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Analysis of Cavity and Composite Walls to Improve the Comfort in Building Envelope using Ecotect

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Abstract- *Cavity and Composite walls are used to insulate the inner building environment form the outer. But the Experimental analysis can show many variations due to human errors and instrumental errors. The use of simulation tools can help in determining more reliable results that can be used for complete design of building.*

This document concentrates on comfort analysis of building by analysing the cavity walls and composite walls in Ecotect Analysis, a building thermal simulation tool, for Pune region (lat. 18.5 long. 73.8), a moderate climatic zone in India. It is observed that in this region increased discomfort is due to too hot discomfort degree hours (DDH) and study further concentrates on reducing the too hot discomfort degree hours and increase the comfort level

Keywords: Cavity wall, Composite wall, Comfort, Discomfort Degree Hours, Building envelope

1. INTRODUCTION

A building interacts with the environment through its external facades such as roof, walls, windows and projections referred as building envelope. The envelope acts as a thermal shell, which if thoughtlessly constructed, would result in energy leaks through every component. Hence, each components needs to be properly chosen to ensure an energy efficient building. The choice depend onsite and primary objective is to examine the site conditions. Besides an ideal orientation at the site, proper configuration of building envelope plays a significant role in building's thermal performance.

It is observed in moderate zones in India at Pune (lat. 18.5° long. 73.8°) the increased discomfort level is due to too hot discomfort degree hours, and maximum reduction in too hot DDH is observed for the width of 50 mm for air (minimum possible width) and insulation materials like EPE and EPS.

1.1 Cavity walls

Cavity wall consists of an outer brick or block leaf separated by an inner brick or block leaf by the means of an air gap called as cavity. In cavity walls, the air gap inhibits the transmission of heat into or out of the building as air acts as a bad conductor of heat. In composite walls, the cavities are filled with insulating materials by adjusting its thickness.

1.2 Comfort

Thermal comfort is that condition of mind which expresses satisfaction with the thermal environment. It is also range of climatic condition in which majority of people will not feel discomfort of either heat or cold. Such a zone in still air corresponds to a range of 20 to 30°C of dry bulb temperature and 30 to 60% of relative humidity. Besides, various climatic conditions such as wind speed, vapour pressure and radiation also affect the comfort conditions.

The comfort is measured on the basis of Discomfort Degree hours (DDH). DDH is the sum of the hourly room air temperature outside comfort zone.

2. RESEARCH METHODOLOGY

The analysis consists of following cavities and composite materials

2.1 Selection of Base case for performance evaluation
2.2 Selection of minimum width for air cavity
2.3 Selection of insulation material.
2.4 Selection of efficient width of insulation in walls

2.1 Selection of Base case for performance evaluation

The building envelope acts differently in different climatic zones. Thermal performance of the building can change according to the climate of the region where the building is located, and thus according to the location the availability of material used in construction of the building also differs. Hence, a base case is required to be

considered for reference and creating a base for evaluation of building envelope for given climatic zone.

The base case will include the material used for building envelope for a given region. In this case the region under consideration is Pune (lat. 18.5° long. 73.8°) in Maharashtra state of India, which falls under moderate climatic zone of the six climatic zones in India.

The base case for moderate region is given below

Table 1- Base case for building envelope in moderate zones

Building Components	Material assigned
Wall	Double Brick plaster
Doors	Solid core Pine Timber
Windows	Single glazed Aluminium frame
Floor	Concrete Slab and Tile on Ground
Roof	Concrete and Asphalt

2.2 Selection of minimum width for air cavity

The air cavity is responsible to provide insulation in the cavity wall and acts as barrier to the transmission of heat. Air cavity causes the convective heat transfer which is independent of width of cavity. Due to this the U- value of the air cavity wall remains constant until and the wall material is changed.

Thus it is necessary to select such a width which is minimum and easy for construction of wall and maintain a uniform layer of air between the two leaves of wall.

2.3 Selection of insulation material

Selection of insulation is an important aspect as the material must be low cost, durable, and moisture resistant and most importantly low in thermal conductivity.

