Report No. ENG. R-82-03

Skymark I Air Leakage Study

FINAL REPORT

For
National Research Council of Canada
Division of Building Research
Ottawa, Ontario

ONTARIO RESEARCH

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Attention: Mr. K. Burn

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BUILDING PERFORMANCE CENTRE

30th March, 1982

ONTARIO RESEARCH

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ORF Contract No. 38008

SUMMARY

A study sponsored by the National Research Council of Canada, Division of Building Research, was conducted by ORF to determine the air leakage rates in Skymark I, a highrise condominium in Toronto.

The objective of the study was to determine air leakage rates of the exterior walls of "Florida Rooms" which were constructed by the enclosure of original open balconies. In addition, air leakage between suites was studied to attempt to identify internal leakage paths.

The method used for measurement of the leakage rates was a modification of the pressurization method developed by NRC. Fans were used to pressurize the "Florida Rooms" and suites, and the air flow required to maintain various pressure differentials between inside and outside air was measured.

The leakage rates measured for the Florida Room interior walls were in general higher than those measured for other "highrise" and apartment buildings. A sealing program was carried out, and leakage rates were retested. The new rates were of the same magnitude as those measured for the other buildings.

Leakage rates for the Florida Room exterior walls were close to those of the original balcony walls.

The suites exhibited similar rates for overall leakage. Sealing of identified leak paths around ducts and pipes led to a small reduction in overall leakage.

ACKNOWLEDGEMENTS

ORF would like to thank the National Research Council for financial support of this study. We are especially grateful to Mr. Ken Burn and Mr. C.Y. Shaw for their guidance in the program.

ORF would also like to express its appreciation to the Skymark Study Team, in particular Mr. John Dobbie, for their participation in the air leakage measurements.

A special thanks is given to Mr. Ken Parker, Mr. R. Pearlstein and the staff of Skymark I for their assistance in arranging the tests.

Finally, we wish to thank the residents of Skymark I who allowed us to enter their homes in order to perform the tests.

1. INTRODUCTION

This report is the result of a study funded by the National Resarch Council of Canada, Division of Building Research, for the measurement of air leakage rates in Skymark I, a highrise condominium building.

D B & R was contacted by the consultants retained to investigate air leakage problems in both the exterior shell of the building and between suites. The air leakage problems in the shell appear to result primarily from the post design decision to enclose the balconies so that they could be used by the residents on a year round basis as "Florida Rooms". In addition to this problem, air leakage between apartments has been reported giving rise to concern over easy paths for spread of fire and smoke in the building. This building presented an opportunity to identify air leakage problems associated with the enclosure of balconies. Also, the magnitude of air leakage between suites was measured to demonstrate potential fire and smoke control problems.

2. TECHNICAL DISCUSSION

2.1. Building Air Leakage

Air flow into and out of a building in excess of that required for adequate ventilation is wasteful of energy. Uncontrolled flow of air upwards through a building can lead to rapid spread of smoke and flames in a fire. To control these flows, it is necessary to know the driving force behind them.

Air flows into or out of a building through openings in the building shell. These openings usually consist of cracks around doors and windows, between window sashes and at floor wall joints. This air movement is caused by a pressure difference between the inside and outside of the building. There are two factors which affect the magnitude and direction of the pressure difference. These driving mechanisms are wind pressure and thermal buoyancy (stack effect) caused by a temperature difference between the indoor and outdoor air.

Air flow around a building due to wind creates areas in which static pressure is above or below that in the undisturbed air stream. Wind pressures are positive on the windward side, resulting in inflow of air, and negative on the leeward side, resulting in outflow of air. Pressures on the other sides are negative or positive, depending on wind angle and building shape.

Static pressures over building surfaces are almost proportional to the velocity head of the undisturbed flow. The wind pressure is given by Bernoulli's equation:

$$P_v = \frac{1}{2} \rho V^2$$

where P_v = wind pressure 1 Pa

ρ = air density, Kg/m^3

V = wind speed m/s

At a wind speed of 11.2 m/s (25 mph) the wind pressure is 75 Pa.

Thermal buoyancy or stack effect is a result of temperature differences between the inside and outside which cause density differences and thus pressure differences. During the heating season the warmer inside air rises and flows out of the building near its top. It is replaced by colder outside air which enters the building near its base. During the cooling season the flows are reversed, and are generally less significant due to the lower temperature differences.

The point of the wall where the pressure differential is zero is called the Neutral Pressure Level (NPL). Above this point in the heating season, the interior pressure is higher than the exterior pressure and airflow is outward. Below the NPL the lower interior pressure causes airflow into the building. At zero wind speeds for a building with uniformly distributed openings the NPL will be at the mid-height of the building. The pressure differential increases with distance from the NPL, according to the equation:

$$Ps = \rho_i gh (T_i - T_o)/T_o \qquad (2)$$

where P_s = pressure difference due to stack effect, P_a

ρ_i = air density inside the building Kg/m^3

g = gravitational constant, 9.8 m/s^2

h = distance to neutral level, m (positive if above NPL and negative below)

T_i = absolute temperature inside building, K

T_o = absolute temperature outside building, K

For a highrise building the actual pressure differences are affected by the internal structure of the building. Figure 1a shows the pressure differentials due to stack effect for a building with no internal partitions. In this case, the stack effect acts on the total building height, and the whole pressure difference is across the exterior walls. For a building with airtight separations between the floors, the pressure differentials would be as shown in Figure 1b. Each floor acts independently, so that the pressure differential across the exterior walls is much smaller than for the open building.

In reality highrise buildings are neither totally open or perfectly airtight between stories. Vertical shafts which connect floors, such as stairways, elevator shafts, and service shafts, allow airflow between floors. The actual stack effect would be more like that shown in Figure 1c.

