Modeling of Active Chilled Beam Part I

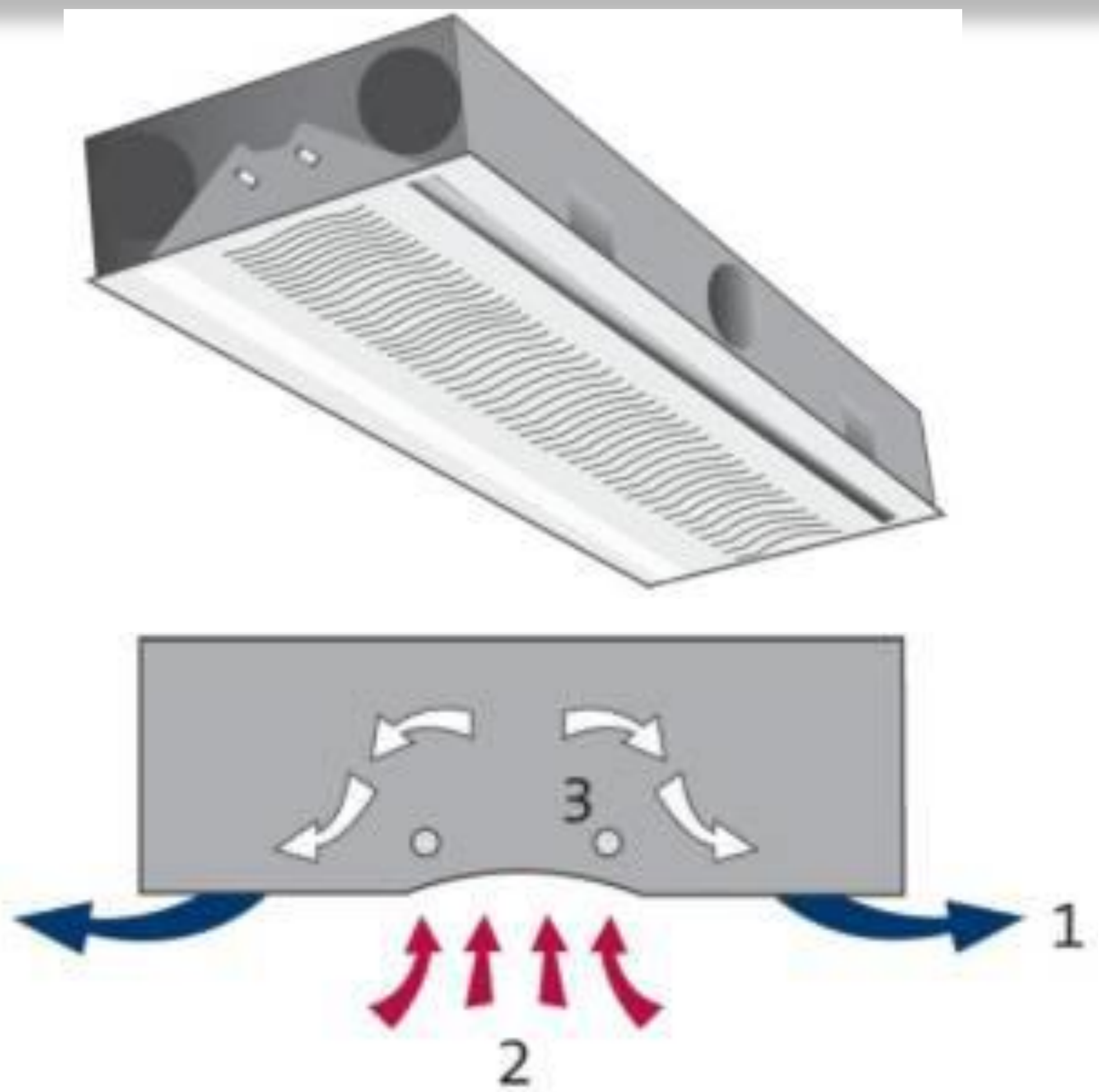
Active Chilled Beam (ACB)

An ACB consists of a fin-and-tube heat exchanger contained in a housing that is suspended from, or recessed in, the ceiling. It contains an integral air supply. Primary air passes through nozzles, which induce air from the space up through the cooling coil. This induction process allows an active chilled beam to provide much more cooling capacity.

