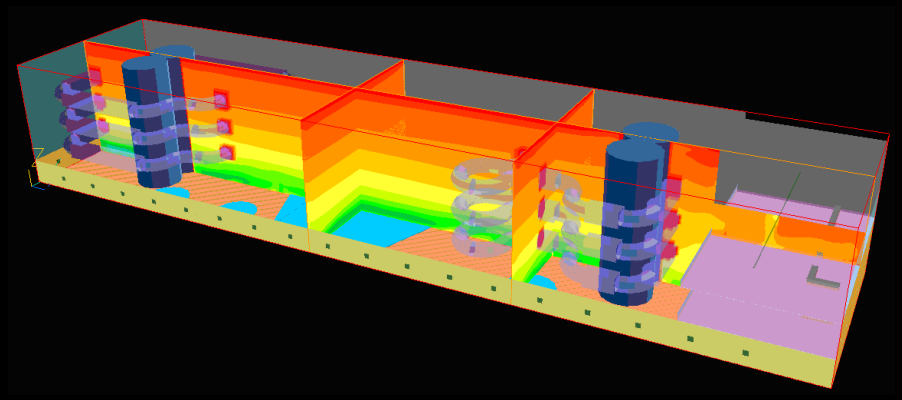
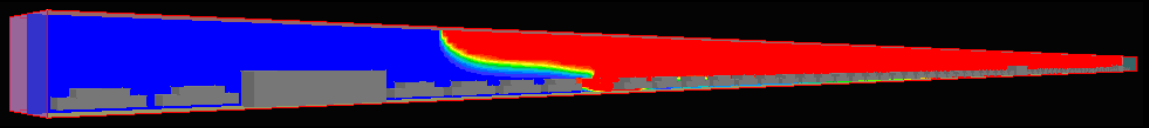
Using PHOENICS to evaluate Air Change Effectiveness (ACE) for Green Star



PHOENICS

- The 1st commercial CFD package in the world
- Developed by CHAM (UK)
- Established on precise fluid dynamics theory with clear mathematical solution control
- Open codes – useful for both in engineering and academic research
- World widely applied to industrial & environmental fluid processes.
- Easy to setup a model with simple post processing
- Good technical support with world wide user forums
- Cost effective



CFD Application – Air Change Effectiveness (ACE) for Green Star

IEQ-2 Air Change Effectiveness

- **Credit Criteria**

  Two points *are awarded where it is demonstrated that the Air Change Effectiveness (ACE) meets the following criteria for at least* ***90%*** *of the NLA:*

Mechanically Ventilated Buildings

*The ventilation systems are designed to achieve an Air Change Effectiveness (ACE) of >**0.95** when measured in accordance with ASHRAE F25-1997. ACE is to be measured in the breathing zone (normally 1m from finished floor level).*

CFD Application – Air Change Effectiveness (ACE) for Green Star

ACE Assessment Approach

- **Nominal Time Constant (NTC) =V_s / V_{sa}** [s]

  V_s: total volume of space (m^3)

  V_{sa}: total supply air volume (m^3/s)

- **Age Of Air (AOA)**

  Calculated by adding a scalar variable to the CFD simulation at a rate of 1 [s-1]. At all supply air point locations the age of air is set to 0.

- **ACE_i = NTC/AOA_i**

  AOA_i : modelled by CFD

  ACE > 0.95: AOA_i < NTC / 0.95

CFD Application – Air Change Effectiveness (ACE) for Green Star

ACE Assessment Approach

- **Example**

NLA = 1000 m^2

H = 2.7m = 3000 m^3

V_s = 1000 x 2.7 = 2700 m^3

V_{sa} = 3 m^3/s

NTC = 2700/3 = 900 s

- **Set upper range of legend in CFD AOA contour**

AOA_{max} = NTC/0.95 = 900 / 0.95 = 947 s

ie, any locations with AOA > 947 s will be identified as not meeting GS IEQ-2 requirement.