The materials selected in this case are Expanded polyethylene (EPE) and Expanded polyesterene (EPS).

Table 2- Thermal conductivity of insulation materials

Material	Conductivity (W/ m-°K)
EPE	0.414
EPS	0.035

2.4 Selection of efficient width of insulation in wall

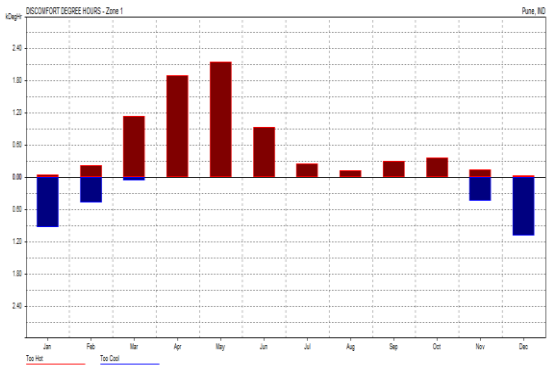
The efficient width of insulation is that which results in maximum reduction of discomfort degree hours and provide maximum comfort as compared to solid walls.

In the region the cavity walls are still not popular in use and thus solid walls are in practise in building envelope.

3. ANALYSIS

Analysis of building envelope is done using the Ecotect Analysis 2011, thermal simulation tool for analysis of buildings. The comfort zone (temperature range) for the given moderate zone is derived from the bio-climatic chart of Pune region (lat. 18.5° long. 73.8°) i.e 22 - 26°C.

The unit of comfort used by the simulation tool is Discomfort Degree Hours (DDH) is the sum of the hourly room temperature outside the comfort zone Thermal analysis of building on the basis of comfort is done for moderate climatic zone. The analysis outcomes obtained from the simulation tool are as follows



Graph 1- Discomfort Degree Hours for Base case

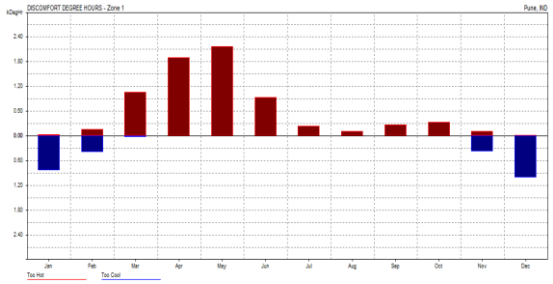
Table 3- Discomfort Degree Hours for Base case

DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	55	935	990
Feb	224	474	698
Mar	1137	65	1202

Apr	1898	0	1898
May	2147	0	2147
Jun	941	0	941
Jul	261	0	261
Aug	134	0	134
Sep	299	0	299
Oct	367	5	372
Nov	146	436	582
Dec	33	1097	1130
TOTAL	7642	3012	10654

The table 3 shows the base case of reference for comfort analysis. These results are used for evaluation of cavity walls and composite walls (Cavity walls filled with insulation)

The solid wall in the base case was replaced by the cavity wall and following results were obtained by thermal analysis.



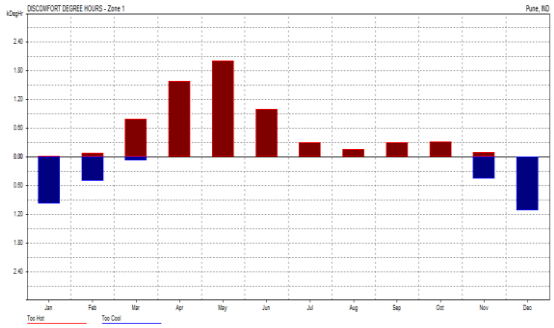
Graph 2-Discomfort Degree hours for air cavity wall

Table 4- Discomfort Degree hours for air cavity wall

DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	30	845	875
Feb	160	397	557
Mar	1057	35	1091
Apr	1893	0	1893
May	2167	0	2167
Jun	940	0	940
Jul	244	0	244
Aug	117	0	117
Sep	270	0	270
Oct	340	3	343
Nov	113	382	495
Dec	14	1011	1026
TOTAL	7345	2673	10018

