WHITE PAPER ON UNDER FLOOR AIR DISTRIBUTION (UFAD)

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WHITE PAPER ON UNDER FLOOR AIR DISTRIBUTION (UFAD)

1.0 EXECUTIVE SUMMARY

The purpose of this paper is to evaluate Under Floor Air Distribution system (UFAD) as an energy efficient system for our commercial buildings, considering both capex and opex. This report mainly addresses the following:

- Concept of UFAD system and types.
- Considerations and benefits of UFAD System.
- Applications of UFAD in our context

This paper is based on a case studies done for 'Lodha Place – T4' and 'Clariant – Plot B – Tower A', where existing ducted system with AHUs were compared with a scenario of UFAD system. While UFAD system is energy efficient and provides more thermal confort, it is observed that it also has following challenges:

- High capex,
- Limited availability of products/monopoly,
- Limited flexibility/option to tenant
- Despite energy savings, there are no monetary benefits to the tenant

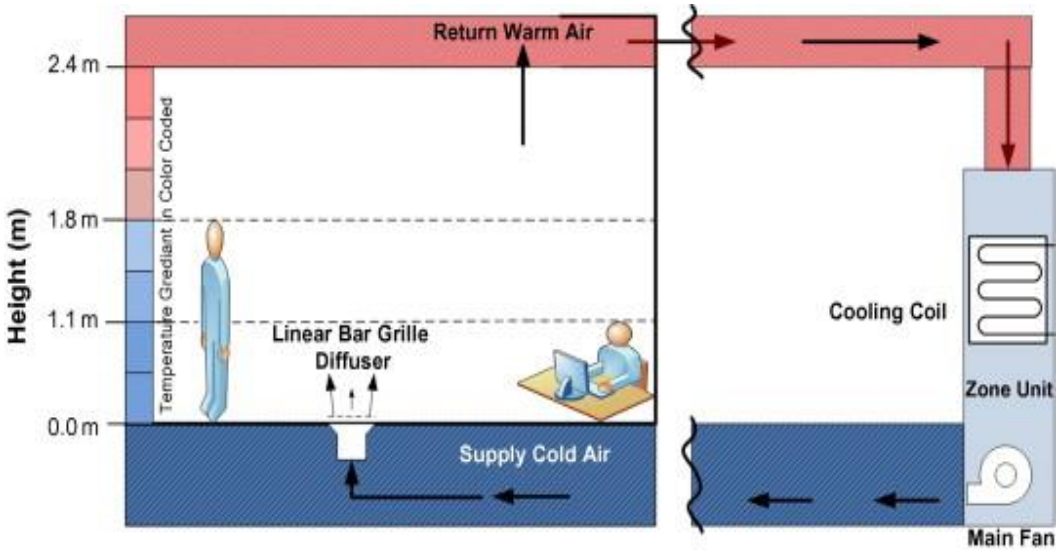
The above challenges can be mitigated by (not entirely in our control):

- Necessary increase in rentals
- Availability of more players in the market
- Lowering of capex such that the benefit of energy gets passed on to the tenant (offset of paying extra rental to us)

The detailed analysis is given in the subsequent sections of this report.

2.0 INTRODUCTION

Underfloor air distribution (UFAD) is a strategy for providing ventilation and space conditioning in buildings as part of the HVAC system. UFAD systems uses the underfloor plenum beneath a raised floor to provide conditioned air through floor diffusers directly to the occupied zone.



Once the air enters through the floor diffusers, it spreads across the floor forming a reservoir of fresh cool air. Any sources of heat (such as people or computers) generate a thermal plume lifting contaminated air to high level for removal from the space.

Since air is supplied in much closer proximity to the occupants than in conventional overhead systems, supply air temperatures must be higher. Usually, a task/ambient conditioning (TAC) system is used to allow individuals to control thermal conditions in small and localised zones.

Under floor air distribution is frequently used in office buildings, particularly highly-reconfigurable and open plan offices with raised floors. UFAD is also common in command centres, IT data centres and server rooms that have large cooling loads from electronic equipment and requirements for routing power and data cables. The ASHRAE Under floor Air Distribution Design Guide suggests that any building considering a raised floor for cable distribution should consider UFAD.

