a shelter to have more than 70cm covered structure on the top and the side of a slab. Therefore the inside temperature of a magazine is change less, but less than the air in summer. It means,

when the high temperature and humidity air flow into the inside, easy to approach the dew point temperature, so the condensation happens.

Especially it is happened rust on the surface of ammunition as condensation in ammunition's case. Because of this, a national defense budget is expanded. In other words, of all defective ammunition, the incidence of a defective ammunition is about 82% for the reason of a defective magazine. It accounts for 4~5% among the saved ammunition. Considering an estimate, the maintenance volume is approximately 12,687ton, the budget required is about four billion seven hundred thirty million won in 2007.

Aims of this study are to suggestion what is included improvement design of natural convection for condensation reduction through mechanism of internal surface condensation depended on experiments and

numerical analysis of natural convection in igloo magazine.

There are research methods and procedure to search for a plan which increases a natural convection for reducing condensation in shelter as follows;

- (1) Check a site for analysis about the research data and an understanding about the reality of condensation.
- (2) Through an experiment about creation of an air current in shelter and simulation modeling, define an inter-relationship between the air current and inside temperature.
- (3) Through an analyzed result, present a plan which increases a natural convection for reducing inside surface condensation.
- (4) This study suggests the design which is included natural ventilation for increasing devices based on analysis results for reduction of internal surface condensation.

This researches are experimented in 207.9m² Igloo magazine without an ammunition.

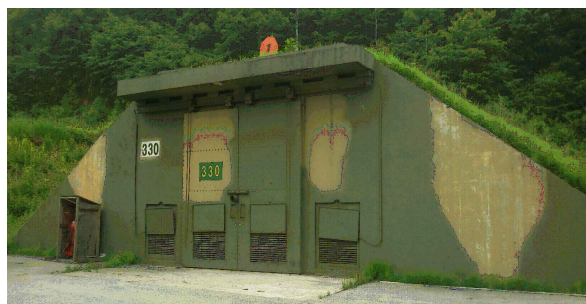


Figure 1: Front view of shelter

2. The actual condition of condensation in shelter

2.1 Synopsis

A shelter is the structure that after building the structure on the ground, covered with earth on slab. Figure 2 is one unit concrete structure as 107.9 m² Igloo magazine.

2.2 Condensation state



Figure 2: Condensation in Igloo magazine

The more go inside from the gate, the condensation is happened at a height of less than 75cm from the ground, especially happens a corner, depth on second inside and a bottom as Figure 2 and 3.

3. Measurement of airflow velocity in shelter

3.1 Experiment conditions

Measured a speed of a flowed air current to a suction hole for 207.9 m² shelter in Uijeongbu OO area, Kyunggi-Do.

Experiment was measured at 10AM to 2PM on 30 May, 2008, a measuring machineries were KIMO transmitter and an airflow CYV200 as Figure 3, 4, 5, 6, 7 and 8.



Figure 3 : measure (1)



Figure 4 : measure (2)



Figure 5 : measure (3)



Figure 6 : measure (4)



Figure 7 : measure (5)



Figure 8 : measure (6)

3.2 Measuring result and analysis

Arranging on the above the measuring result, runs Table 1.

Table 1: Experiment results

Type	Temp. (°C)	Air Vel (m/s)	note
Inlet of outdoor	19.6	0	Δ Temp. 3.6°C
Inlet of indoor	15.8	0	
Opening Exit	18.7	0	H:0.5m
Open Exit (center)	19.2	0.11	H:1.3m
Open Exit (upper)	17.7	0.24	H:2.5m
Open Exit (inside)	17.4	0.07	H:1.3m

Analyzing this Table 1, runs as follows;

It's very weak to flow the air as inlet, at a lower fate on both sides, even though open

the front gate, a speed of the air current is very weak.

However, the more go upside, the more increase the velocity of the airflow, because 0.24m/s at a height of 2.5m.

This is the measuring result, when a door is opening, an inside temp. is low in shelter, especially find the low temp. air to intercept an inflow of the air. Differences of temperature are caused by measurement point locations between indoor and outdoor. 3.6 °C gap is reported between inlet and outlet on landfill cover soil in shelter parts, however 1.8°C temperature difference exists in case of opened door

Exactly, as measuring result of a temp. of Clause 3.2, the lowest temp. point is the bottom, as it makes a low heavy air stratum and stays the low part, caused by condensation. With this fact, installing inlet at the upper is better than the low part.