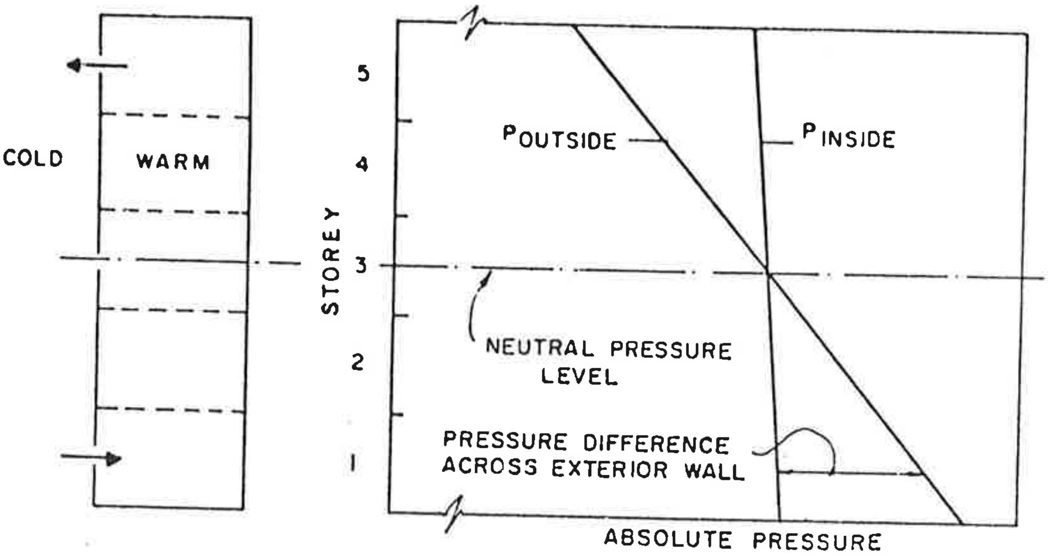

FIGURE 1a STACK EFFECT IN BUILDING WITH NO INTERNAL PARTITIONS

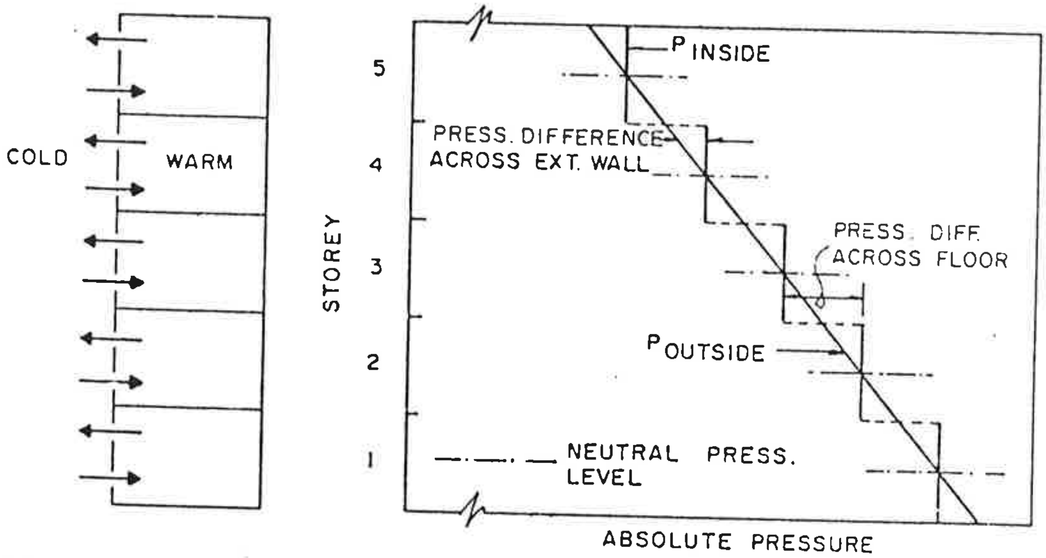

FIGURE 1b STACK EFFECT IN BUILDING WITH AIRTIGHT SEPARATION OF EACH STOREY

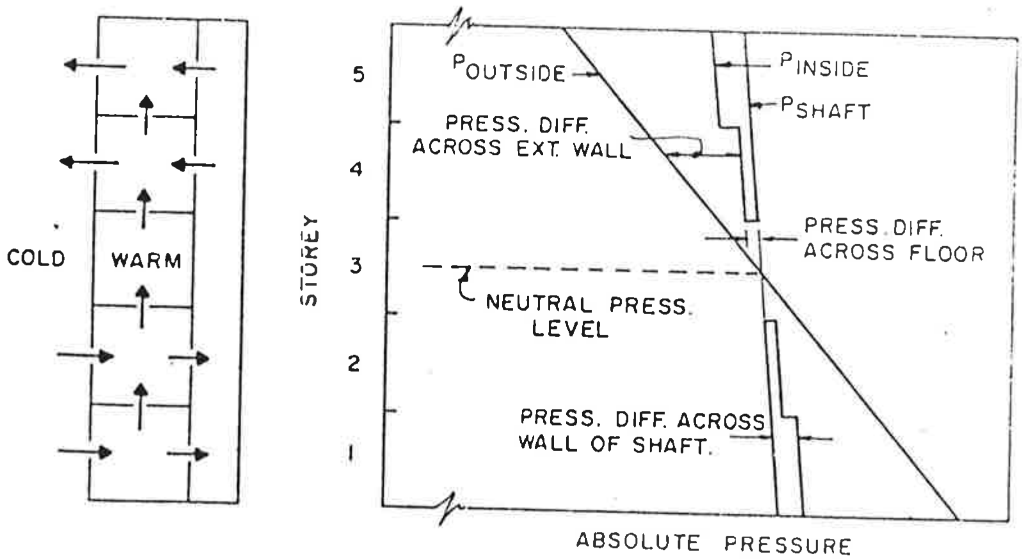

FIGURE 1c STACK EFFECT FOR IDEALIZED BUILDING

2.2. Air Leakage Measurement

The measurement of air leakage rates in apartment buildings can be done by pressurization of the building and measurement of the air flow required to maintain a certain pressure differential across the walls. This procedure works well for small buildings, however, for large highrise apartment buildings the volumes of air required make this method impractical. As an alternative, a method was developed by NRC for measurement of air leakage through individual walls and components of the buildings. For these tests, a rigid chamber must be placed over the wall assembly or component to be tested. This method is easy to use and works well in unfurnished apartments. However, in furnished, occupied apartments, as is the case in Skymark I, a full wall testing would be inconvenient due to the fact that furnishings must be moved away from the outside walls in order to perform the tests. Also, apartments surrounding the test apartment must be entered to install pressure balancing fans.

In order to avoid this difficulty, a modified procedure for testing air leakage in occupied apartments was proposed.

Measurement of air leakage through the exterior walls of the "Florida" room was carried out using the NRC method, with the interior wall of the room serving as the test chamber wall. This interior wall was sealed with tape, to reduce air leakage into the apartment. A panel was placed in the door opening between the "Florida" room and the apartment. The ductwork for the pressure test was installed through an opening in this panel. The fan and air flow meter were connected to the duct. In addition, a similar panel, duct and fan were installed in the doorway to the apartment, and used to maintain the pressure in the apartment close to that in the Florida room, to reduce leakage. Air leakage tests were carried out at four different pressure levels, up to a maximum of 75 pascals, as measured between the interior of the Florida room and the exterior of the building.

Following the initial tests, a leak sealing program was carried out in the apartments by the contractors to reduce air leakage through identified paths. Part of this work involved caulking of exterior joints around the Florida rooms and sealing of duct and pipe penetrations through floors and walls.

The sealing work which was performed consisted of:

(a) sealing of an opening between the exterior precast concrete slab and the floor slab

(b) sealing of openings around pipes which penetrated floor slabs

(c) sealing of openings between the exterior concrete panels of the balcony enclosures and the floor slab

(d) sealing around exhaust duct at penetration of exterior wall

(e) sealing of panels under windows

After sealing, pressurization tests were carried out on the Florida room and the full site.

2.3. Testing Procedures and Equipment

A series of six tests was carried out on suites 204, 1408, 2505 and 3302. Four tests were carried out prior to the sealing program, and two tests were done after the retrofit. These tests are described as follows:

1. Test of the Florida room with a plastic sheet taped over the windows to exclude air leakage through the windows, and the wall between the Florida room and apartment sealed.

2. Test of the Florida room with the plastic sheet over the windows removed, to measure the full wall leakage.

3. Test of the full suite with the Florida room windows closed, and the door to the Florida room from the apartment open.

4. Test of the full suite with the Florida room windows open, and the doors to the Florida room from the apartment closed.

5. After sealing, a test of the Florida room similar to test number 2.

6. After sealing, a test of the full suite, similar to test number 3.

The difference in flow rates between tests number 1 and 2 were considered to be the leakage rates of the Florida room windows.

Test number 4 was carried out to determine the difference in leakage rates between the present exterior wall of the Florida room and the original suite exterior wall, which is now the wall between the Florida room and the suite.

A more detailed description of the test procedure is given below.

2.3.1 Florida Room Tests

i) To determine window leakage rates, polyethylene is placed on the inside surface of the windows and taped around the edges to provide a seal.

ii) A rigid panel is placed in the doorway to the Florida room, and taped in place to seal.

iii) All joints in the wall between the Florida room and suites are taped to reduce internal leakage.

iv) A fan (0 to 200 ℓ/s capacity), flowmeter (Laminar flow element, or airbar) and duct work are installed through the door panel as shown in Figure 2.

v) A tube is connected from a pressure tap on the test chamber to one side of a differential pressure sensor (manometer). Another tube is connected to the other side of the pressure transducer and terminated on the exterior of the building outside of the suite.

vi) A pressure balancing fan is set up in a panel in the apartment doorway as shown in Figure 2.

vii) The apartment is pressurized to a level slightly below the test pressure (-2.Pa).

viii) The Florida room is pressurized to the required test pressure, and allowed to stabilize. The flow meter reading and pressure differential are recorded.

iv) Steps vii) and viii) are repeated for as many pressures as required.

x) The plastic is removed from the windows and steps vii) to ix) are repeated.

2.3.2 Suite Tests

i) A panel is installed in the doorway from the suite to the corridor and taped in place.

ii) A fan (0 - 500 ℓ/s capacity) flowmeter (airbar) and duct work are installed through the panel as shown in Figure 2.

iii) A tube is connected from the exterior of the building to a differential pressure transducer (monometer). The other side of the pressure transducer is connected to the suite.

iv) Inlets to exhaust fans in the kitchen and bathroom are taped.

v) The suite is pressurized to the required test pressure and allowed to stabilize. The flowmeter reading and pressure differential are recorded.

vi) Step v) is repeated for as many times as required.

A schematic of the testing equipment used is shown in Figure 2.

Pressures were measured using inclined manometers manufactured by Airflow Development Incorporated, with scale divisions of 0.001" W.C. (0.25 Pa).