With UFAD systems, conditioned air from the air handling unit (AHU) is ducted into the underfloor plenum where it typically flows freely to the supply outlets. Underfloor systems are generally configured to have a relatively large number of smaller supply outlets, many in close proximity to the building occupants, as compared to a conventional overhead system

2.1 TYPES OF UFAD

A. Pressurized Floor

Pressurized floors operate with small amounts of air pressure in the floor plenum - typically 0.10-inch water gauge (wg). This pressure causes conditioned air to be pushed through floor registers or diffusers to the space or room above. Typically, one diffuser for every 100 square feet of floor space is used. These diffusers deliver air in a swirling pattern that's intended to mix with existing room air and provide heating or cooling.

B. Zero Pressure Floor

Zero-pressure floors rely on small fan-powered distribution boxes to push air up into the conditioned space. Some designs with fan-powered boxes in the floor keep the plenum at negative pressure relative to the space to draw return air back into the supply air and moderate its temperature. Such systems are usually thermostatically controlled as opposed to the manually controlled swirl diffusers that are more common. If necessary, zero-pressure floors and pressurized floors can be combined. For example, conference rooms or perimeter spaces that are far from the core supply risers can use fan-powered boxes; open interior zones can use simple floor outlets.

2.2 SYSTEM COMPONENTS



Raised Flooring

UFAD system requires space between the access floor and the structural floor for air movement. Which is generally created by the raised floor. First the floor panel seams must provide a tight seal to prevent air leakage from the plenum into the space. In some cases ductwork is run through the space to special variable load areas and the space may need partitioning for life safety or thermal zoning. Generally the Raised flooring is supplied by the same vendor supplies the UFAD products and different finishes and color available to suit the ID intent.

Air Diffusers

Room air distribution is accomplished through one of two types of floor diffusers. Interior spaces are controlled through a system of adjustable passive floor mounted diffusers. Each diffuser consists of an adjustable swirl plate located in a mounting basket and mounts through a hole cut in the concrete floor panel. The basket catches any dirt or spilled liquids and prevents contamination of the space below the floor. The adjustable swirl plate allows the occupants to adjust their diffusers to a comfortable level in their space. The diffusers are design to achieve mixing of the approximately 65 F degree supply air within a very tight radius of the diffuser and at very low velocity. Typical diffuser airflow is about 60 to 100 CFM per diffuser.

Air Boosters

These units are designed to fit underfloor in the space between pedestals and the grids of the access flooring system. Size ranges from 280 CFM to 1200 CFM. They are used for perimeter spaces, conference rooms and other spaces with a highly variable load pattern. They typically use supply air from the floor plenum and increase the volume delivered to the room to meet the variable needs. The same style box can be used with ducted primary air when that option is required to meet high thermal load requirements. Heating can be provided with either hot water coils or with electric heaters.

Air Units – Floor/Zone AHUs

One box is used per plenum temperature zone and is mounted in a closet or utility space to control the airflow to the underfloor plenum. The product uses a standard Carrier DDC controller configured for UFAD on a parallel fan powered box to control the temperature and pressure of the zone. The box uses standard 55°F supply air from an air source and blends the air with return air from the zone to provide the 63°F discharge air required in the plenum. The ECM motor in the box varies speed as required to control plenum temperature by varying the amount of recirculated air introduced into the plenum, while the primary air damper simultaneously maintains the plenum pressure by controlling the amount of primary air introduced into the plenum. Minimum position stops assure that ventilation air is always provided. Plenum pressure is maintained at approximately 0.05-0.10 - inch WG

Chillers

The Zone AHUs and Treated fresh air units are connected to chilled water system. Air/Water cooled chillers are located in plant room generates the chilled water required for the system. Two separate chilled water circuit/system is required in UFAD system compared to conventional system. One chilled water system produces chilled water with temperature of 7 and 12 Deg C supply and return respectively. This chilled water is used for Treated a fresh air unit which takes care of entire latent heat. Other chilled water system produces chilled water with temperature of 14 and 19 Deg C supply and return respectively. This chilled water is used for zone/floor AHUs to take care of the sensible load.

AHUS – TFAs

The Fresh air requirement in UFAD system is higher compared to conventional system. The treated fresh air AHUs(TFA) located in plant room/terrace shall supply the fresh air to individual zone/floor through ducts. This fresh will be then mixed with return air through zone/floor AHUs and then supplied to space through under floor air diffuser.