4. Analysis of the inside natural convection in shelter to use CFD

4.1 Synopsis

With this experiment, an air flowed into the shelter gate is very weak. Therefore, the flow of air on the inside is restricted; it has not an influence on reducing surface condensation. For this reasons, with CFD,

All of these are considered as parameters those are analysis in condition of that is controled interior air-flow in intake variable, interior air-distribution and velocity due to changing intake arrangements, and temperature variable. The former is reflected in valuation of condensation sensitivity.

In this research, the program used CFD analysis is as Figure 10.

4.2 Simulation modeling

We are modeling 207.99 m² shelter like a Figure 9.

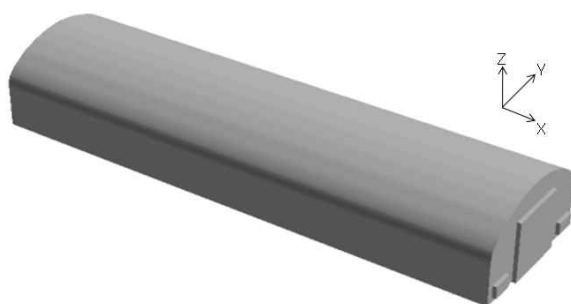


Figure 9 : CFD modeling and axis

Numerical model for CFD is k-ε Turbulence model using High Reynold Number

4.3 Analysis of the inside convection and temperature in shelter to use CFD

(1) Boundary condition

Make up for the air conditions to set standard for weather data in Uijeongbu OO area, Kyunggi-Do, it follows the Table 2.

Table 2: Boundary condition

Type	Aver.
Out Temp.	26.88(°C)
Inner Temp.	23.73(°C)
Inner Rel. Humidity	97.3(%)
Inner Abs. Humidity	0.0092(kg/kg')
Out air vel.	1.7(m/s)
Main direction of wind	W-NW
Turbulence Model	K-ε/High Reynolds number

Set standard for the direction of the wind and wind velocity, analyze CFD about a suction hole of the shelter, it follows Figure 10.

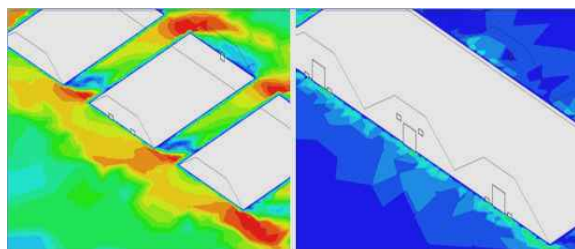


Figure 10 : analysis of outer airflow

Magazine is similar to the structure inside the ground except the front. The depths of covered with earth structure are the upper part is about 0.6m and the side is 1~5m, apply to the temperature inside the ground, it follows the Table 3.

Table 3: earth temp. in kyunggi-Do(Aug)

Type	Temp.(°C)	Type	Temp.(°C)
surface	27.6	3m	17.6
1m	24.1	4m	15.2
2m	19.9	5m	14.2

The Table 4 shows boundary conditions of materials of a structure, distinguish by a wall, a bottom, a slab and front side wall, calculating thermal resistance($\text{m}^2\text{h } ^\circ\text{C/kcal}$), it could be each 3.836, 0.814, 0.61, 0.0054.

Table 4: material properties

Type	Thick-ness (m)	Thermal Conduct-ivity ($\text{kcal/mh } ^\circ\text{C}$)	Resist-ance ($\text{m}^2\text{h } ^\circ\text{C/kcal}$)
Inner Wall	Mortar	0.02	0.998
	Cement brick	0.1	1.2
	Space	0.05	0.023
	Con'c	0.26	1.4
	Sheet	0.03	0.1
Floor	Sand	0.25	1.57
	Con'c	0.3	1.4
	gravel	0.26	0.6
Ceiling	Sand	0.25	1.57
	Sheet	0.03	0.1
	Con'c	0.21	1.4
Front Wall	Con'c	0.3	1.4
Steel door	Steel	0.2	37

(2) Simulation result

Prepare a valuation basis for analyzing the result of a simulation, it's Figure 11. A X axis is to find condensation which is generated as flowed an inside magazine, a Y axis is a vertical section, and a Z axis is a height.

It's caused by the low bottom and the wall. With the last study, based on the truth which condensation is generated less than 75cm height and inner of X2 and the surface of the wall.