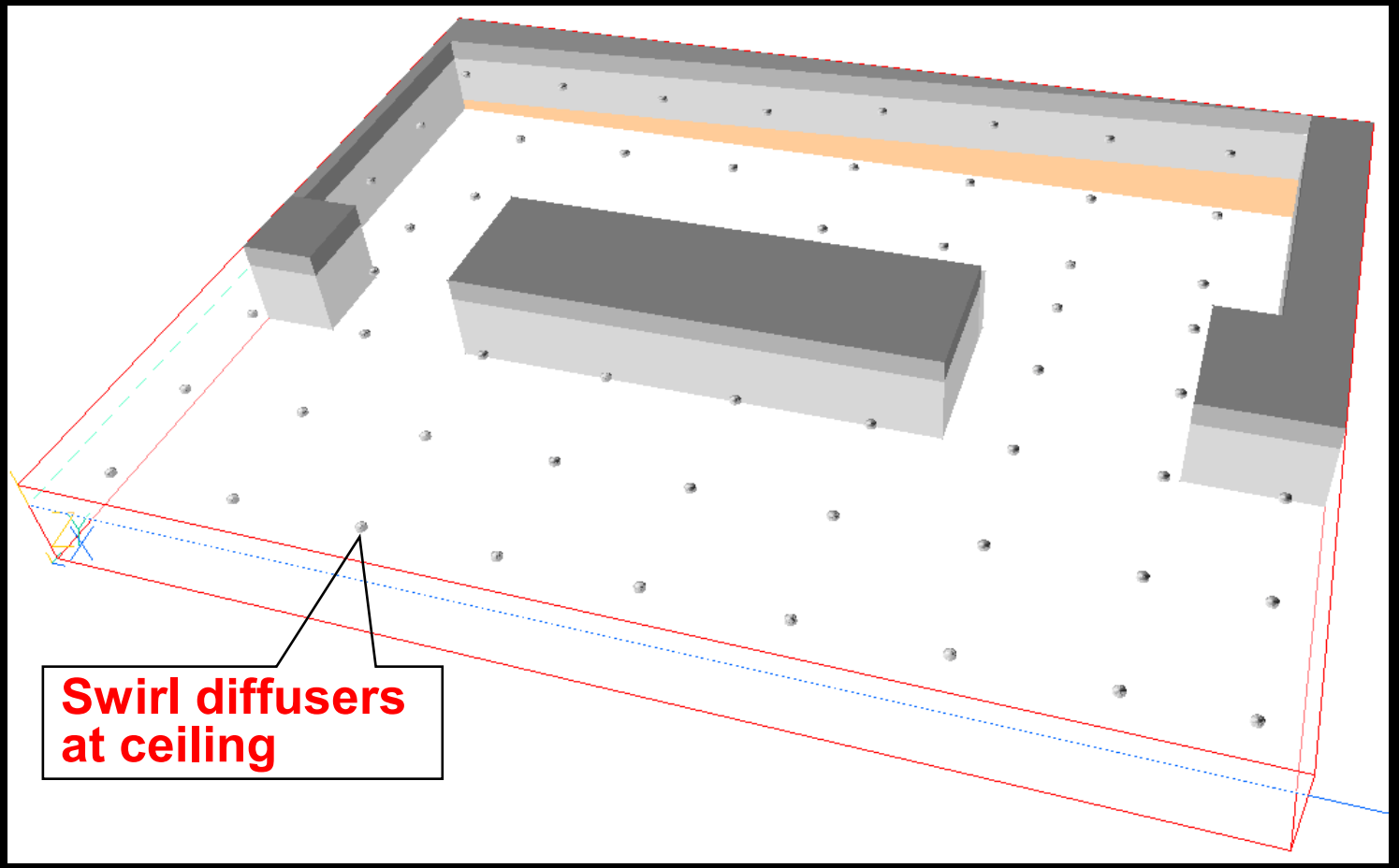
CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 1

- Office floor with VAV + high induction swirl diffusers
- Supply air temperature = 11 ^{o}C
- Return air → ceiling slots beside light fittings →