2.3 COMPARISION

Sl No	Parameters	Type Of Air Distribution	
		Under Floor Air Distribution (UFAD)	Conventional Overhead Air Distribution
1	Supply air Temperature	65 Deg F (18 Deg C)	55 Deg F (12 Deg C)
2	Principle	Natural Buoyancy to remove heat & Contaminants	Works on Principle of Dilution system
3	Air Mixing	Mixes the Occupied Zone Only. Mixing the Occupied Zone instead of whole space can result in energy savings in spaces with high ceilings.	Mixes the Entire System.
4	Temperature & Contaminant Levels	Stratified Temperature and Contaminants levels	Uniform temperature & Contaminants levels
5	Indoor Air Quality	Improved ventilation effectiveness as Supply air is directly delivered into occupied zone and contaminants naturally flow upwards into the return air system and out of the breathing area.	Chances of mixing of contaminant with air is higher due to downward throw.
6	Flexibility	Diffusers can be reconfigured at a fraction of time and Cost as compared to Overhead system.	Limited flexibility considering Overhead duct routing and coordination of above false ceiling services.
7	Thermal Comfort	Reducing a likelihood of cold sensation due to introduction of air at higher temperature (Approx. 18 Deg C) than Overhead system. Local air supply can be controlled by the occupants, allowing comfort conditions to be optimized.	Chances of cold sensation are high due to lower supply temperature (Approx. 12 Deg C) in the absence of proper air balancing.
8	Energy Savings	UFAD conditions only six feet of the space in the room reducing supply air requirements, and reducing chiller & primary fan capacity as a result.	Higher plant capacity due to cooling of entire height of office.
9	Capital Cost	Capital cost will be high as compared to overhead distribution due to following reasons. 1) Chillers need to be selected for higher	Lower capital cost due to:- 1) Chillers with standard CHW temperatures. 2) Conventional air handling units with higher
10	Operational Cost	Reduced operating cost due to reduced energy usage, reduced plant capacity, flexible / adaptable services.	Higher operational cost as compared to UFAD.

3 ANALYSIS

The analysis in this report is a comparison between the existing Conventional AHUs and ducted air distribution system UFAD.

Below are the System details

Description	Tower-4		Clariant	
	Conventional	UFAD	Conventional	UFAD
Total Working cooling capacity, TR	3,150	2,800	924	680
Total Installed cooling capacity, TR	3,750	3,200	1,380	1,020

3.1 Capex

Both High side and Low side equipement cost has been considered for holystic system comparison. The cost is derived from Vendor input at the time of this paper and same is volatile and may shall vary time to time and vendor to vendor. A representative table with detailed costing is covered in Annexure 1 & Annexure 2. This extra capital cost can be recovered by Lodha by seeking proportionately higher rental for the property (clarified in the cost benefit analysis in item 3.4)

The summary of the cost differences is as follows:

Capex	Tower-4		Clariant	
	Conventional	UFAD	Conventional	UFAD
Total Capex. In Cr.	24.34	54.45	7.5	17.5
Additional Capex in Cr.		30.11		10

3.2 Opex

Both water side and air side operating cost has been considered for a holystic system comparison. The consumption is derived from the vendor's (Schneider) input at the time of this paper, and the same may vary time to time and vendor to vendor. A representative table with detailed costing is covered in Annexure 1 & Annexure 2

The summary of the cost differences is as follows:

Opex per Year	Tower-4		Clariant	
	Conventional	UFAD	Conventional	UFAD
Water Side Opex. per year in Cr.	8	6.2	2.34	1.5
Air Side Opex. per year in Cr.	2.5	0.7	0.72	0.16
Total Opex. per year in Cr.	10.5	6.9	3.06	1.66
Opex. Savings per year in Cr.		3.6		1.4

3.3 Payback period

Pay Back Period Tower-4		
Additional Capex : 30.11 Cr	Opex Savings : 3.6 Cr	Payback Period : 8.6 Years
Pay Back Period Clariant		
Additional Capex : 10 Cr	Opex Savings : 1.4 Cr	Payback Period : 7.2 Years

3.4 Cost Benefit Analysis

	World Towers T4	Kolshet Plot B	
Lever	Value (Rs psf)	Value (Rs psf)	Comments
Rental Impact	-4.79	-4.10	Increase in rent (for Lodha)
CAM Impact (Water Side)	1.82	2.23	CAM would be reduced (for tenant)
Electricity Impact (Tenant)	1.86	1.51	Lower energy costs (for tenant)
Net impact	-1.11	-0.36	No monetary benefit to the tenant

3.5 Supply chain

The lead time for the UFAD system components are listed below (Reference :-Schneider) :

- Access Floor : 10 to 12 Weeks
- Air booster/units : 6 to 8 weeks
- Diffusers : 10 to 12 weeks

The lead time provided are vendor specific and may vary depending upon the availability and vendors.