The results shown in the table 4 are same for all widths (50 mm, 100mm, 150mm, 200mm) analyzed. These results are same because only cavity width is varied and thickness of two leafs is kept constant. As through the air cavity convective heat transfer takes place and it is independent of thickness of cavity, so the U- value of the cavity wall of all widths remains constant, and thus the heat transfer through the wall. Hence, the comfort calculations show the same results. Thus it can be seen that the 50mm cavity width is effective for obtaining comfort level more than that in case of solid walls.

a. For cavity filled with EPE insulation, following results were obtained-



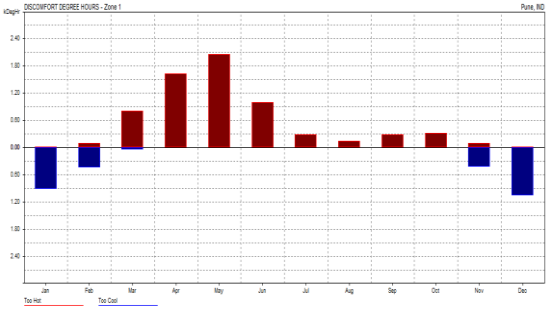
Graph 3-DDH for EPE insulation of 50 mm width

Table 5- DDH for EPE insulation of 50 mm width

DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	15	983	997
Feb	74	499	573

Mar	792	77	869
Apr	1577	0	1577
May	2004	0	2004
Jun	992	0	992
Jul	308	0	308
Aug	153	0	153
Sep	305	0	305
Oct	321	7	328
Nov	96	465	561
Dec	5	1127	1132
TOTAL	6642	3158	9800

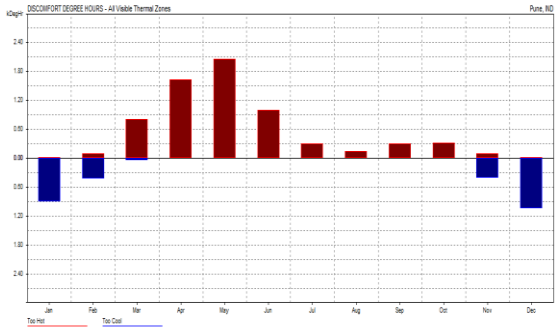
Table 5 shows the results obtained when the 50 mm air cavity was filled with EPE insulation of same width.



Graph 4-DDH for EPE insulation of 100 mm width

Table 6- DDH for EPE insulation of 100 mm width

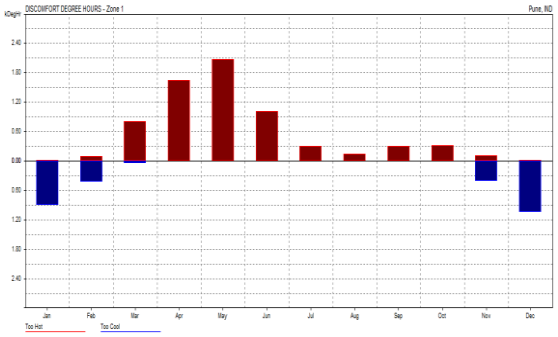
DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	21	911	932
Feb	89	439	528
Mar	806	50	857
Apr	1625	0	1625
May	2050	0	2050
Jun	992	0	992
Jul	290	0	290
Aug	143	0	143
Sep	289	0	289
Oct	314	4	318
Nov	100	422	522
Dec	11	1060	1071
TOTAL	6730	2886	9616



Graph 5-DDH for EPE insulation of 150mm width

Table 7- DDH for EPE insulation of 150mm width

DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	22	903	925
Feb	90	435	525
Mar	812	49	861
Apr	1635	0	1635
May	2061	0	2061
Jun	1001	0	1001
Jul	295	0	295
Aug	146	0	146
Sep	293	0	293
Oct	318	4	322
Nov	102	418	520
Dec	11	1052	1064
TOTAL	6786	2861	9647