The pressurization fan capacities required were 200 ℓ/s for the florida room tests, and 500 ℓ/s for the full suite tests. Centrifugal blowers with inlet dampers for flow control were used for the tests.

Flow measurements were made using a laminar flow element (meriam model 50MC2-4) with an accuracy of ±0.5%, or an airbar with an accuracy of ±2%. Flow rates were corrected for temperature and barometric pressure, to standard conditions of 21.1°C and 101.3 Kpa.

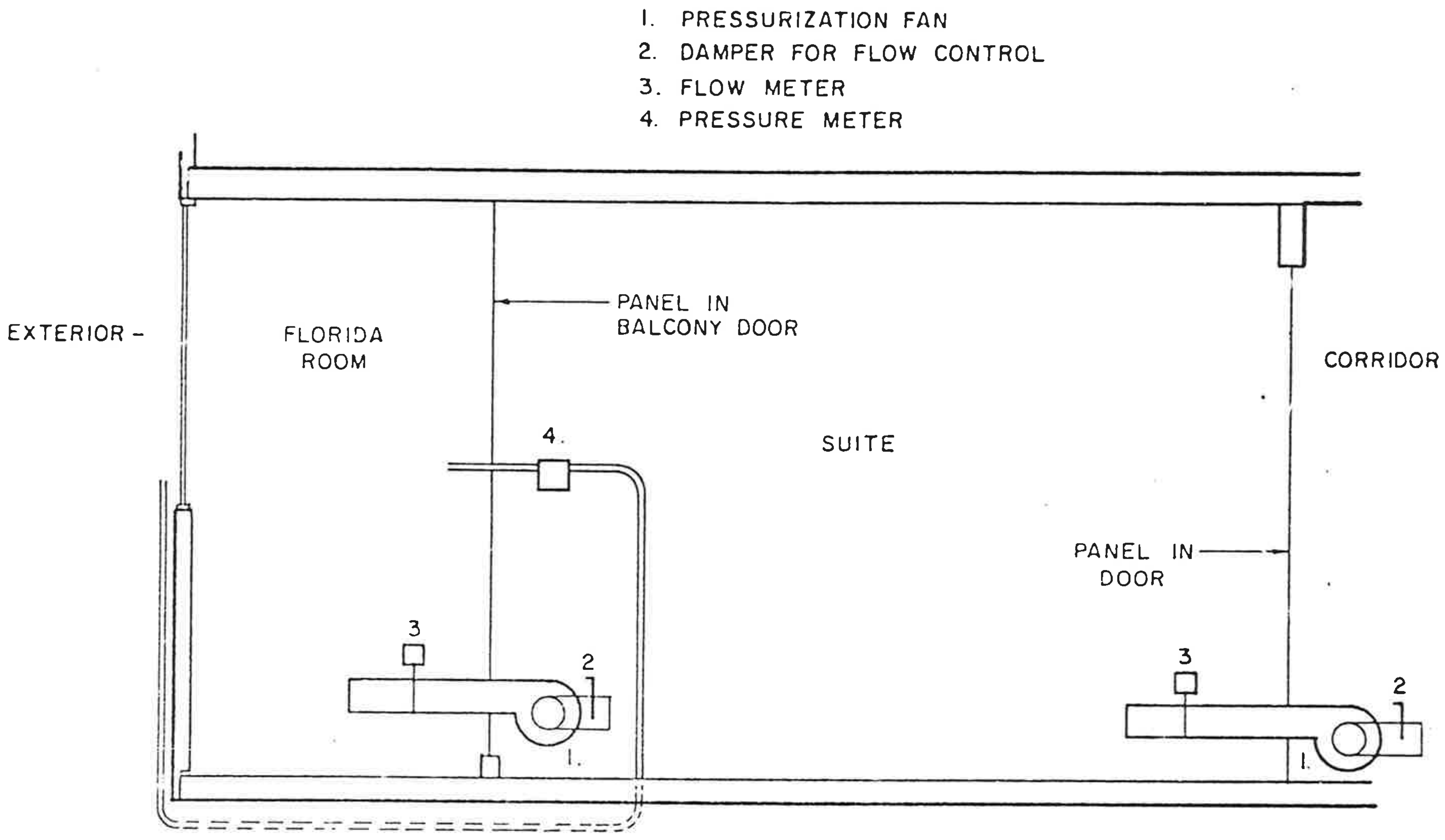

FIGURE 2 EXPERIMENTAL SET-UP FOR MEASUREMENTS OF AIR LEAKAGE RATES

3. RESULTS AND DISCUSSION

The results of the air leakage tests are presented in Tables 2 to 25 of Appendix B. These results are shown graphically in Figures 7 to 20. The air leakage rates measured for the Florida rooms were divided by the exterior wall of the Florida rooms to allow comparison of leakage rates. The air leakage rates for the apartments were divided by the enclosure area of the apartment. This was defined as the area of floor, ceiling, corridor wall, walls to other suites, and exterior wall. The areas for each apartment are given in Table 1. The layouts of the suites tested are shown in Figures 3 to 6 in Appendix A.

Figure 7 shows the results for the florida rooms before treatment, along with results of previous studies on office and apartment buildings carried out by NRC and ORF. It can be seen that in their original condition, the air leakage rates were generally higher than those found in other studies. Figure 8 shows the air leakage rates after treatment of the Florida rooms. The sealing brought the leakage rates closer to those measured in previous studies.

Leakage rates for the Florida room windows were calculated based on leakage per meter of crack length.

The ASHRAE standard for window leakage is 0.77 ℓ/s.m., at a 75 Pa pressure differential. Of the four sets of windows tested, one was below this standard, and three were above.

Air leakage rates can generally be expressed in terms of pressure differential by the following equation:

$$Q = CA\,(\Delta P)^n$$

where

Q = air leakage rate, L/S

C = flow coefficient, L/s m^2 $(Pa)^n$

A = area of envelope, m^2

ΔP = pressure difference across walls Pa

n = flow exponent

If we assume a flow exponent of .70 for the suites in this case, changes in leakage rates can be determined by the change in the flow coefficient, C. Table 1 shows the flow coefficient for the Florida rooms and full suites before and after treatment.

Leakage rates for the windows in the Florida rooms ranged from 10 to 42% of the wall leakage before treatment and from 12 to 70% after treatment.

The full suite leakage rates at a 75 pascal pressure differential ranged from .8 to .98 $\ell/s.m^2$ before treatment and from .68 to .83 $\ell/s.m^2$ after treatment. There are no previous similar tests with which this data can be compared.

The difference in suite leakage rates in the initial tests between the condition with the Florida room windows open and door closed, and the tests with the windows closed and the doors open were very small. This indicates that the leakage characteristic of the Florida room exterior walls are similar to those of the original apartment balcony walls.

4. CONCLUSIONS

The air leakage rates through the exterior walls of the Florida rooms before treatment were above the average rates of other highrise buildings previously tested. After treatment, the leakage rates were generally in the same area as the other buildings.

In three of four cases, the window leakage rates were above recommended standards.

The test showed that the leakage characteristics of the Florida room exterior walls are similar to those of the original balcony walls.

5. RECOMMENDATIONS

The presentaly available methods of air leakage measurement are useful for determination of air leakage rates through exterior walls and components. The method used in this study also allowed measurement of leakage to interior sections of the building. However, it was not possible to identify what leakage was from floor to floor, suite to suite, or suite to corridor. Since floor to floor leakage is an important factor in stack effect and fire and smoke control, a method should be investigated to measure floor to floor air leakage rates.

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CMcG:df
March 30th, 1982

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3. ASHRAE Handbook of Fundamentals, 1981.

