Review of Exhibition Hall Air-Conditioning Options
SOPA Exhibition Halls 2, 3 & 4
Royal Agricultural Society

Report ref:
44855
8 July 2010
Revision 02

aurecon

Document prepared by:

Aurecon Australia Pty Ltd
ABN 54 005 139 873
116 Military Road
Neutral Bay
New South Wales 2089 Australia

T: +61 2 9465 5599
F: +61 2 9465 5598
E: sydney@ap.aurecongroup.com
W: aurecongroup.com

Document control

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Document ID: S:\44855\Eng\Mechanical\Reports\Analysis Of Exhibition Hall Air Conditioning Options Rev 02.Doc

Rev No	Date	Revision details	Typist	Author	Verifier	Approver
01	22 June 2010	Issued For Information	JSP	GDR		
02	8 July 2010	Issued	JSP	GDR	PJB	GDR

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1. Introduction

The proposed redevelopment of the exhibition halls includes the construction of a new concourse adjoining the exhibition halls and the upgrade of the air-conditioning system to the existing halls. The new concourse will link the exhibition halls along their northern entrances.

The existing air-conditioning installation currently serving exhibition halls 2, 3 and 4 does not maintain acceptable conditions and the Royal Agricultural Society (RAS) of NSW requires the air-conditioning installation to be upgraded to meet the needs of the exhibitors.

The original natural ventilation concept for the exhibition halls was not accepted by the exhibition market and generated high dust levels, was transparent to event noise and contributed to the operable wall ‘blow out’ problem. RAS recently installed 24 packaged air-conditioning units as a temporary air-conditioning measure. These temporary air-conditioning units are to be used as part of the permanent air conditioning design.

This report reviews the various air conditioning options investigated by the project team during the concept design phase of the project.

2. Executive summary

The redesign of the exhibition hall air conditioning systems aims to provide increased comfort conditions to the occupants during both winter and summer conditions. The main focus of the redesign relates to the ability to distribute the air evenly through the hall, particularly during winter periods.

The following options were investigated:

1. Low level displacement air distribution
2. Side-blow air distribution
3. Overhead air distribution

The preferred design for the air-conditioning within the exhibition halls 2, 3 and 4 is the distribution of air via 4 main ducts running lengthways through each hall. The supply air ducts will be connected to the existing air handling units (AHUs) on the south side of the hall and the existing relocated AHUs on the north side. The existing return air grilles are grouped on the southern side and new return air grilles will be located on the northern side of the halls.

A Computational Fluid Dynamic (CFD) analysis was undertaken of the preferred option and indicates that the concept design provides evenly distributed cooling and heating to the halls.

The route of the existing operable doors prevents supply air ductwork entering from the side of the building. Supply air ductwork will have to be run external to the building prior to re-entering the building once the ducts are clear of the door rails.

3. Air-conditioning options

3.1 General

The exhibition halls are used for a large variety of functions and exhibitions. Certain exhibitions involve the construction of significant display stalls and partitions, some displays are constructed over two levels and can be up to 6m in height. The air conditioning system must be capable of adapting to the various layouts in both cooling and heating modes.

The critical space is the area 2m above the floor, which is the occupied zone for all functions and exhibitions. The next 4m is important but less critical. The space above 6m off the floor is deemed uncontrolled space and temperatures are allowed to fluctuate significantly.

3.2 Options

The following three air-conditioning options were selected as being appropriate for the exhibition halls and were further investigated:

i) Low level displacement air distribution
ii) Side blow distribution
iii) Overhead distribution

3.2.1 Low level displacement air distribution

This system of air conditioning is used in exhibition hall 1 in conjunction with a chilled floor.