3.6 List of Vendors

- Schneider Electric
- Sevcon

3.7 List of Projects in India

- Standard Chartered Office – Mumbai
- Raheja Platinum - Mumbai
- Sify – Navi Mumbai
- Wipro – Pune & Bangalore

4 RECOMMENDATION

The above analysis, practical considerations and market discussions help us to recommend as follows:

- This technology doesn't provide any monetary benefits in terms of capex or opex (off set by increased rentals) to either Lodha or the Tenant, so not recommended for now, except is it can be used as a differentiator and for non-tangible benefits like better comfort.

- Reassessment of the costs and market conditions after 18-24 months, as the present analysis shows that the overall savings by the tenant are lower than the extra rental sought by Lodha.

- Since the rental increase is in the range of Rs.4-5/psf:

    - it is not recommended in the price conscious rental market (Thane, Palava),
    - it can be recommended in the premium segment rental market, on new buildings starting construction after Dec 2019 (after reassessment of costs)

5 REFERENCES

1. https://www.schneider-electric.com/en/download/document/APC_FFAI-A7XC8M_EN/
2. http://sevcon.in/ufad-dv-vavs/

6 ANNEXURE

6.1 Annexure-1: Cost Analysis for Lodha Place Tower-4

Description	TR	Conventional (100 % Capacity)	UFAD (100 % Capacity)
Total Working cooling capacity, TR (water cooling -W/C)		**3,150**	**2,800**
Total Installed cooling capacity, TR (water cooling -W/C)		**3,750**	**3,200**
Capital cost for the each system			
Cost of chiller working at 7/12 degc - Conventional	3,750	54,375,000	
Cost of chiller working at 14/19 degc - UFAD	1,920		27,840,000
Cost of chiller working at 7/12 degc - UFAD	1,280		18,560,000
Low side work for chiller system (piping/ valves/ TFA)		100,800,000	42,000,000
AHU costs		34650000	136,332,000
Low side work in shell (ducting, diffusers, Access flooring, etc)		-	274,961,205
Cost of Electrical Work		53,550,000	44,800,000
Total capital cost		243,375,000	544,493,205
Net additional capital cost for UFAD/Hybrid			**301,118,205**
Water side operating cost estimated			
Chiller working at 7/12 degc - Conventional	3,150	79,852,500	
Chiller working at 14/19 degc - UFAD	1,680		34,070,400
Chiller working at 7/12 degc - UFAD	1,120		28,392,000
Water side operating cost estimated		79,852,500	62,462,400
Saving in Chiller opex water side			**17,390,100**
Air side operating cost estimated			
AHU - Conventional	3,150	24,570,000	
Zonal AHU - UFAD	1,680		3,276,000
TFA unit - UFAD	1,120		3,494,400
Air side operating cost estimated		24,570,000	6,770,400
Saving in Chiller opex air side			**17,799,600**
Net Operating cost savings per year			**35,189,700**
Pay Back period in years			**8.6**

6.2 Annexure 2: Cost Analysis for Commercial Tower Clariant

Description	TR	Conventional (100 % Capacity)	UFAD (100 % Capacity)
Total Working cooling capacity, TR (water cooling -W/C)		924	680
Total Installed cooling capacity, TR (water cooling -W/C)		1,386	1,020
Capital cost for the each system			
Cost of chiller working at 7/12 degc - Conventional	1,386	20,097,000	
Cost of chiller working at 14/19 degc - UFAD	612		8,874,000
Cost of chiller working at 7/12 degc - UFAD	408		5,916,000
Low side work for chiller system (piping/ valves/ TFA)		29,568,000	10,200,000
AHU costs		10164000	33,109,200
Low side work in shell (ducting, diffusers, Access flooring, etc)		-	106,260,000
Cost of Electrical Work		15,708,000	10,880,000
Total capital cost		75,537,000	175,239,200
Net additional capital cost for UFAD/Hybrid			**99,702,200**
Water side operating cost estimated			
Chiller working at 7/12 degc - Conventional	924	23,423,400	
Chiller working at 14/19 degc - UFAD	408		8,274,240
Chiller working at 7/12 degc - UFAD	272		6,895,200
Water side operating cost estimated		23,423,400	15,169,440
Saving in Chiller opex water side			**8,253,960**
Air side operating cost estimated			
AHU - Conventional	924	7,207,200	
Zonal AHU - UFAD	408		795,600
TFA unit - UFAD	272		848,640
Air side operating cost estimated		7,207,200	1,644,240
Saving in Chiller opex air side			**5,562,960**
Net Operating cost savings per year			**13,816,920**
Pay Back period in years			**7.2**