- ❖ No fan power
- ❖ High temperature water supplied
- ❖ Silence
- ❖ No discomfort due to cold wind
- ❖ Design freely

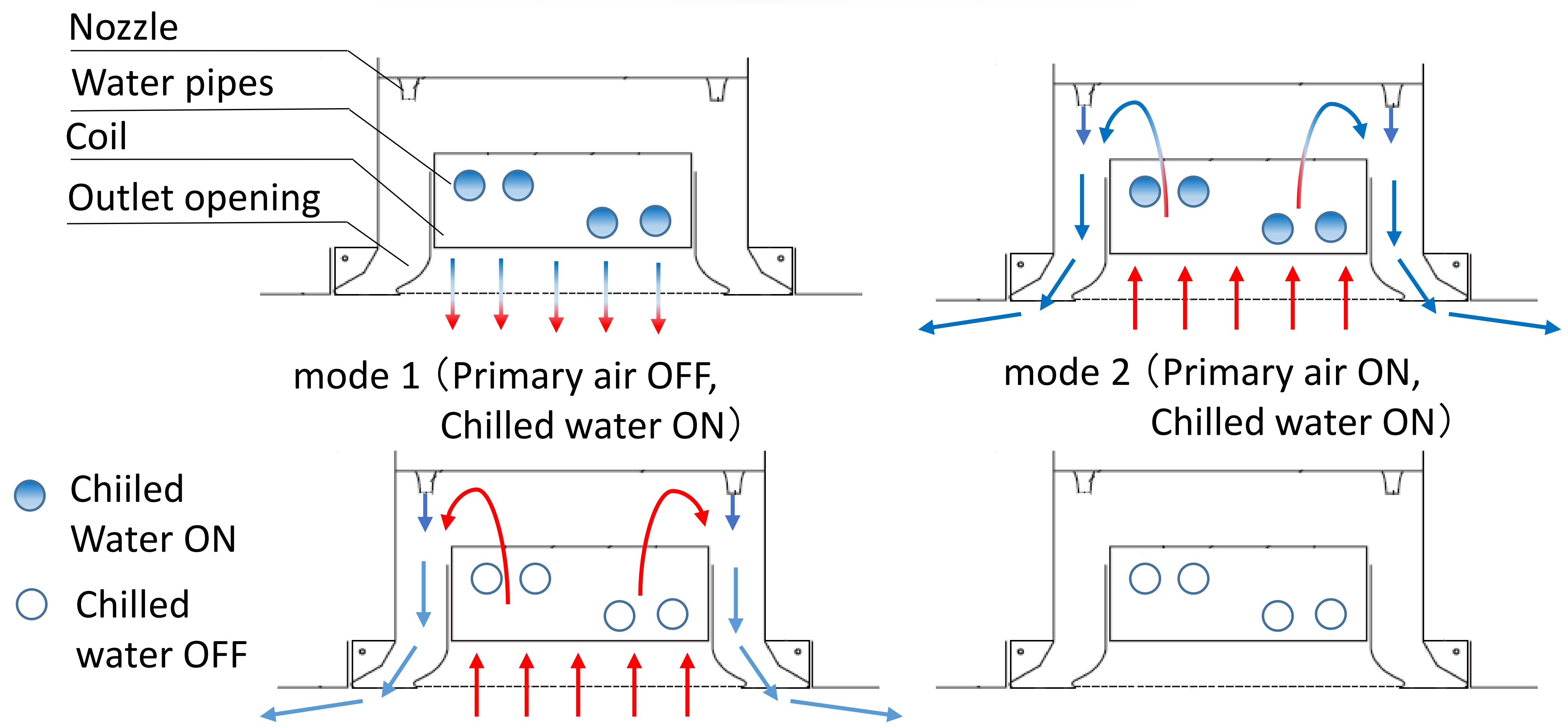
Purpose

In recent years, the active chilled-beam which has the characteristic of high energy efficiency, comfort and silence has been widely used all over the world. In order to reproduce the operating condition of the equipment and to predict the thermal environment in the building space where it was installed, the task of modeling the active chilled beam first is pointed out.