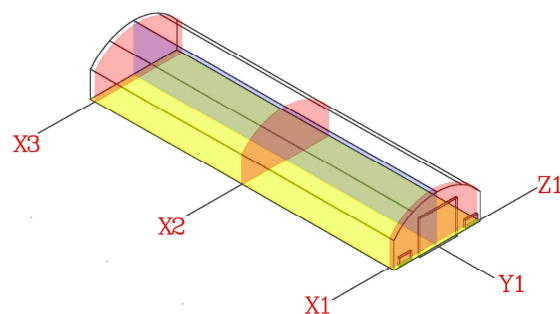


Figure 11: Valuation basis of CFD

The locations about each point in Figure 11 are Table 5.

Table 5: Location of each point

	Type	X(m)	Y(m)	Z (m)
X	X-1	+26.3	0	0
	X-2	+12.6	0	0
	X-3	+0.4	0	0
Y	Y-1	0	0	0
Z	Z-1	0	0	+0.10

Figure 12 shows an airflow speed about the air intake, and Figure 13 is the airflow speed, when changing the location of the air intake.

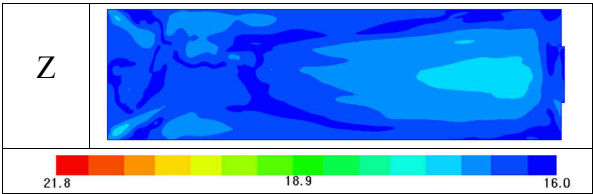
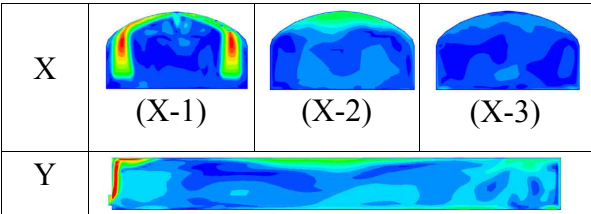


Figure 12: Airflow of the existing condition

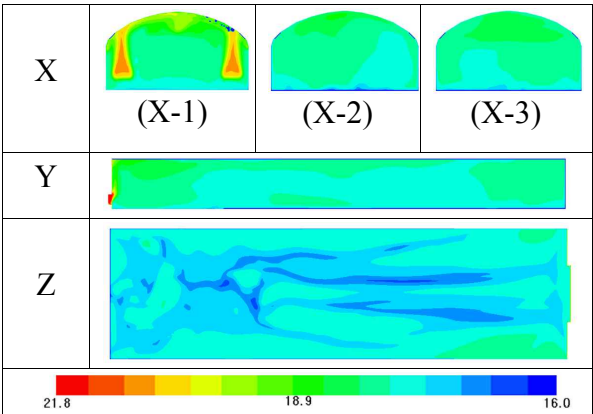


Figure 13: Temperature of the existing condition

Figure 14 is a change of a airflow about the air intake, and Figure 15 is a change of a temp., when changing the location of the air intake.

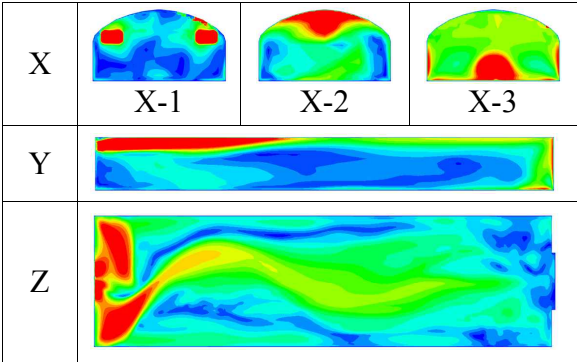
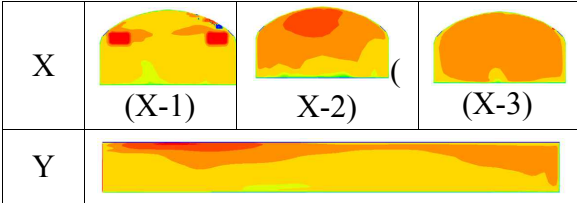


Figure 14: Airflow when changing the location of the air intake



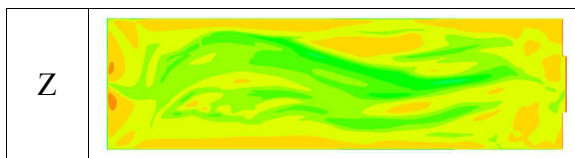


Figure 15: Temperature when changing the location of the air intake

On the basis of this simulation results comparing interrelationship between an air and a temperature, Table 6.