APPENDIX A

APARTMENT LAYOUTS

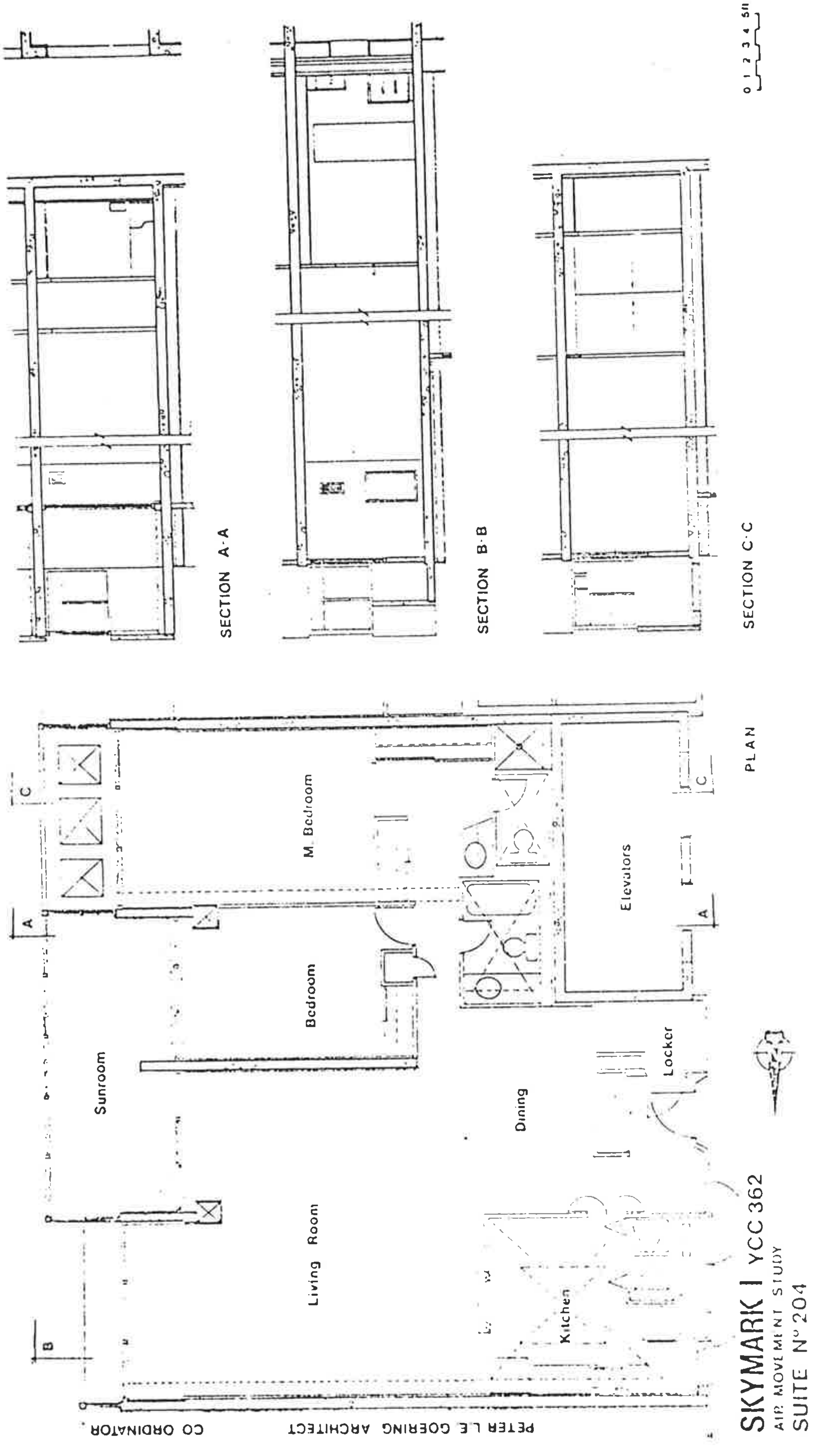

FIGURE 3 - LAYOUT OF SUITE 204

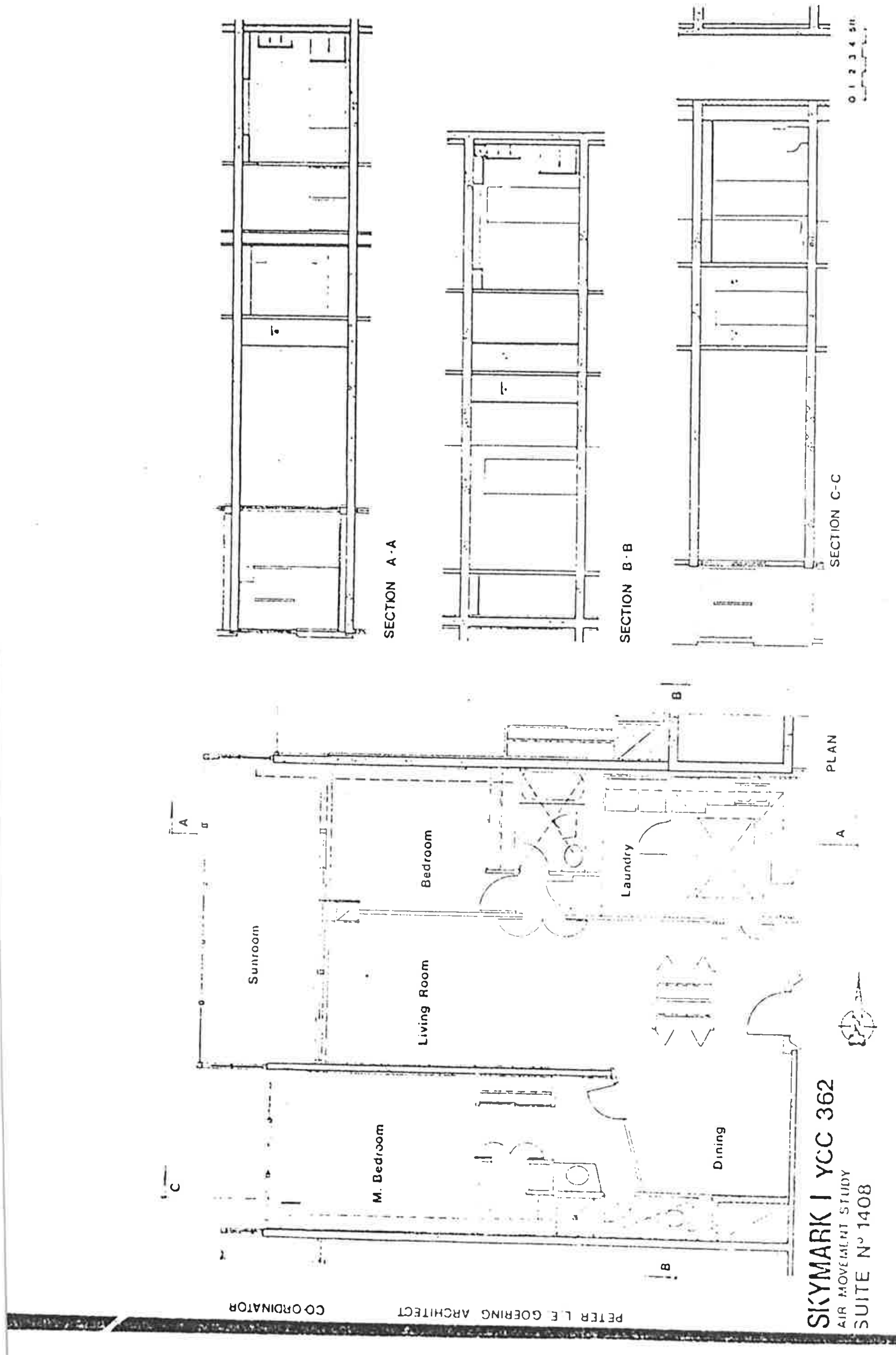

FIGURE 4 - LAYOUT OF SUITE 1408

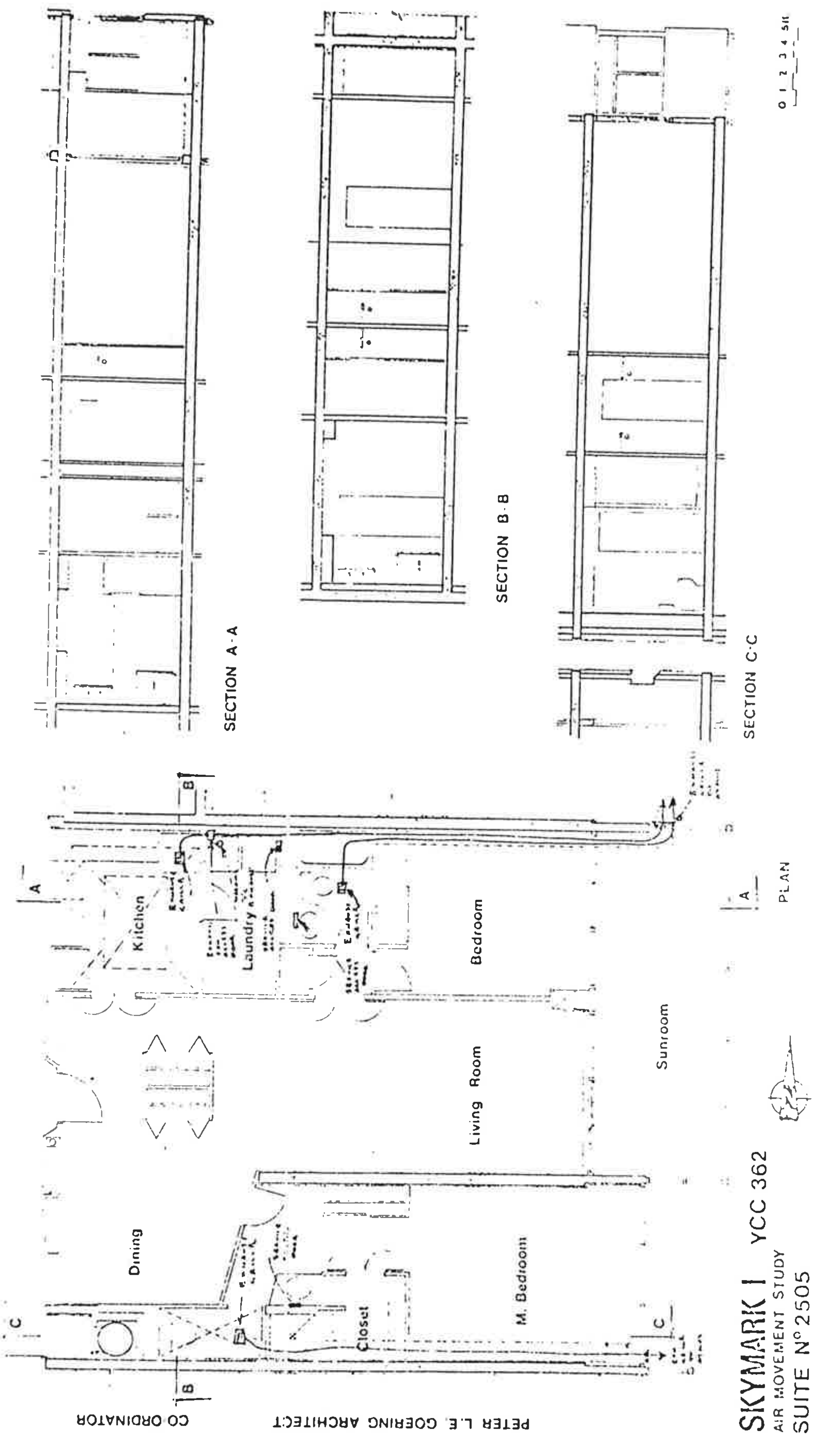

FIGURE 5 - LAYOUT OF SUITE 2505

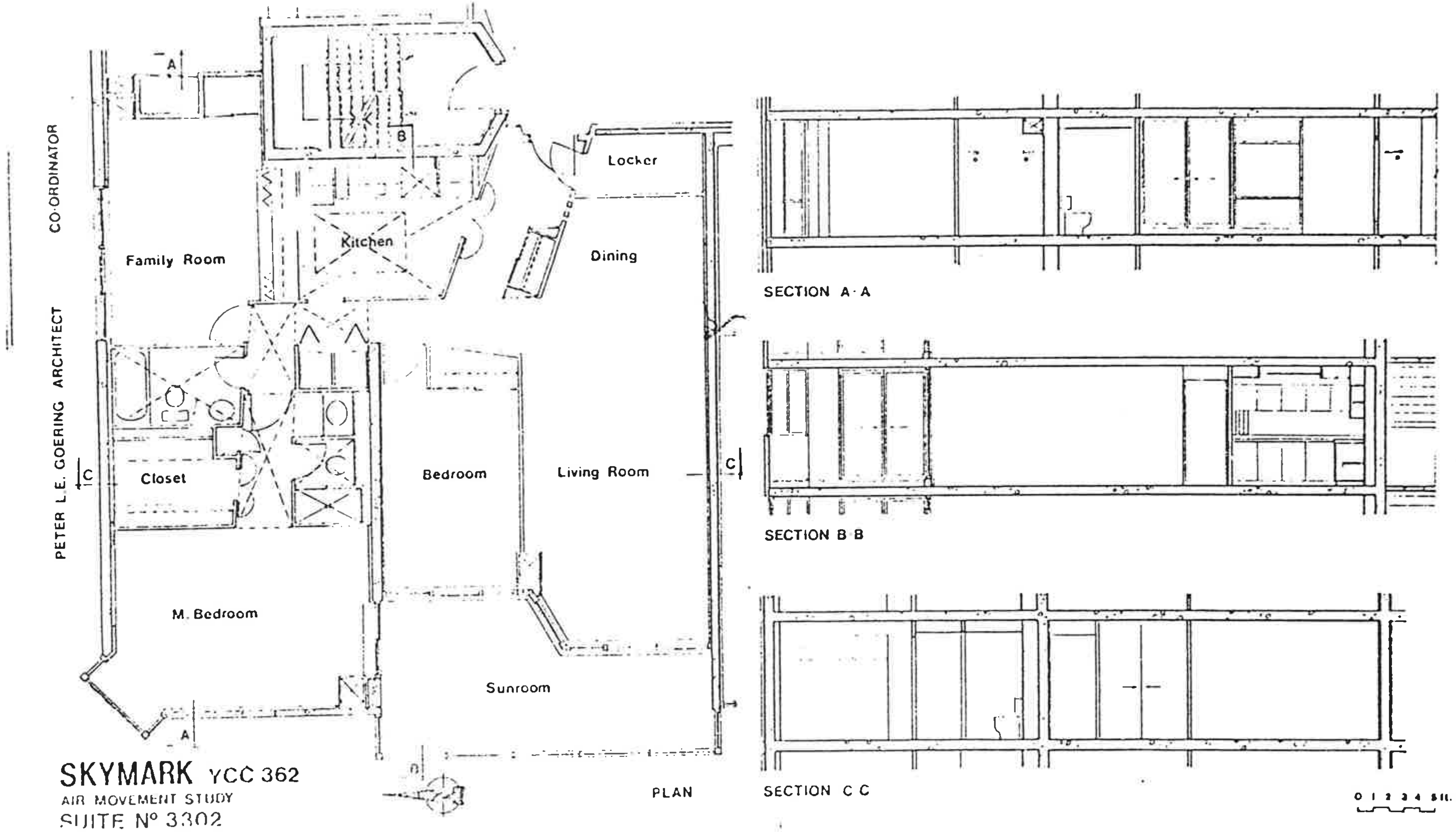

FIGURE 6 - LAYOUT OF SUITE 3302

APPENDIX B

RESULTS

TABLE I:

FLOW COEFFICIENT C. ($L/s.m^2$ $(Pa)^{0.7}$) AND ENCLOSURE AREAS

Suite No.	Exterior Wall Area m^2	Florida Room		% Change	Apartment Enclosure Area m^2	Apartment		% Chang
		Before Treatment	After Treatment			Before Treatment	After Treatment	
204	22.7	.21	.18	14	426	.044	.041	9
1408	24.5	.17	.14	18	384	.045	.042	13
2505	24.5	.18	.11	41	364	.042	.036	10
3302	20.3	.22	.14	36	421	.040	.032	22

TABLE 2

AIR LEAKAGE RATE, SUITE 204, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM DOORS OPEN

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
17.50	133.80	0.31
30.00	177.00	0.42
42.50	264.80	0.62
72.50	399.60	0.94

TABLE 3

AIR LEAKAGE RATE, SUITE 204, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM DOORS CLOSED WINDOWS OPEN

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
22.50	159.30	0.37
35.50	218.50	0.51
47.50	273.20	0.64
72.50	374.50	0.88

TABLE 4

AIR LEAKAGE RATE, SUITE 204, FULL SUITE
AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
20.00	145.80	0.34
34.00	212.60	0.50
45.00	230.60	0.[illegible]4
57.25	302.80	0.71

TABLE 5

AIR LEAKAGE RATE, SUITE 204, FLORIDA ROOM
TOTAL WALL, BEFORE TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW AREA L/S/SQ.M
12.50	28.10	1.24
25.00	49.30	2.17
50.00	76.30	3.36
75.00	91.80	4.04

TABLE 6

AIR LEAKAGE RATE, SUITE 204, FLORIDA ROOM
TOTAL WALL, AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	22.10	0.97
27.50	43.50	1.92
50.00	66.30	2.91
76.25	79.50	3.50