1 Air supply 2 Air induced 3 Mixing of primary and induced air

Operation modes of ACB



mode 1（Primary air OFF, Chilled water ON）

mode 2（Primary air ON, Chilled water ON）

mode 3（Primary air ON, Chilled water OFF）

mode 4（Primary air OFF, Chilled water OFF）

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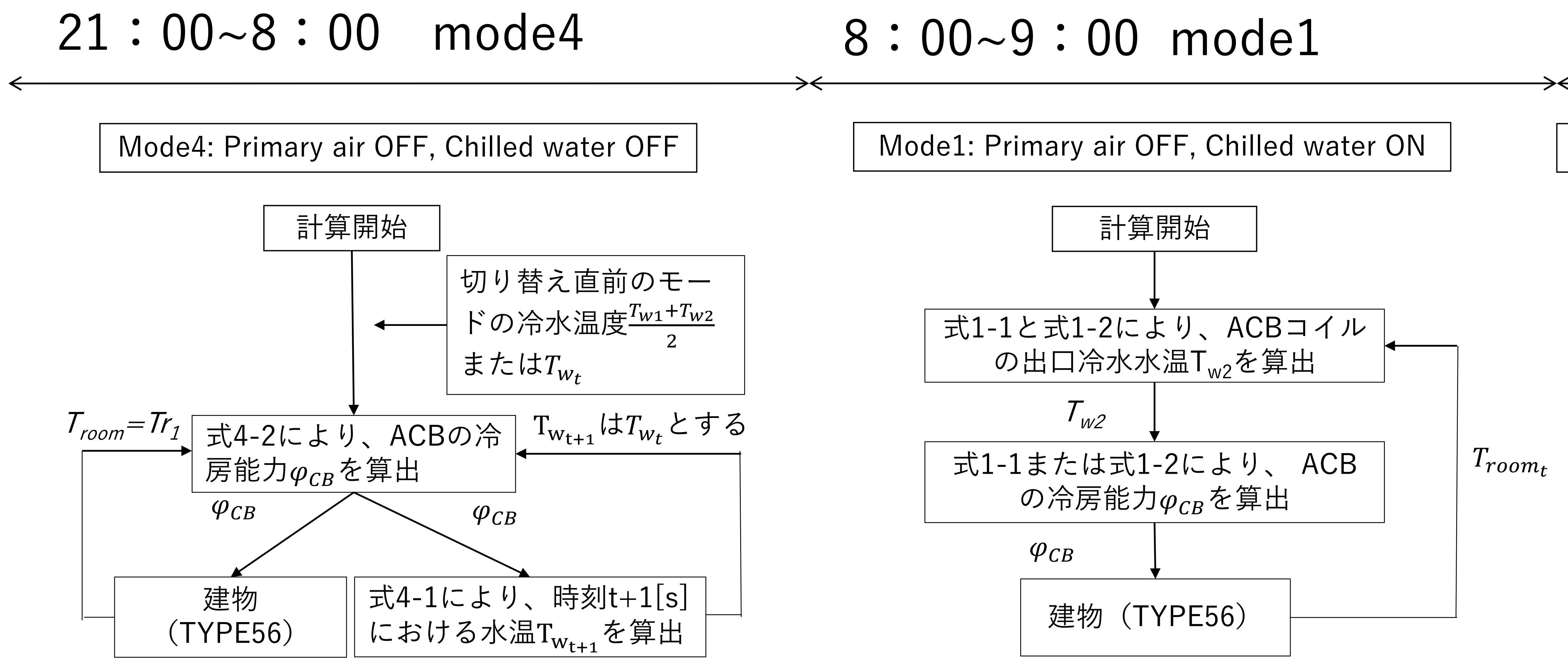
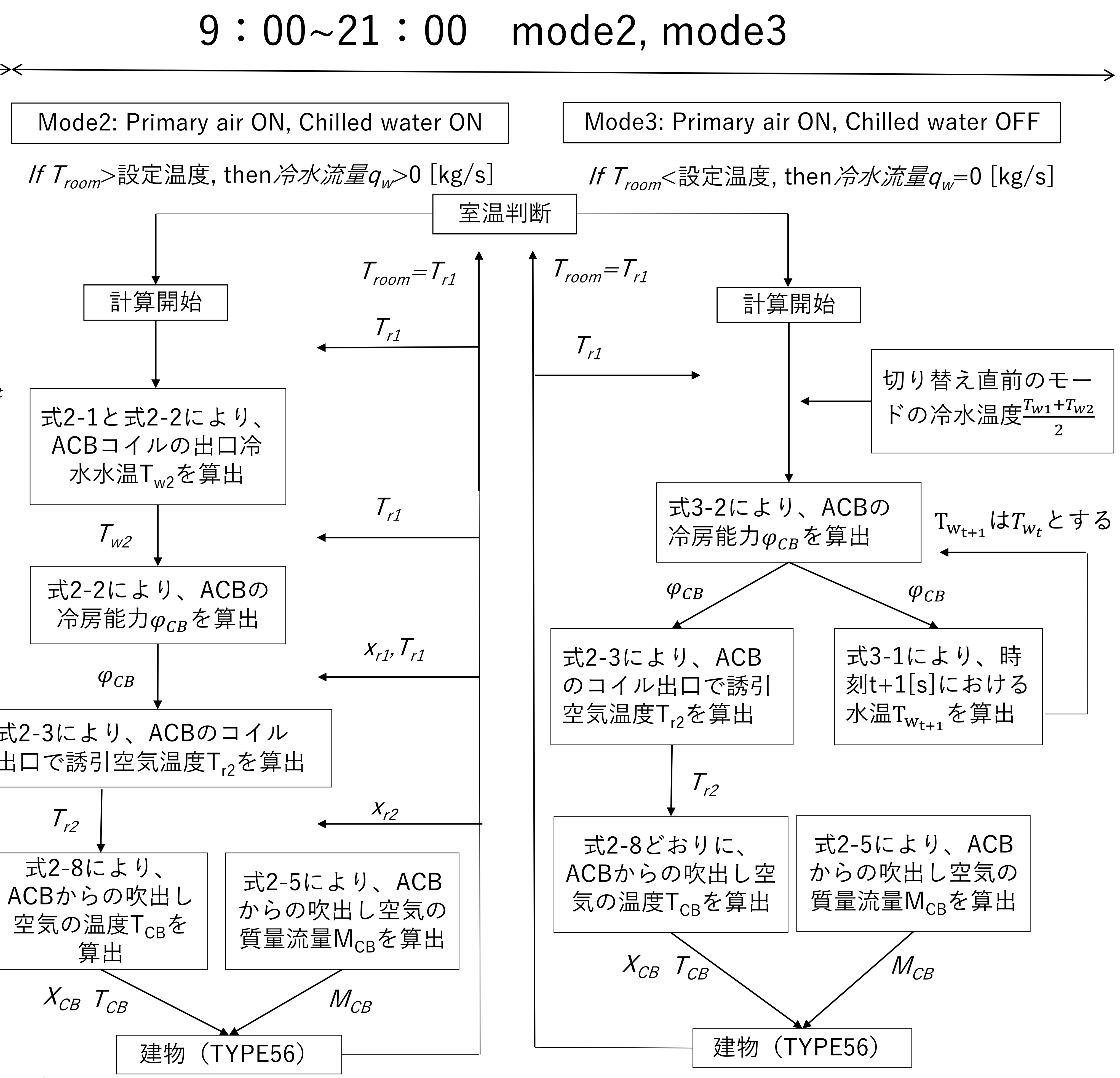
Modeling of Active Chilled Beam　Part II