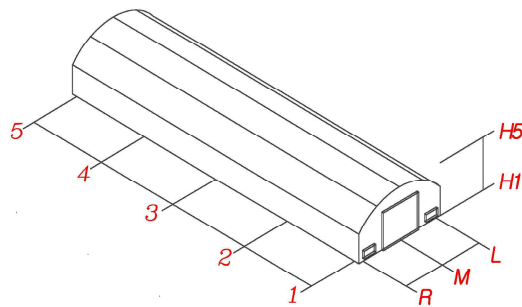


Figure 16: Measure point

Location of M is the center of the vertical axis, L and R are kept off the vertical axis each 3.42m, 1,2,3,4 and 5 are kept off each gate 0.40m, 6.69m, 13.38m, 20.06m, 26.35m, H1 and H5 are kept off the ground each 10cm and 4.04m.

Table 6: Results in L-H1-(1~5)

Type	Upper vent		Lower vent	
	Temp.	Air vel.	Temp.	Air vel
L-H1-1	20.36	0.064	17.61	0.022
L-H1-2	20.40	0.070	17.84	0.032
L-H1-3	20.34	0.060	17.85	0.063
L-H1-4	20.36	0.062	17.71	0.076
L-H1-5	20.24	0.162	17.80	0.100

Table 7: Results in M-H1-(1~5)

Type	Upper vent		Lower vent	
	Temp.	Air vel.	Temp.	Air vel
M-H1-1	20.26	0.044	17.71	0.041

M-H1-2	19.05	0.113	17.79	0.115
M-H1-3	19.89	0.121	17.77	0.084
M-H1-4	20.41	0.084	17.49	0.059
M-H1-5	19.99	0.201	17.67	0.030

Table 8: Results in M-H5-(1~5)

Type	Upper vent		Lower vent	
	Temp.	Air vel.	Temp.	Air vel
M-H5-1	20.47	0.029	19.85	0.179
M-H5-2	21.12	0.217	18.81	0.232
M-H5-3	21.11	0.301	18.72	0.226
M-H5-4	21.06	0.293	18.49	0.210
M-H5-5	20.93	0.124	18.46	0.085

(3) Analysis of the CFD simulation result

Convection of the internal magazine is 0.022m/s to 0.232m/s around the air intake, the more approach an inner wall, the more a speed of an air current gets weaker. The flow of an air current is good at the middle-top part.

After approaching the inner wall, the more go the inside, the more the speed of the air current is fast, but the other point is slow.

Changing the air intake to the upper part, a speed of an air current would be a more increase than before as 0.044m/s to 0.301m/s, especially the middle-top part is more fast. Finding a temperature based on a shift of the air current, an inner temperature would be about 17.49°C to 17.85°C in the magazine.

However, changing the air intake to the upper part, it would be about 19.05°C to 21.11°C. It means the temperature rises about 1.56°C to 3.26°C in general. With this, install an air intake in the upper part for increasing ventilation of a covered structure, the inner mean temperature will rise about 2.4°C.

5. Conclusion

This study suggests the activated plan of the natural convection for reducing the surface condensation in covered magazine. The summary runs as follows;

- (1) The effusion velocity of the external air intake of Igloo type magazine is 0.1 m/s, when 1.7m/s is the standard, and installing an air intake to the upper part of a gate, the effusion velocity would be 0.7m/s.
- (2) With an air inflow from the air intake, the inner convection and temperature are each 0.022m/s to 0.232m/s, 17.49°C to 17.85°C.
- (3) Changing the location of the air intake to the upper part of the gate, the convection and the temperature would rise 0.17m/s, 2.4 °C on the average.
- (4) All location of the air intake in the magazine brings to increase the mean temperature, so reduce condensation.

REFERENCES

- [1]JC Lee, The Reform Measure for Reduce to Surface Condensation of Ammunition in Igloo Magazine, Architectural institute of KOREA. v.23 n.3(2007-03)
- [2]JC Lee, An Analysis of the Surface Condensation of Stored Ammunition in a Igloo-Magazine with Using Numerical Method, architectural institute of KOREA, v.22 n.11(2006-11)
- [3]MJ Lee, Analysis of condensation in buried ammunition depot and prevention of condensation on surface by CFD, Academic thesis of Yonsei University, 2007
- [4]CD-adapco, STAR-CD command manual, 2001