TABLE 7

AIR LEAKAGE RATE, SUITE 204, FLORIDA ROOM WINDOWS

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M	AIR FLOW/ LENGTH OF CRACK L/S/M
12.50	2.41	0.11	.11
25.00	4.23	0.19	.20
50.00	6.69	0.30	.32
75.00	9.43	0.42	.45

TABLE 8

AIR LEAKAGE RATE, SUITE 1408, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM DOORS OPEN

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	145.10	0.38
25.00	201.80	0.53
50.00	288.10	0.75
75.00	377.74	0.98

TABLE 9

AIR LEAKAGE RATE, SUITE 1408, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM WINDOWS OPEN DOORS CLOSED

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW AREA L/S/SQ.M
12.50	116.12	0.30
25.00	186.69	0.49
50.00	270.15	0.70
75.00	344.94	0.90

TABLE. 10

AIR LEAKAGE RATE, SUITE 1408, FULL SUITE
AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	111.90	0.29
25.00	162.49	0.42
50.00	238.50	0.62
75.00	319.36	0.83

TABLE 11

AIR LEAKAGE RATE, SUITE 1408, FLORIDA ROOM
TOTAL WALL, BEFORE TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	21.95	0.90
25.00	40.73	1.66
50.00	69.91	2.85
75.00	87.28	3.56

TABLE 12

AIR LEAKAGE RATE, SUITE 1408, FLORIDA ROOM
TOTAL WALL, AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	23.61	0.96
25.00	33.76	1.38
50.00	53.56	2.18
56.25	56.17	2.29

TABLE 13

AIR LEAKAGE RATE, SUITE 1408, FLORIDA ROOM WINDOWS

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M	AIR FLOW/ LENGTH OF CRACK L/S/M
12.50	5.17	0.21	.24
25.00	11.28	0.46	.53
50.00	18.46	0.75	.87
75.00	29.14	1.18	1.37

TABLE 14

AIR LEAKAGE RATE, SUITE 2505, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM DOORS OPEN

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	81.76	0.22
25.00	143.95	0.40
51.00	231.25	0.64
80.00	316.67	0.87

TABLE 15

AIR LEAKAGE RATE, SUITE 2505, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM WINDOWS OPEN DOORS CLOSED

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	83.64	0.23
25.00	151.66	0.42
50.00	236.65	0.65
75.00	305.51	0.84

TABLE 16

AIR LEAKAGE RATE, SUITE 2505, FULL SUITE
AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
15.00	51.47	0.14
25.00	120.71	0.33
50.00	195.99	0.54
72.50	249.52	0.69

TABLE 17

AIR LAKAGE RATE, SUITE 2505, FLORIDA ROOM
TOTAL WALL, BEFORE TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	24.17	0.99
25.00	42.03	1.71
50.00	69.80	2.85
75.00	91.96	3.75

TABLE 18

AIR LEAKAGE RATE, SUITE 2505, FLORIDA ROOM
TOTAL WALL, AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	15.50	0.63
25.00	24.45	1.00
50.00	40.55	1.65
75.00	55.17	2.25

TABLE 19

AIR LEAKAGE RATE, SUITE 2505, FLORIDA ROOM WINDOWS

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S SQ.M	AIR FLOW/ LENGTH OF CRACK L/S/M
12.50	7.99	0.33	.37
25.00	14.57	0.59	.68
50.00	26.79	1.09	1.26
75.00	38.30	1.56	1.80

TABLE 20

AIR LEAKAGE RATE, SUITE 3302, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM DOORS OPEN

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	87.50	0.21
25.00	164.49	0.39
50.00	267.51	0.64
75.00	358.59	0.85

TABLE 21

AIR LEAKAGE RATE, SUITE 3302, FULL SUITE
BEFORE TREATMENT, FLORIDA ROOM WINDOWS OPEN DOORS CLOSED

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	83.56	0.20
25.00	153.71	0.37
50.00	263.02	0.62
75.00	353.40	0.84

TABLE 22

AIR LEAKAGE RATE, SUITE 3302, FULL SUITE AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	39.98	0.10
27.50	109.49	0.26
55.00	223.51	0.53
77.50	289.70	[illegible]

TABLE 23

AIR LEAKAGE RATE, SUITE 3302, FLORIDA ROOM
TOTAL WALL, BEFORE TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
12.50	21.71	1.04
25.00	40.18	1.93
50.00	73.10	3.51
75.00	102.65	4.93

TABLE 24

AIR LEAKAGE RATE, SUITE 3302, FLORIDA ROOM
TOTAL WALL, AFTER TREATMENT

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S/SQ.M
13.75	20.3	0.97
30.00	32.52	1.56
54.00	47.17	2.27
65.00	54.51	2.62

TABLE 25

AIR LEAKAGE RATE, SUITE 3302, FLORIDA ROOM WINDOWS

PRESSURE DIFFERENCE PASCALS	AIR FLOW L/S	AIR FLOW/AREA L/S SQ.M	AIR FLOW/ LENGTH OF CRACK L/S/M
12.50	5.94	0.29	0.28
25.00	9.82	0.47	0.47
50.00	15.42	0.74	0.73
75.00	22.44	1.08	1.07

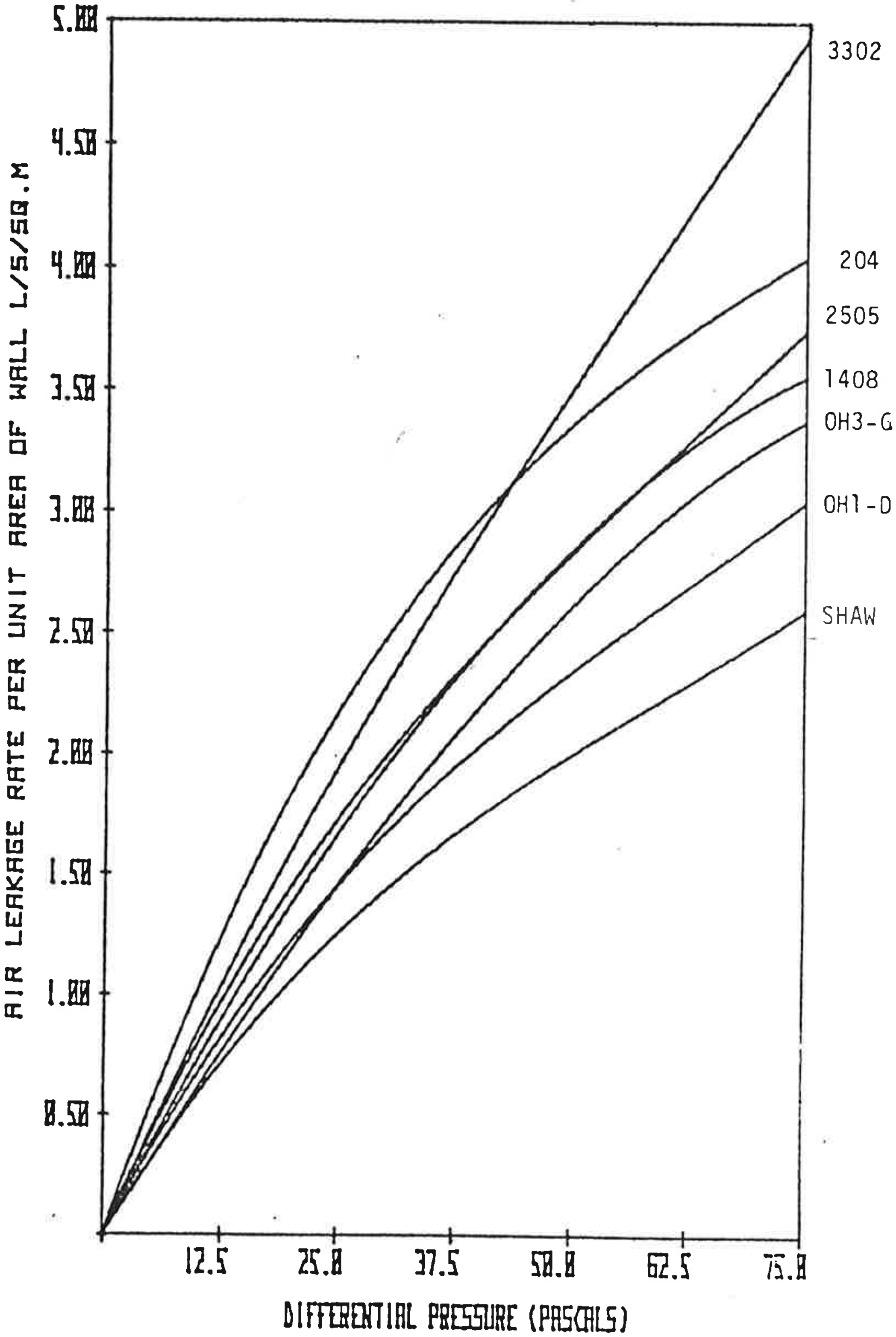

FIGURE 7 - FLORIDA ROOM AIR LEAKAGE RATE BEFORE TREATMENT. COMPARISON WITH PREVIOUS STUDIES.