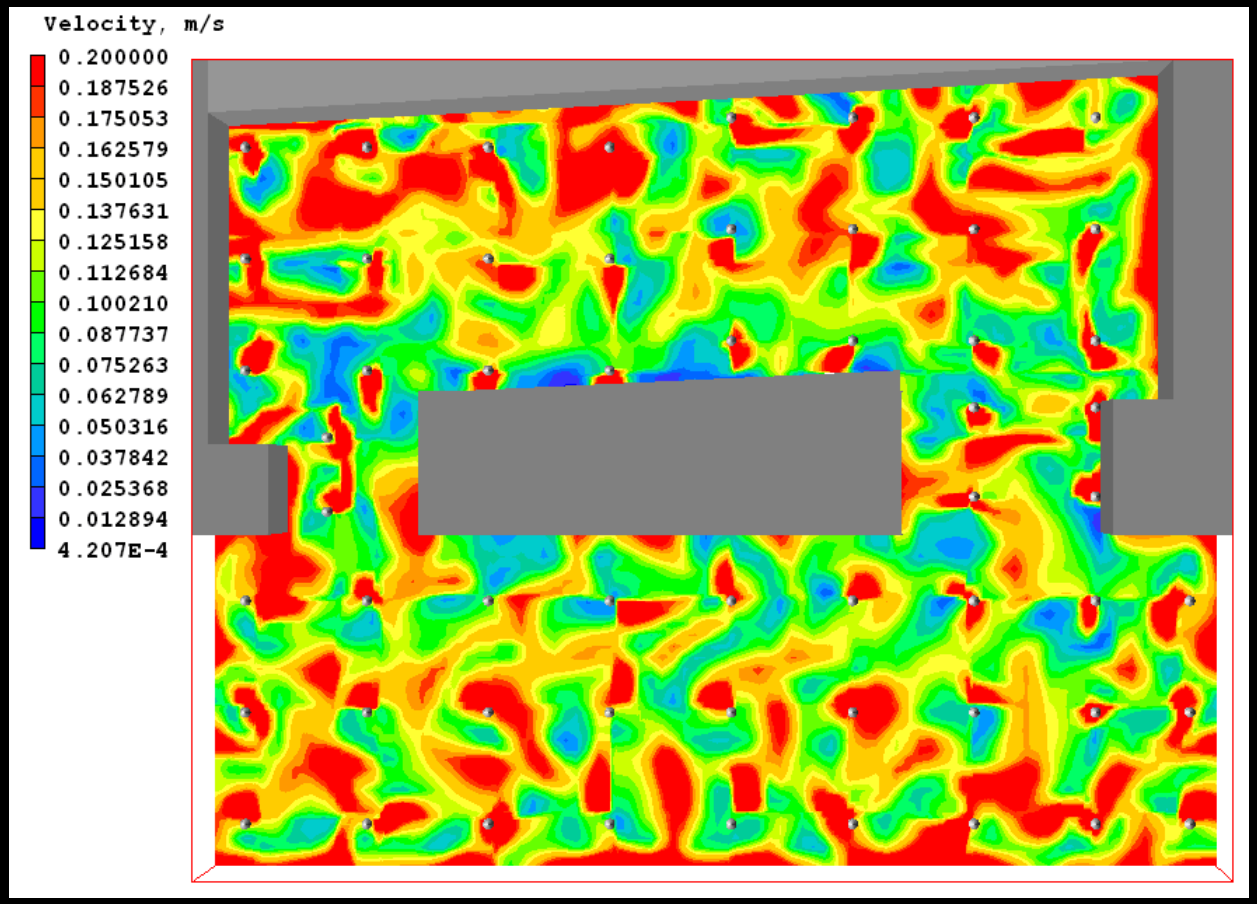
CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 1 – CFD Model Domain