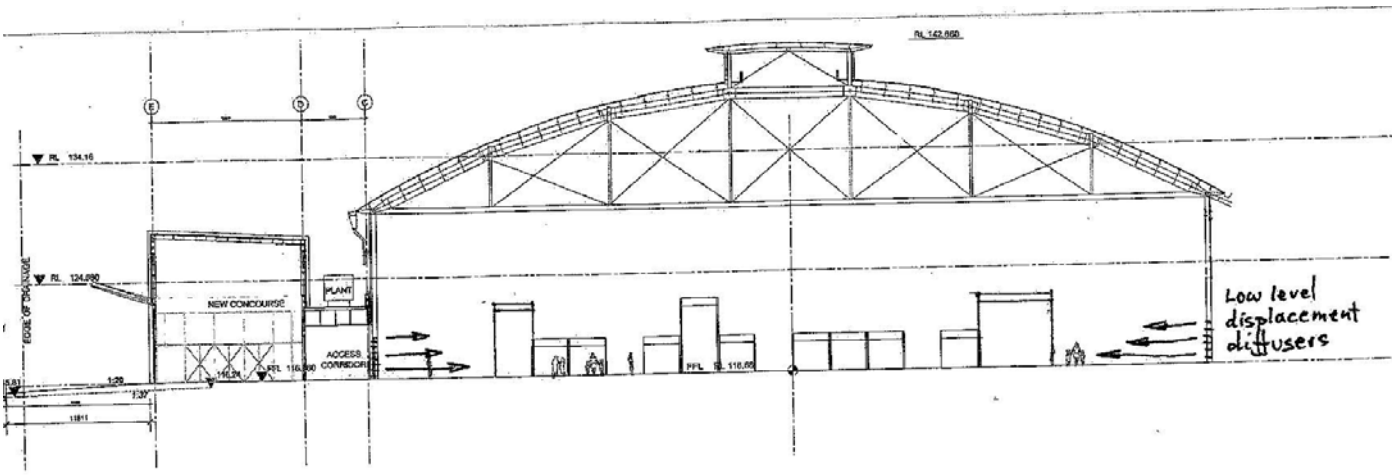

Figure 1 Air-conditioning via Low Level Displacement Diffusers

RAS are not happy with the performance of the existing displacement system in hall 1, as it is easily disrupted by the construction of display stalls and partitions and the conditioned air does not always flow to the centre of the hall.

To overcome this issue, permanent clearways will have to be designated to allow cool air to flow from the perimeter into the centre of the halls. RAS do not wish to impose restrictions on the layout of exhibits to ensure that a displacement type of air conditioning system will work, this means that this system of air-conditioning is not suitable for the intend use of the space.

3.2.2 Side blow air distribution

This system of air-conditioning is currently used in exhibition halls 2, 3 and 4.

Figure 2 Existing Side Blow Diffusers

The RAS confirm that the system works reasonably well in cooling mode but fails to heat the space in winter, as the diffusers cannot deliver the warm air to the lower occupied levels. The warm air tends to rise up to the underside of the roof.

To address this problem the RAS carried out ductwork modifications as noted in Figure 3 to direct the air downwards. This improved conditions at the perimeter but did little to provide heating to the middle of the halls.

Figure 3 Existing Ductwork Modifications

The other problem associated with side blow distribution is that it restricts the use of banners hung from the roof structure. Significant discharge air velocity is required to jet the conditioned air to the centre of the halls.

Increasing the effectiveness of the side blow distribution system will not result in a significant improvement of the air conditioning system and there is no guarantee that an even temperature distribution will be achieved in the space.

3.2.3 Overhead air distribution

This system of air–conditioning is currently used in the Sydney Convention and Exhibition Centre at Darling Harbour. Ductwork is run at high level and diffusers jet the air down into the occupied zone.

Figure 4 Sydney Convention & Exhibition Centre Ductwork Reticulation

This system of air-conditioning provides an even distribution of air across the space and is not troubled by partitions, banners and stalls. It is the only system that will guarantee good air distribution to the centre of the halls.

Motorised diffusers will be required to increase the discharge velocity in heating mode to force the warm air down into the occupied space.

A disadvantage is the intrusion of large exposed ducts into the halls.

3.3 Preferred option

The only option which will provide an even distribution of air both in cooling mode and heating mode throughout the halls, without drafts, is the overhead distribution option.

The proposed air-conditioning system is designed to provide heating and cooling to the hall via the 4 main supply air ducts with a total of 44 supply air swirl type motorised diffusers. The diffusers are spaced and directed to distribute the air down into the occupied zone of the hall. Each hall is supplied with approximately 74,000 L/s of supply air being supplied at 13m above the floor.