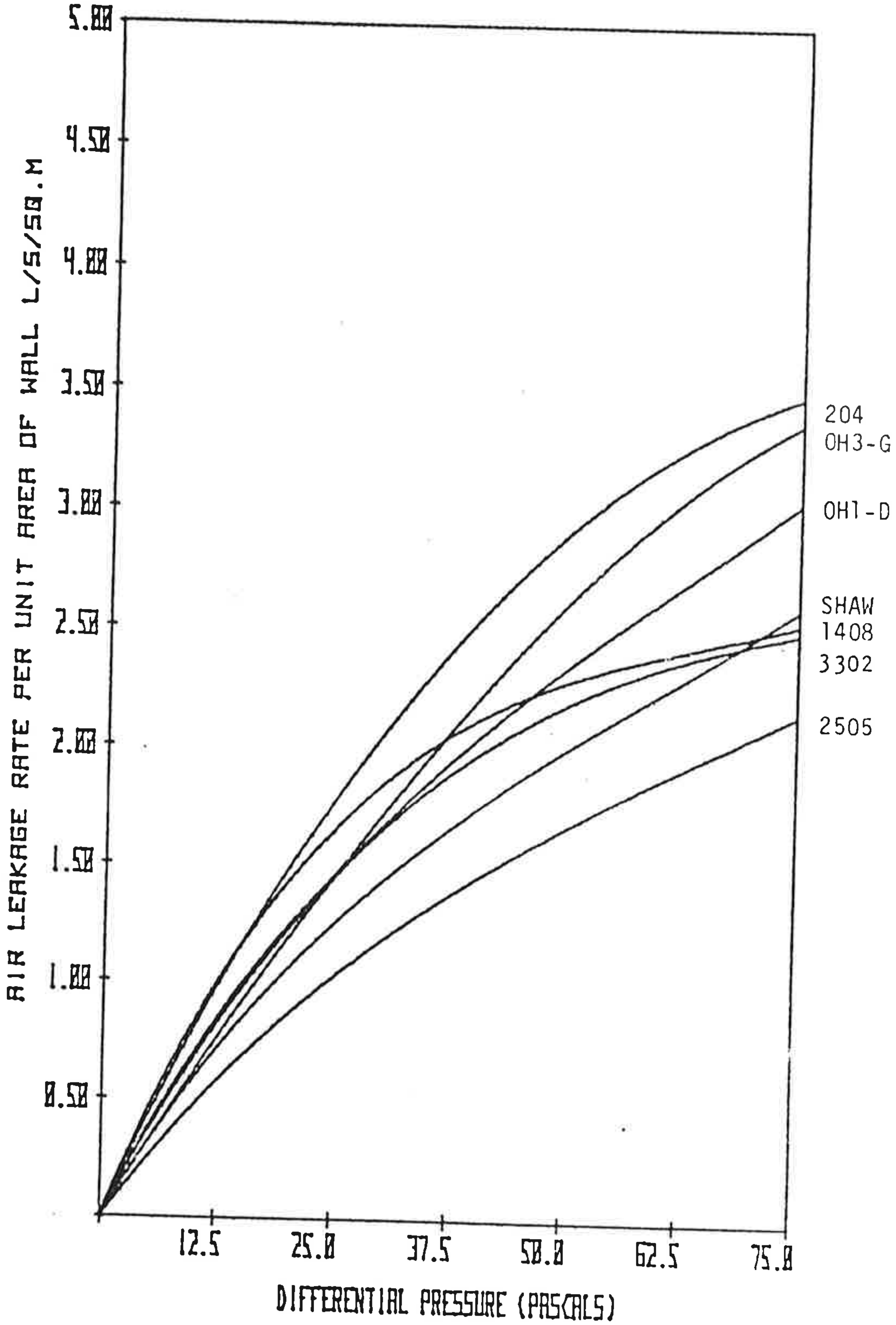

FIGURE 8 - FLORIDA ROOM AIR LEAKAGE RATE AFTER TREATMENT COMPARISON WITH PREVIOUS STUDIES.

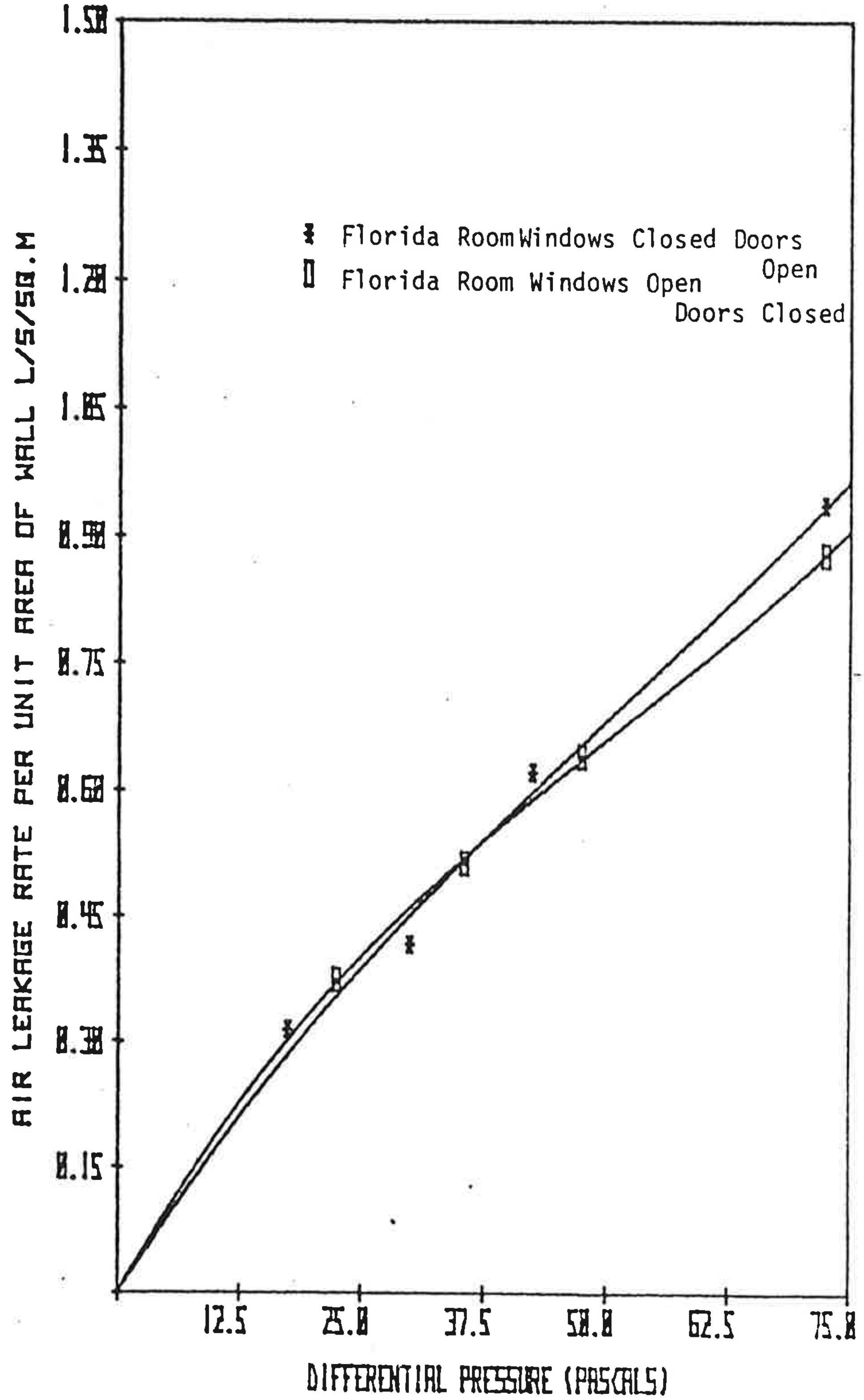

FIGURE 9 - AIR LEAKAGE RATE PER UNIT OF APARTMENT ENCLOSURE, BEFORE TREATMENT. APARTMENT 204.