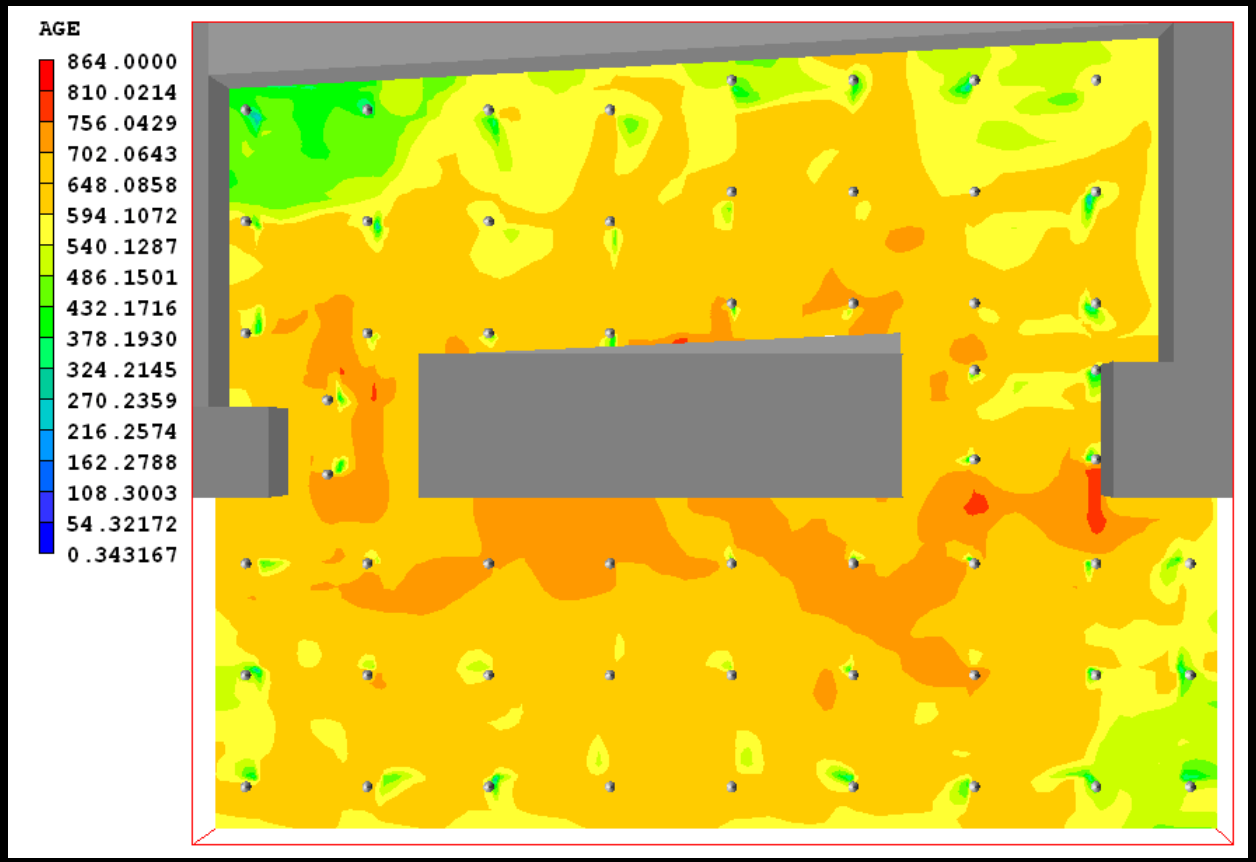
CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 1 - Velocity Profile at 1m from Floor



CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 1 - AOA Profile at 1m from Floor



<u>100% of NLA</u> is predicted to have an ACE of better than 0.95

Meets the Green Star credit requirements by IEQ-2 in order to be reward with 2 points

CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 2

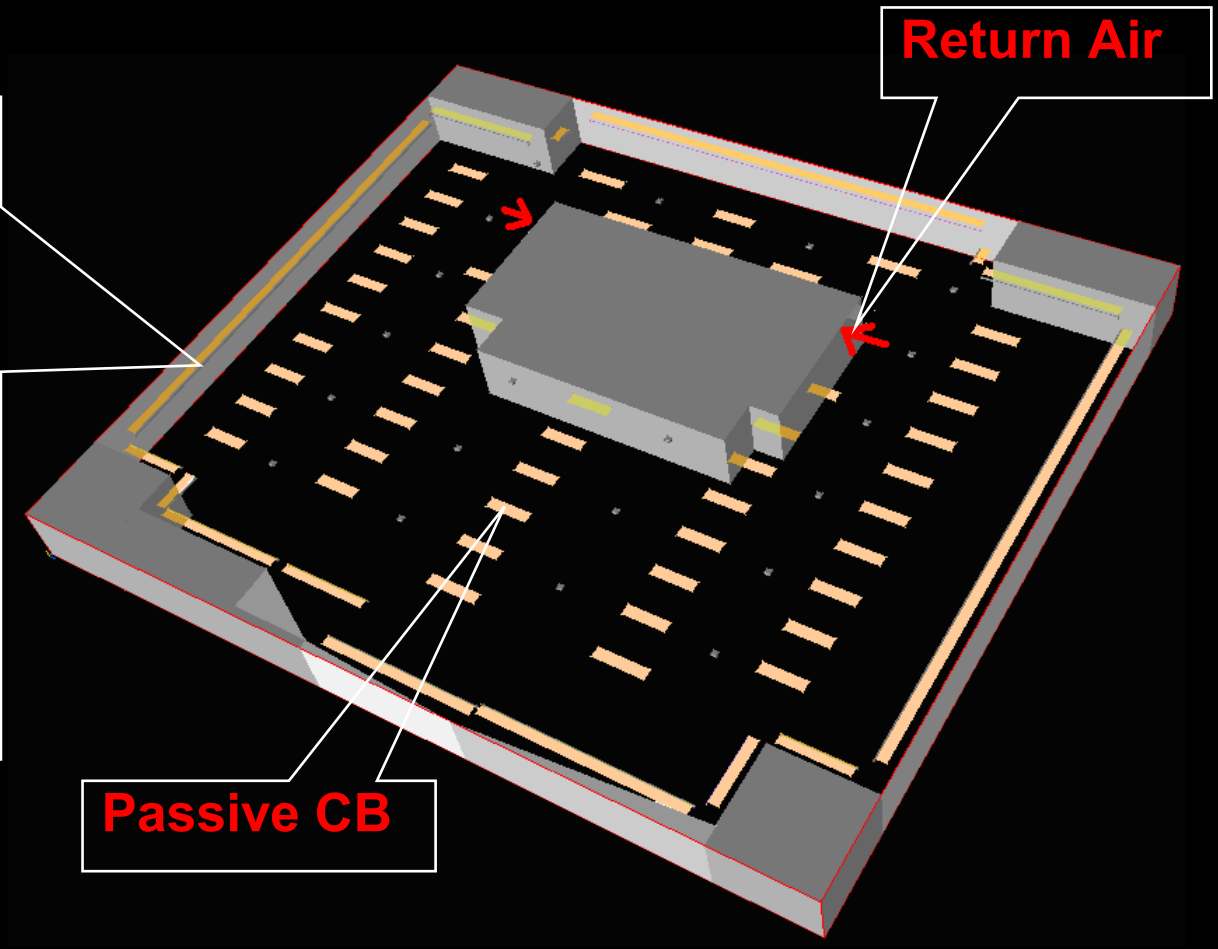
- Office floor with Chilled Beams + high induction swirl diffusers
  - Perimeter: active CB provides cooling + fresh air
  - Internal: passive CB + ceiling swirl diffusers
- Supply air temperature = 12 ^{o}C
- Return air → two RA ports at core area below ceiling

CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 2 – CFD Model Domain

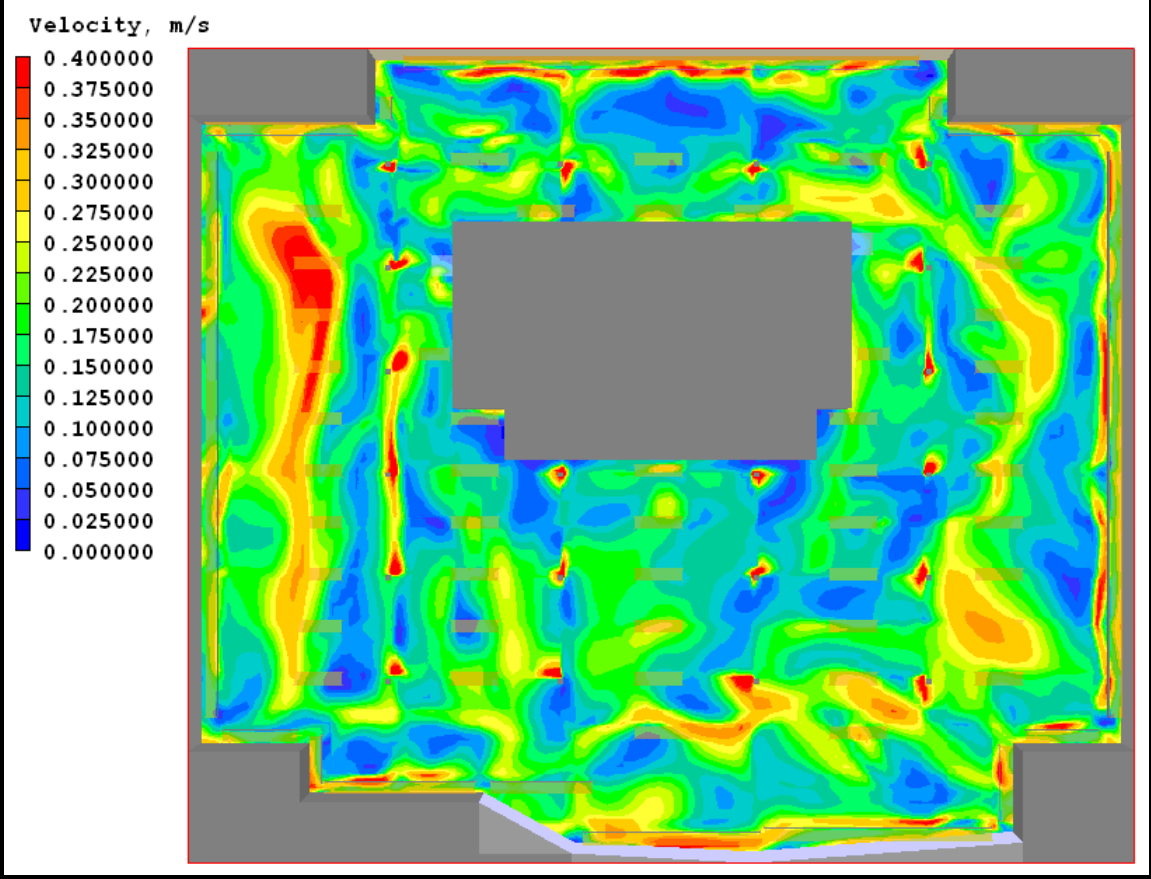
Active CB was modelled as passive CB to simplify CFD process