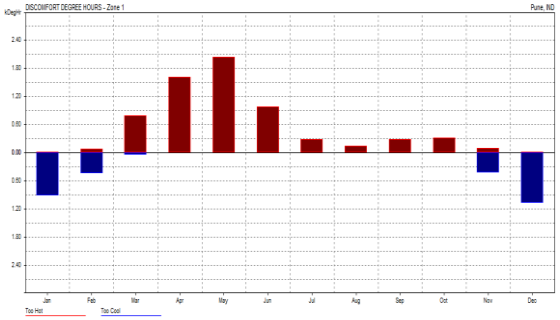
Graph 6-DDH for EPE insulation of 200 mm width

Table 8- DDH for EPE insulation of 200 mm width

DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	22	899	922
Feb	91	432	523
Mar	815	48	863
Apr	1640	0	1640
May	2066	0	2066
Jun	1005	0	1005
Jul	298	0	298
Aug	148	0	148
Sep	296	0	296
Oct	321	4	325
Nov	103	416	519
Dec	12	1048	1060
TOTAL	6817	2847	9664

From table 5, 6, 7 and 8 it can be seen that the EPE insulation has proved to be effective in reducing the total discomfort degree hours up to 8.01%, 9.75%, 9.45% and 9.29% for insulation widths of 50 mm, 100 mm, 150 mm and 200 mm respectively. This reduction the total discomfort degree hours includes the considerable amount of reduction in too hot degree hours which is maximum with 13.08% which is for 50 mm insulation width. While the too cool degree hours reduction is maximum for 200 mm width i.e 5.47. If only the too hot degree hours are to be considered as in Pune (lat. 18.5° long. 73.8°) region the discomfort level is mostly due to too hot degree hours the width of 50 mm can be considered most efficient in case EPE is used for insulating the cavity.

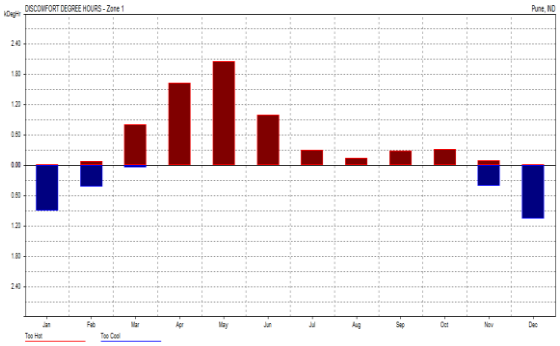
b. For cavity filled with EPS insulation, following results were obtained-



Graph 7-DDH for EPS insulation of 50 mm width

Table 9- DDH for EPS insulation of 50 mm width

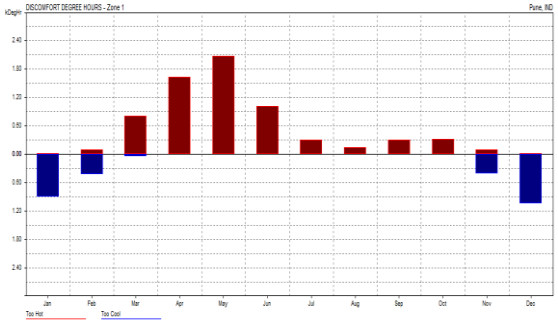
DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	19	920	939
Feb	84	445	529
Mar	798	53	850
Apr	1613	0	1613
May	2040	0	2040
Jun	988	0	988
Jul	288	0	288
Aug	141	0	141
Sep	287	0	287
Oct	310	4	314
Nov	97	427	524
Dec	9	1070	1079
TOTAL	6674	2919	9593



