3.0 BREADTH WORK – COMPUTATIONAL FLUID MODEL ANALYSIS

3.1 ANALYSIS OF ATRIUM SPACES

When the Art Institute of Pittsburgh chose to restore the Try Street Terminal Building for student housing, many features and amenities were included in the renovation design in order to add to the residents' campus experience. Two of these features include a two-story lobby and exercise room located in the building core of the 1st floor. The first floor areas of these spaces are 1,650 ft^2 and 2,750 ft^2, respectively. However, on the second level the floor intrudes this atrium space reducing the total opening over these areas to approximately 90 ft x 30 ft. Also, the lightwell above the lobby and exercise room provides natural light to these spaces through (4) 30 ft^2 skylights. Additionally, the lobby area has (4) 330 cfm and (2) 140 cfm supply air diffusers, while the exercise room has (4) 1000 cfm supply diffusers. Some typical problems associated with atriums are air and temperature distribution due to the improper location of diffusers. Therefore, to analyze if these problems occur in the Try Street Terminal Building a Computational Fluid Model of the space was developed using Phoenics VR.

3.1.1 PHOENICS MODEL

Using the Phoenics VR Editor a three dimensional model of the atrium space was developed. The dimensions of the lobby and exercise room were added and entered in meters for the domain size. The equivalent size of the domain is 36m x 12.192m x 5.6m. The geometric setup of the model also included choosing the cell size, number of cells, number of regions, and cells per region. The distribution of the computational grid mesh created is important because it effects the calculations which are performed in each cell in the model. Three thousand iterations were set to be calculated in this model. This means that each cell in the model will be calculated 3,000 times. Therefore, Phoenics will have to complete millions of calculations simultaneously. The calculation time needed to perform these calculations was 4 hours.

Figure 3.1-a below shows the location of major blockages such as the walls, columns, and floors. Inlets for the diffusers were then inserted into the model with the appropriate flow rate. Because no exhaust is shown on the mechanical plan the only outlets represented in the model are doorways into the spaces. The estimated total heat gain in the lobby and exercise room was also determined based on occupancy, occupancy activity and average incident solar radiation through the skylights. A total of 5000 W was calculated for the lobby and 12,000 W for the exercise room. To account for this, a heat source was then introduced into each space as a flat plat on the floor surface. The approximate heat gain was then evenly distributed throughout this surface.