Separate cooling capacity was added to the supplied fresh air along perimeter zones



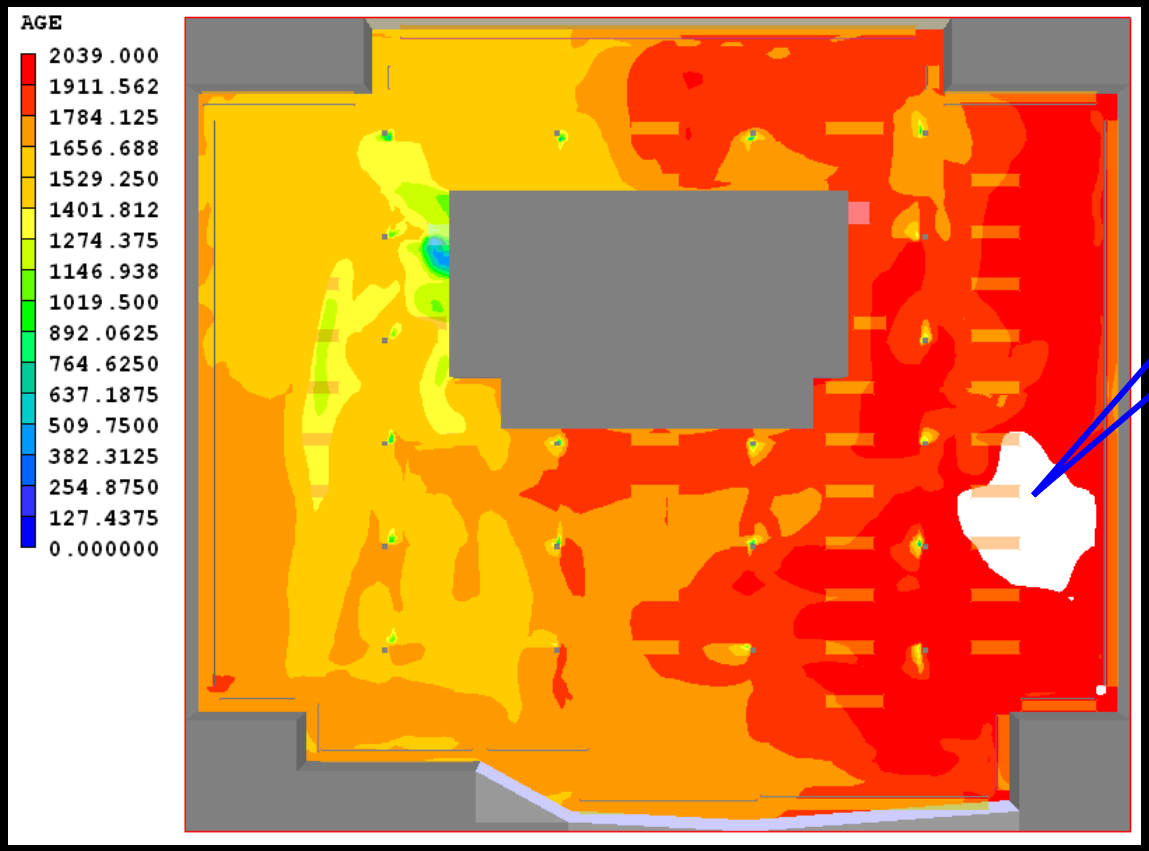
CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 2 - Velocity Profile at 1m from Floor



CFD Application – Air Change Effectiveness (ACE) for Green Star

Case Study 2 - AOA Profile at 1m from Floor



4% NLA having ACE > 0.95

<u>96% of NLA</u> is predicted to have an ACE of better than 0.95

Meets the Green Star credit requirements by IEQ-2 in order to be reward with 2 points