$\varphi_{CB}=C_w*q_w(T_{w2}-T_{w1})$	1-1
$\varphi_{CB}=K_1*A\,(T_{room_t}-\frac{T_{w1}+T_{w2}}{2})$	1-2
$\varphi_{CB}=(A1q_n+B1)*(A2q_n+B2)*[A3\left(\frac{T_{w1}+T_{w2}}{2}-T_{r1}\right)+B3]$	2-1
$\varphi_{CB}=C_w*q_w(T_{w2}-T_{w1})$	2-2
$T_{r2}=T_{r1}-\varphi_{CB}/(q_r*\rho_{air}*(C_{air}+C_v*x_{r1}))$	2-3
$q_r=\mu*q_n$	2-4
$M_{CB}=\rho_{air}*(q_n+q_r)$	2-5
$k_n=q_n/(q_n+q_r)$	2-6
$x_{CB}=k_n*x_n+(1-k_n)*x_{r2}$	2-7
$T_{CB}=\frac{k_n*T_n(C_{air}+C_v*x_n)+(1-k_n)*T_{r2}(C_{air}+C_v*x_{r2})}{(C_{air}+C_v*x_{CB})}$	2-8
$\varphi_{CB}=W*C_w\frac{dT_w}{dt}$	3-1
$\varphi_{CB}=(A1q_n+B1)*(A2q_n+B2)*[A3(T_{w_t}-T_{r1})+B3]$	3-2
$\varphi_{CB}=W*C_w\frac{dT_w}{dt}$	4-1
$\varphi_{CB}=W*C_w\frac{dT_w}{dt}$	4-2

φ_{CB}: ACBの冷却能力[W]
A1,B1:一次空気流量とACBの基本冷却能力との関係係数
A2,B2:一次空気流量とACB長さとCBノズル直径による修正係数との関係係数
A3,B3: ACB冷却係数と(平均冷却水温度-室内温度)との関係係数
K_1:モード1におけるコイルの有効対流熱伝達率[W/m²・K]
K_4:モード4におけるコイルの有効対流熱伝達率[W/m2・K]
A:コイルの有効熱交換面積[m²]
W:コイル内の水の重量[kg]
T_W:コイル内の水温度[°C]

T_{Wt}: 時刻t[s]におけるコイル内の水温度 [°C]
q_w : ACBのコイル定格冷水質量流量[kg/s]
T_{w1} , T_{w2}:コイル冷水入、出口温度[°C]
T_{r1}, T_{r2}: ACBのコイルの入、出口での誘引空気温度[°C]
T_{CB}: ACBから吹出し空気の温度[°C]
T_n: ACBの一次空気の温度[°C]
T_{room} : 室温[°C]
T_{room_t} : 時刻t[s]における室温[°C]
q_n : ACB一次空気体積流量[m³/s]

M_{CB}: ACBからの吹出し空気の質量流量[kg/s]
k_n : ACB一次空気の質量分率
μ : ACBで一次空気と誘引空気の割合[-]
C_{air} : 乾き空気の定圧比熱1006[J/kg・k]
C_v: 水蒸気の定圧比熱1846[J/kg・k]
C_w: 水の定圧比熱4181[J/kg・K]
x_{r1}, x_{r2}: ACBコイルの入、出口での誘引空気の絶対湿度[kg/kg`]
x_{CB}: ACBからの吹出し空気の絶対湿度[kg/kg`]
x_n: ACBへの一次空気の絶対湿度[kg/kg`]