7481

INTERMODEL COMPARISON OF AIR FLOW THROUGH LARGE OPENINGS

1. Introduction

In order to evaluate the accuracy of COMIS predictions for large openings, and to study its sensitivity, two tests have been performed. In the first test, COMIS is used together with four existing multizone air flow models to calculate natural ventilation in a building for various climatic and opening configurations. In the second test, COMIS predictions are compared with single-sided ventilation measurements taken in test cells. The results of the tests are reported below.

2. First Test - Inter-model Comparison

Four multizone air flow models have been used together with COMIS to calculate the air flow patterns in a real building under various climatic conditions and architectural configurations.

The aim of the comparison was:

- To compare the predictions of COMIS with the predictions of other existing multizone air flow models, and
- to study the sensitivity of the existing air flow models and the deviation and errors of the predictions.

The models used for the comparison are: AIRNET (1), ESP (2), BREEZE (3), PASSPORT-AIR, (4), and COMIS (5). The models are applied to predict the air flow patterns in the building of the National Observatory of Athens, operating under natural ventilation conditions. This building is being monitored inside the PASCOOL research project of the European Communities. The building consists of three zones. Zone A has an external window, W1, while Zone B has two external windows, W2 and W3, and Zone C has an external Door , W4. Zone A communicates with zone B through a door, P1, and zone B with zone C through a door, P2. There is no direct communication between zone A and C. The main characteristics of all openings are given in Table 1.

The following architectural configurations have been studied:
Case 1 : All openings are opened,
Case 2 : W1, W2, W3 opened and W4 closed. All internal doors opened,
Case 3 : W1, W2, W4 opened, W3 closed. All internal doors opened,
Case 4 : W1 and W2 opened. W3 and W4 closed. All internal doors opened,
Case 5 : W1 and W3 opened. W2 and W4 closed. All internal doors opened,
Case 6 : W1 opened. W2, W4 and W3 closed. All internal doors opened.

Table 1: Characteristics of the openings of the NOA building.

	W1	W2	W3	W4	P1	P2
Azimuth	135	45	235	235	Internal	Internal
Surface [m^2]	3.12	3.12	3.12	5.4	2.2	2.89
Width [m]	1.25	1.25	1.25	1.59	0.8	1.05
Height [m]	2.5	2.5	2.5	3.4	2.75	2.75

Calculations have been performed for a wind speed equal to 1.5 m/sec and an ambient temperature equal to 26.8 C. Three wind directions have been considered. a) Wind on W1 with an incident angle equal to 22.5 degrees. b) Wind on W1 with an incident angle equal to 67.5 degrees. c) Wind parallel to W1.

Therefore, 18 different cases have been studied. Internal temperatures have been obtained from ESP simulations. The pressure coefficients used for each case are taken from the ESP data base and are presented in Table 2. The same inputs have been used for all the models.

Table 2: Pressure Coefficients.

	W1	W2	W3	W4
Incidence angle = 22.5 degrees	0.525	-0.075	-0.300	-0.300
Incidence angle = 67.5 degrees	-0.075	0.525	-0.450	-0.450
Incidence angle = 90.0 degrees	-0.500	0.700	-0.500	-0.500

The results obtained for each case studied are reported in detail in (6). The predicted value of the in- and out-flow for each external opening as predicted by every model as well as the standard deviation and the standard error are given for each case. In the following the results of two representative cases are reported.

Simulation 1: All external and internal openings opened. Wind on W1 with an angle of 22.5 degree. Temperature of zone A = 26.4°C. Temperature of zone B = 25.8°C. Temperature of zone C= 25°C. Cp values and wind velocity as previously described. The outputs are given in Table 3, and are expressed in kg/s.

Table 3: Flow Characteristics of Internal and External Openings.

	W1	W2	W3	W4 inflow	W4 outflow	P1	P2
AIRNET	2.54	1.32	2.21	0.24	1.90	2.54	1.66
ESP	2.48	1.18	2.30	0.33	1.77	2.50	1.43
BREEZE	2.23	1.01	1.93	0.10	1.40	2.23	1.30
PASSPORT	2.19	1.24	2.00	0.22	1.65	2.18	1.43
COMIS	2.38	1.04	2.06	0.82	1.95	2.38	1.14
S.DEVIAT.	0.15	0.13	0.15	0.28	0.22	0.16	0.19
S.ERROR	0.07	0.06	0.07	0.12	0.16	0.07	0.09

Simulation 18: W1 opening is opened, W2 , W3 and W4 are closed. Wind on W1 with an angle of 90 degrees. Temperature of zone A = 27.2°C. Temperature of zone B = 27.6°C. Temperature of zone C= 25°C. Cp values and wind velocity as previously described. The obtained results are given in Table 4.

Table 4: Flow Characteristics of Internal and External Openings, in kg/s

	W1 in	W1 out	P1 in	P1 out	P2 in	P2 out
AIRNET	0.15	0.15	0.16	0.162	0.47	0.476
ESP	0.00	0.00	0.16	0.16	0.47	0.47
BREEZE	0.00	0.00	0.20	0.20	0.48	0.48
COMIS	0.42	0.41	0.17	0.16	0.55	0.55
PASSPORT	0.01	0.00	0.14	0.14	0.43	0.43
S.DEVIAT.	0.02	0.02	0.04	0.04	0.18	0.18
S.ERROR	0.01	0.01	0.02	0.02	0.08	0.08

In general it can be concluded that the prediction differences, regarding the total zone flow between the five tools are between 8 to 38%. For the majority of the cases the maximum difference is close to 17%. It is found that COMIS together with AIRNET present the highest predicted values.

Test 2 - Comparisons with Measurements

Single-sided ventilation experiments have been performed in the PASSYS Test Cells. Tracer gas techniques have been used while all indoor and outdoor climatic and meteorological parameters have been measured on the site. The surface and the volume of the zone is 8.6 m^2 and 28.3 m^3 respectively. The surface of the opening is 2.24 m^2. and the height 2.2 m. Detailed information on these experiments are given in (7).

COMIS was used to calculate the air flow for four different experiments. The discharge coefficients are considered equal to one. The main climatic data as well as the measured and calculated air flows and the necessary discharge coefficients required to have equal predicted and measured values are given in the following Table.

Table 5: Experimental Set-up

	Indoor Temp. [°C]	**Outdoor Temp. [°C]**	**Wind Speed [m/s]**	**Air Flow (Measured) [m^3/h]**	**Air Flow (Predicted) [m^3/h]**	**Cd [-]**
Experiment 1	23.4	24.1	3.35	198	1146	0.17
Experiment 2	24.3	24.7	2.51	202	1070	0.19
Experiment 3	26.2	25.7	3.82	245	801	0.31
Experiment 4	26.6	25.5	3.56	323	605	0.53

As shown from the above table the discharge coefficient for the same geometric configuration but for different climatic conditions varies between 0.17 and 0.53. This shows that more research is necessary in order to describe better single-side ventilation phenomena.

In the next step, COMIS will be compared with 18 different single-sided ventilation experiments with variable geometric and climatic data. The results will be communicated in a following report.

References

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