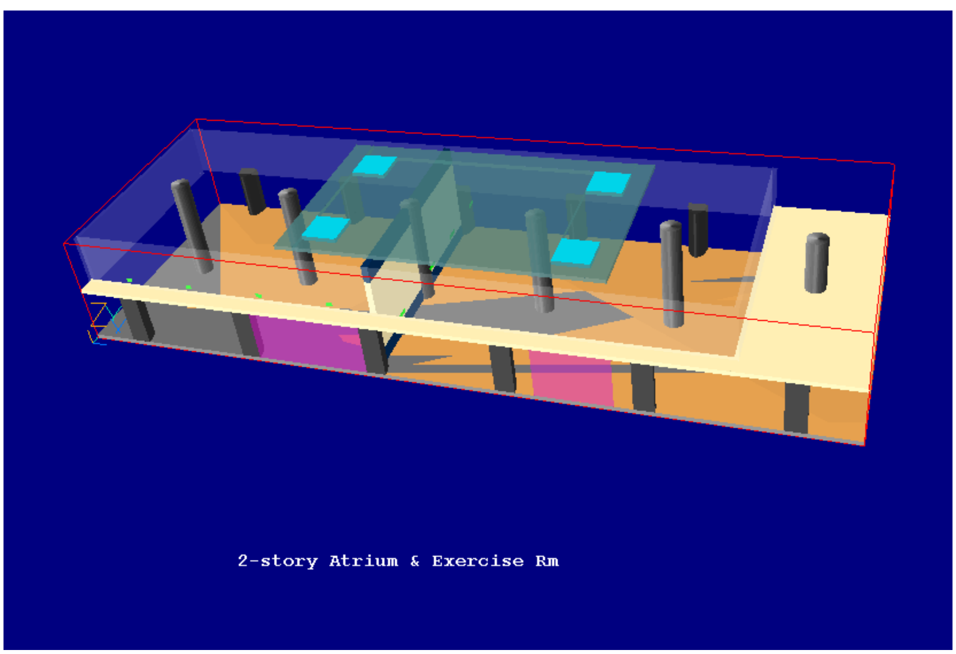

Figure 3.1-a Phoenics 3-D Building Model

3.1.2 PHOENICS RESULTS

After the model was set up and the Solver completed the calculations, the results could be viewed in the VR Viewer. The following figures in this section will show the resulting velocity and temperature files of the Phoenics program. Shown in Figure 3.1-b is the result for the model after 3,000 iterations. Since the values of the variables on the left convergence monitor have not fully approached a constant value the resulting calculated flow field parameters may not be reliable. However, for educational purposes the results will serve as a demonstration of the realistic result.

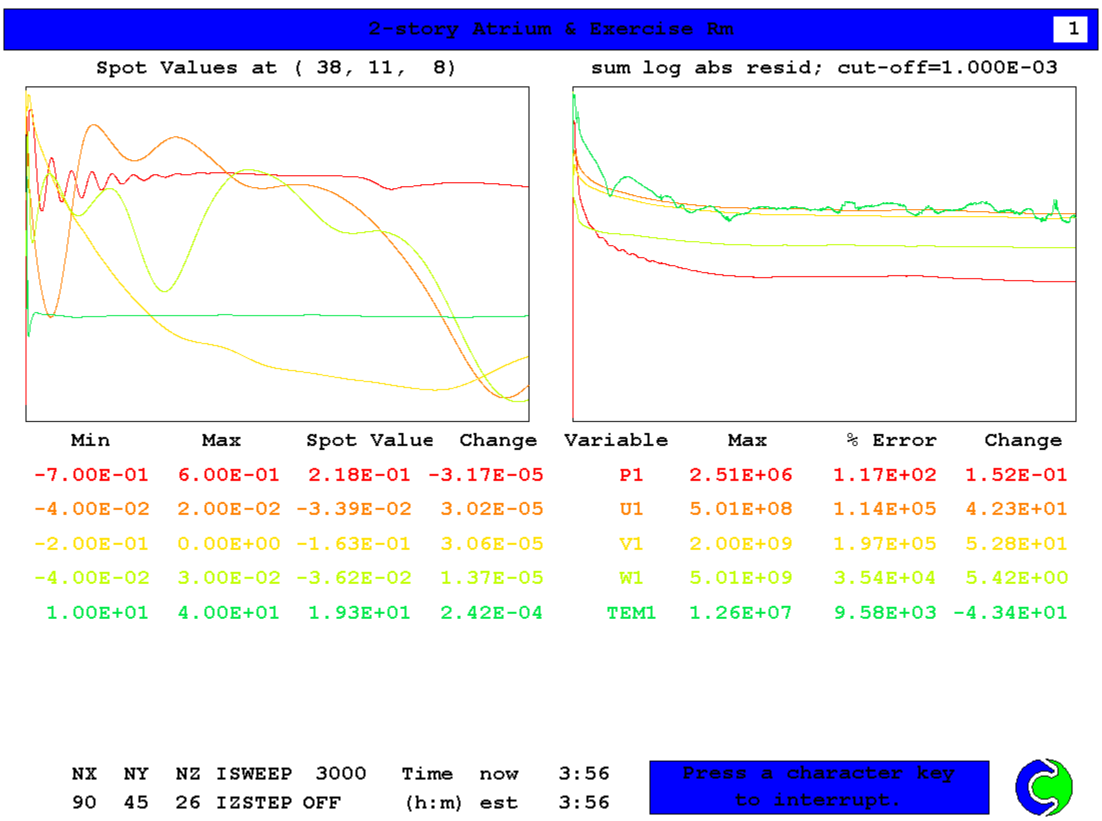

Figure 3.1-b Phoenics Result

Figure 3.1-d to Figure 3.1-g below show velocity cuts on the X, Y and Z axis. The velocity Z slices are taken at the level of the diffusers and directly through them. From these figures one can tell that the direction of air flow is correct. Referring to the side velocity legend in the figures shows that the velocity ranges from 0.88 - 3 m/s. This maximum velocity only appears in the slices directly through the diffusers and at the 2.6 m height of the diffusers. The velocity in the area beneath the diffusers and closer to the level of occupants at 1.5 m is an air velocity of less than or equal to about 1 m/s. This velocity would still be considered acceptable. Even thought the air movement might be slightly more noticeable the majority of the occupants should have a pleasant comfort level.