Graph 8-DDH for EPS insulation of 100 mm width

Table 10- DDH for EPS insulation of 100 mm width

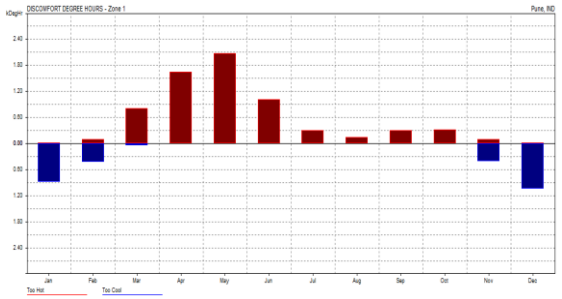
DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	20	904	925
Feb	86	435	521
Mar	807	49	856
Apr	1630	0	1630
May	2058	0	2058
Jun	1000	0	1000
Jul	294	0	294
Aug	145	0	145
Sep	292	0	292
Oct	316	4	320
Nov	100	419	518
Dec	10	1054	1064
TOTAL	6758	2865	9623



Graph 9-DDH for EPS insulation of 150 mm width

Table 11- DDH for EPS insulation of 150 mm width

DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	21	897	918
Feb	88	430	518
Mar	811	47	859
Apr	1638	0	1638
May	2066	0	2066
Jun	1006	0	1006
Jul	298	0	298
Aug	147	0	147
Sep	294	0	294
Oct	319	4	323
Nov	101	415	516
Dec	11	1047	1057
TOTAL	6800	2840	9640



Graph 10- DDH for EPS insulation of 200 mm width

Table 12- DDH for EPS insulation of 200 mm width

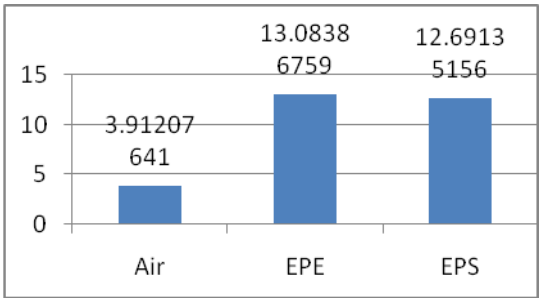
DISCOMFORT DEGREE HOURS			
Zone: Zone 1			
Zone is not air-conditioned.			
Occupancy: Weekdays 00-24, Weekends 00-24.			
Comfort: Band = 22.0 - 26.0 C			
	TOO HOT	TOO COOL	TOTAL
MONTH	DegHrs	DegHrs	DegHrs
Jan	21	894	915
Feb	88	427	516
Mar	814	47	861
Apr	1642	0	1642
May	2071	0	2071
Jun	1009	0	1009
Jul	300	0	300
Aug	148	0	148
Sep	296	0	296
Oct	321	4	325

Nov	102	413	515
Dec	11	1043	1054
TOTAL	6823	2828	9651

The table 9, 10, 11 and 12 show the results obtained from the analysis when cavity was filled with EPS insulation with 50 mm, 100 mm, 150 mm and 200 mm. The reduction in total discomfort degree hours observed are 9.95 %, 9.67%, 9.57% and 9.41% at the widths of 50 mm, 100 mm, 150 mm and 200 mm respectively. Maximum reduction observed in too hot discomfort degree hours was 12.66% at the width of 50 mm of EPS in the cavity while that of too cool discomfort degree hours was 6.1% at the width of 200 mm. Thus it can be said that 50 mm width is efficient in reducing the discomfort as Pune (lat. 18.5° long. 73.8°) region felt maximum discomfort due to too hot degree hours.

4. CONCLUSION

1. Increase in the width of air cavity in the cavity walls does not affect the heat transfer rather keeps it constant.
2. For building envelope the width of cavity must be minimum as possible from the view of ease of construction.
3. Insulation material can be opted for use instead of relying on air cavity for reducing the discomfort level inside the building.



Graph 11-Percentage reduction in Too Hot Discomfort Degree Hours

4. As in case of Pune (lat. 18.5° long. 73.8°) ,India region, the increased discomfort level is due to too hot discomfort degree hours, and maximum reduction in too hot DDH is observed for the width of 50 mm for air (minimum possible width) and insulation materials like EPE and EPS.

Results can be obtained for various other climatic zones in India. The Ecotect Analysis 2011 building simulation tool can be used for thermal analysis for use of materials in building envelope.

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