In heating mode the motorised supply air swirl diffusers will be automatically adjusted to increase the velocity of the supply air. The air will be introduced at a higher velocity and thus be blown down into the occupied space, the hall will largely be conditioned as the heat spreads from the floor to roof.

The proposed air-conditioning design for each hall has 4 ducts running lengthways through the hall with motorise diffusers at regular intervals. See Figure 5 below for a typical hall layout.

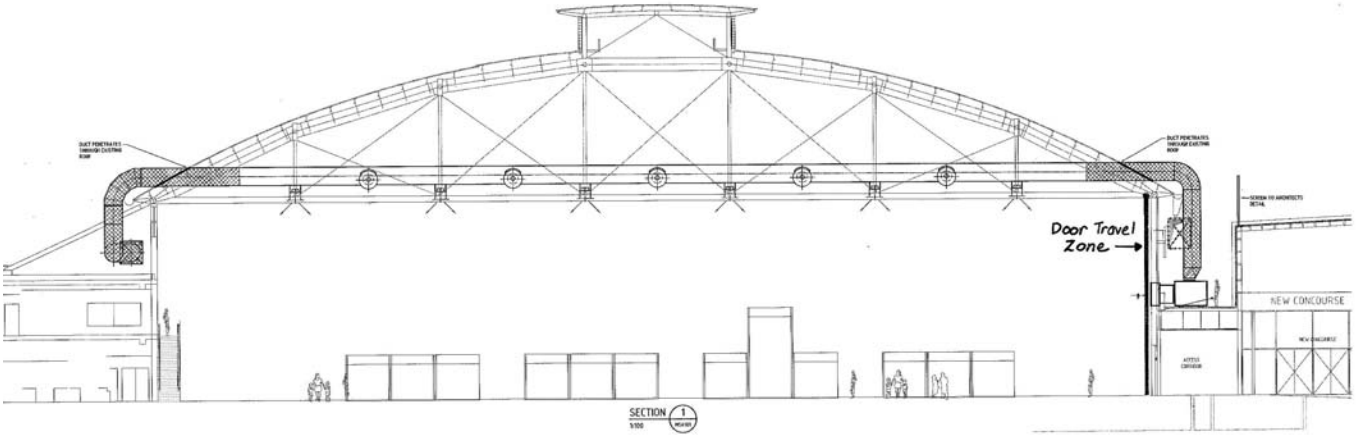

Figure 5 Exhibition Hall Duct Layout

As noted on the above sketch the travel zone for the existing operable doors prevents the supply air ductwork from entering the halls below the roof line. The only method of reticulating the ducts is externally, over the edge gutter. The supply ductwork and diffusers are located just above the internal structural steelwork,
A Computational Fluid Dynamic (CFD) analysis was undertaken of this option and indicates that the design provides evenly distributed cooling and heating to the halls.

In cooling mode the air can be provided at low velocity through the diffusers and descends to the occupied space. The cool air descending to the occupied zone provides cooling while the upper sections of the hall are largely unconditioned. In heating mode the motorised supply air swirl diffusers will be automatically adjusted to increase the velocity of the supply air.

In heating mode the air will be introduced at a higher velocity and thus be blown down into the occupied space and the hall will largely be conditioned as the heat spreads from the floor to roof.

4. Conclusion

The CFD analysis shows that the preferred concept design of overhead ductwork with swirl type motorised diffusers for the airconditioning air distribution system, is able to provide both cooling and heating to the occupied space within the exhibition halls. The results indicate the height of the grilles does not negatively impact the system performance in heating or cooling mode. The results also indicate that the layout of the grilles and ductwork provides for an even distribution of air within the hall.

The overhead air delivery system is the only system which will provide acceptable air conditioning to the exhibition halls.

The route of the existing operable doors prevents supply air ductwork entering from the side of the building. Supply air ductwork will have to be run external to the building (as shown in figure 5) prior to re-entering the building once the ducts are clear of the door rails.

Based on the above results and findings, the preferred concept design should be further developed in the detailed design phase of the project.