Air Velocity - Comfort	
m/s	**Occupant Comfort**
0.25	unnoticed
0.25-0.51	pleasant
0.51-1.02	geneally aware of air movement
1.02-1.52	drafty
>1.52	problem

Figure 3.1-c Occupant Comfort as result of Air Velocity

The X and Y axis model slices only go to further show the points discussed above. These figures simply depict the results in a different perspective.

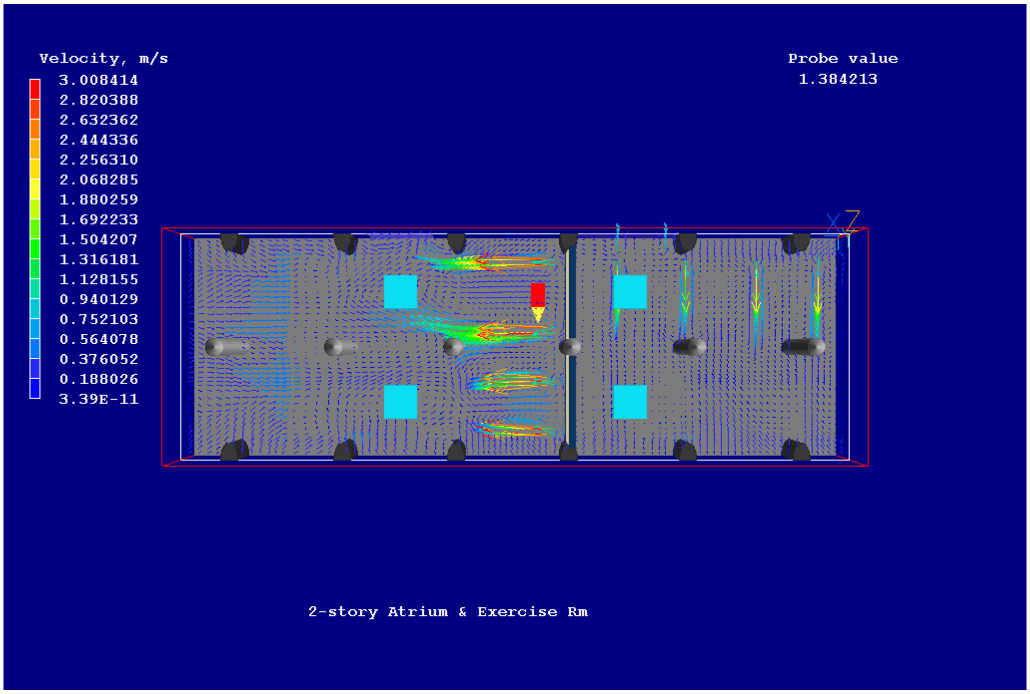

Figure 3.1-d Phoenics Velocity Z Slice 1

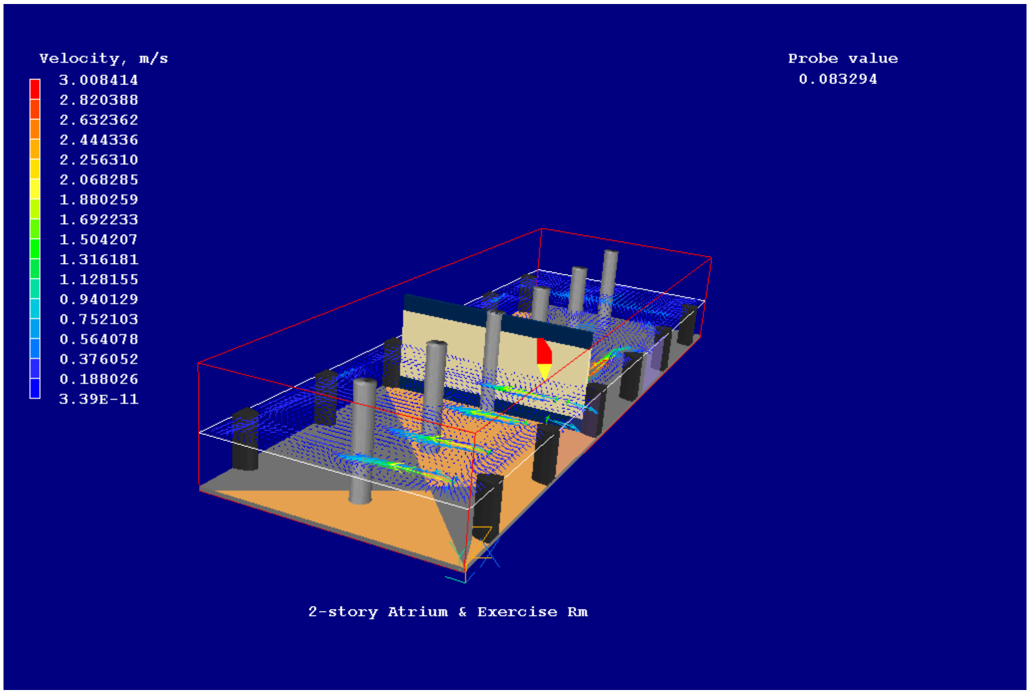

Figure 3.1-e Phoenics Velocity Z Slice 2

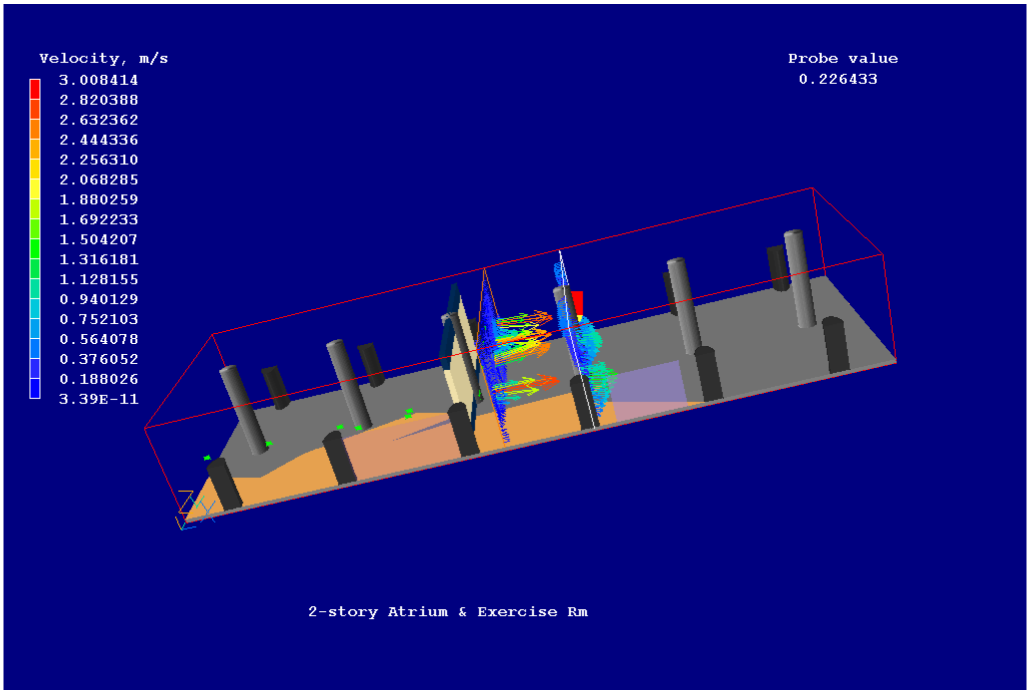

Figure 3.1-f Phoenics Velocity X Slice

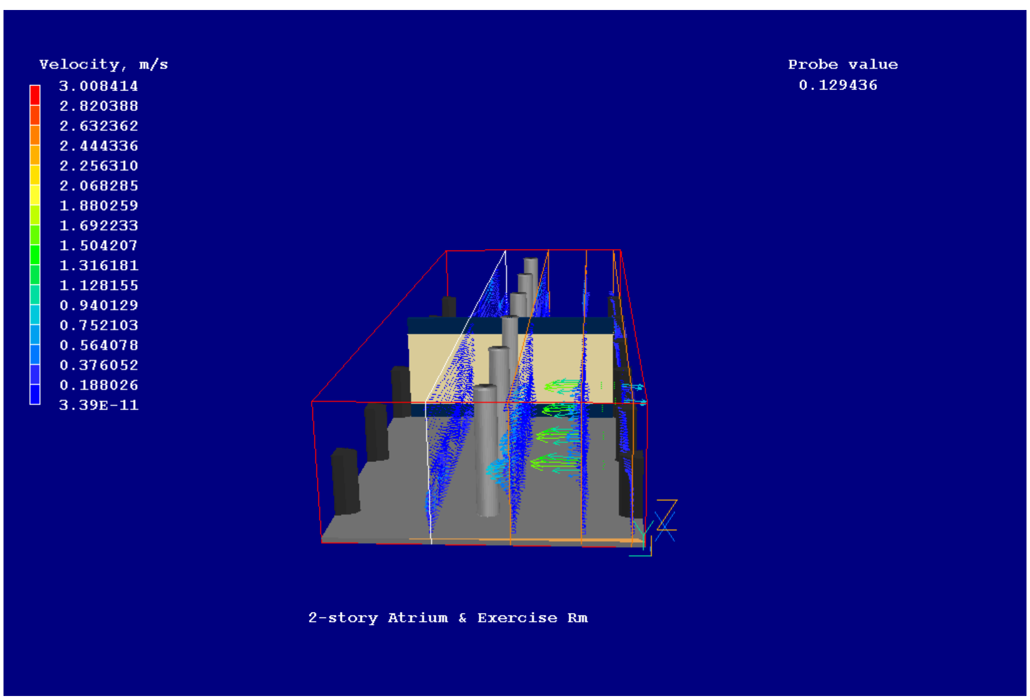

Figure 3.1-g Phoenics Velocity Y Slice

Now, Figure 3.1-h through Figure 3.1-k will portray the temperature results. It is important to note that this atrium space was evaluated for cooling with a supply air temperature of 55 F or 13 C. Similar to the velocity profiles, the Z slices through the diffuser show the extreme conditions. The dark blue in the diffuser stream represents a temperature of about 59 F. Based on the figures below the temperatures seem to be distributed throughout the space well. Most temperatures in the lower level of the atrium appear to be around 66F (19 C).

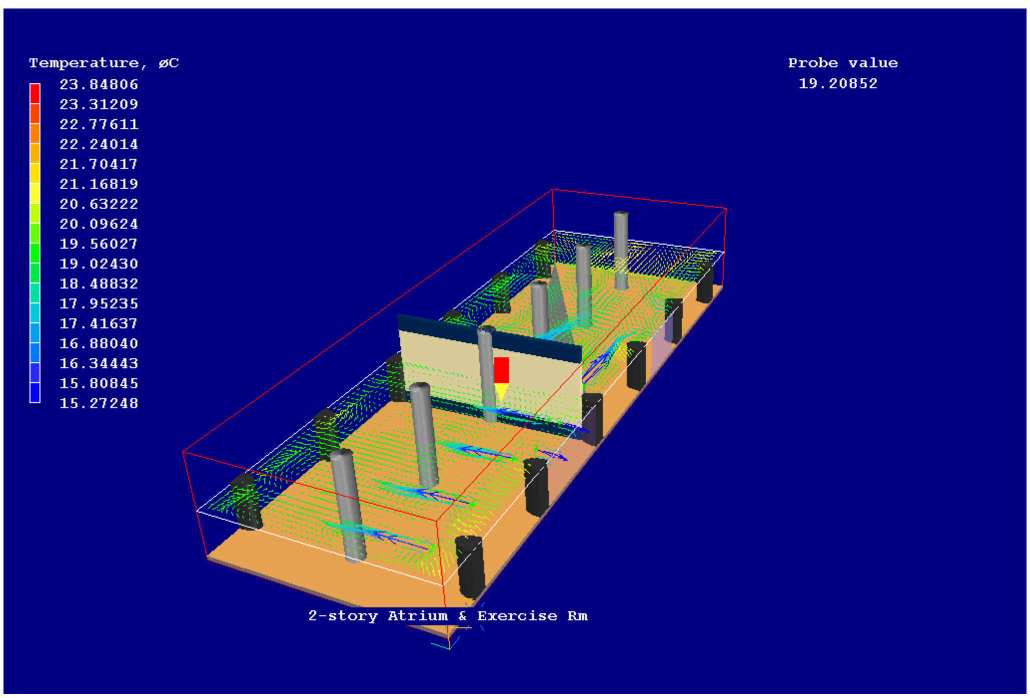

Figure 3.1-h Phoenics Temperature Z Slice 1

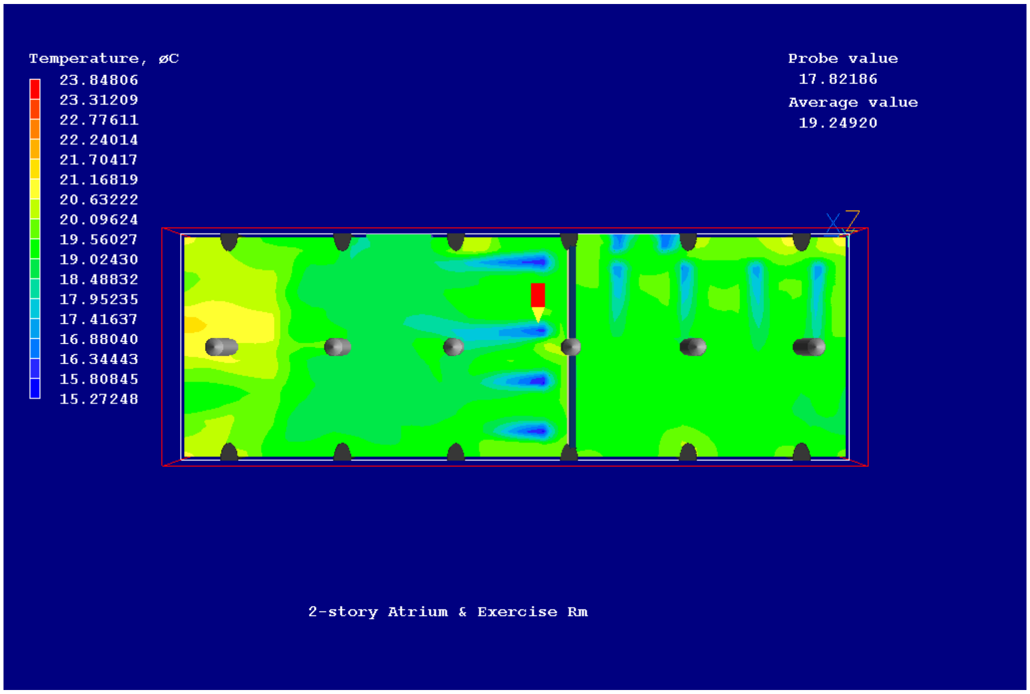

Figure 3.1-i   Phoenics Temperature Z Slice 2

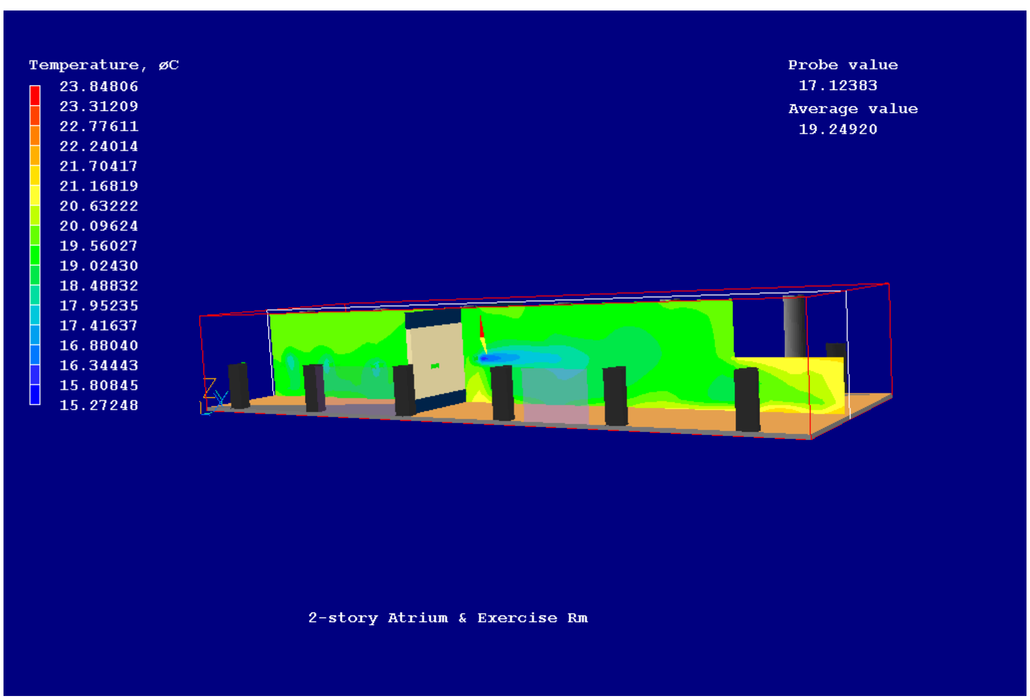

Figure 3.1-j   Phoenics Temperature Y Slice 1

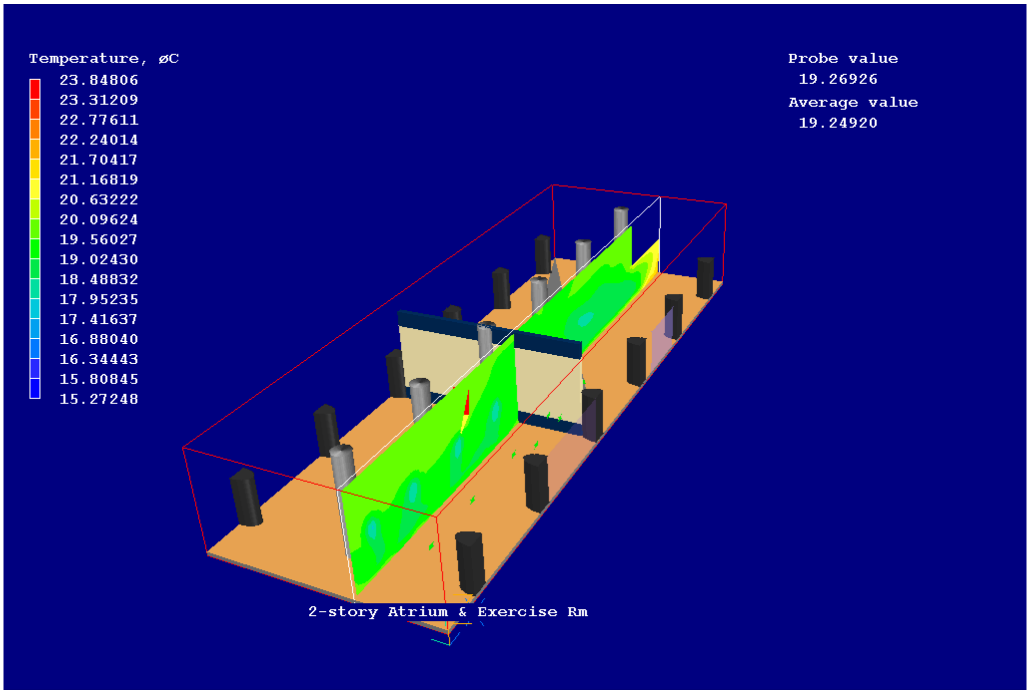

Figure 3.1-k Phoenics Temperature Y Slice 2

3.1.3 CONCLUSION DRAWN FROM MODEL

Based on the computational fluid model the design appears to sufficiently distribute the temperature and air throughout the atrium. Even though the convergence monitor did not completely approach a constant value, the results of the model appear to be a reasonable representation of the atrium space. Therefore, the conclusion is that the current diffuser layout and supply flow rates are acceptable.