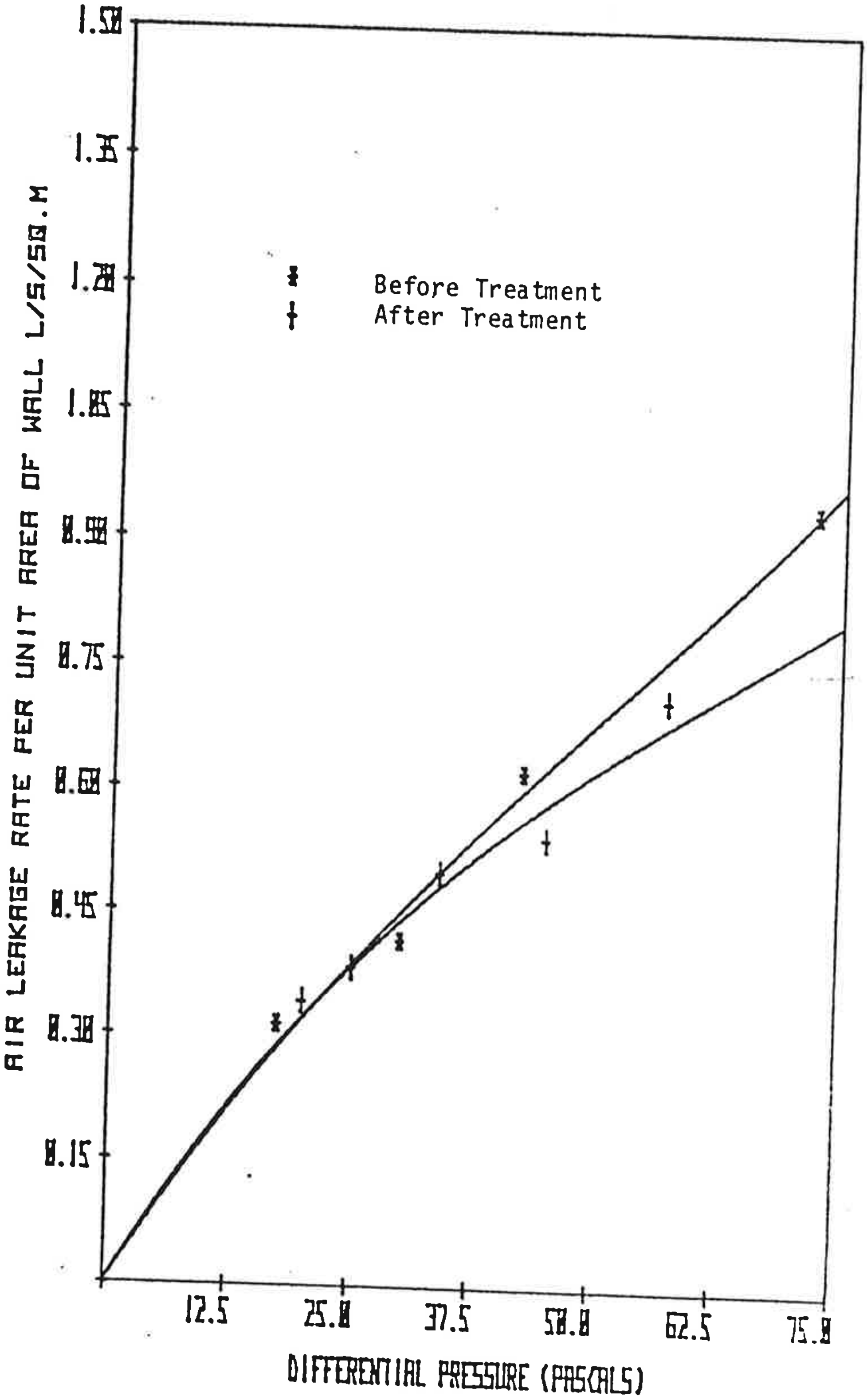

FIGURE 10 - AIR LEAKAGE RATE PER UNIT AREA OF APARTMENT ENCLOSURE, BEFORE AND AFTER TREATMENT. APARTMENT 204.

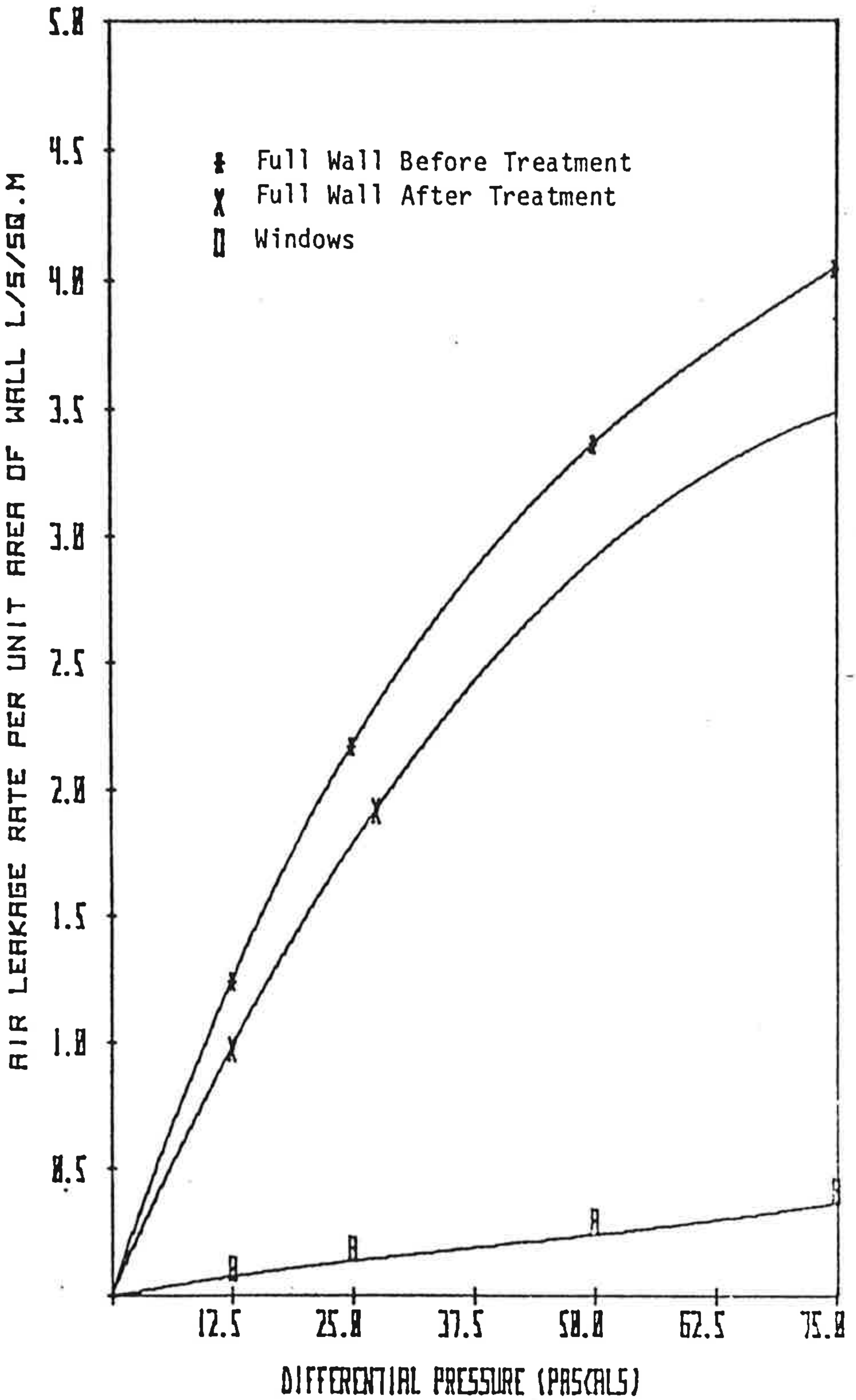

FIGURE 11 - FLORIDA ROOM AIR LEAKAGE RATE PER UNIT AREA OF EXTERIOR WALL. APARTMENT 204.

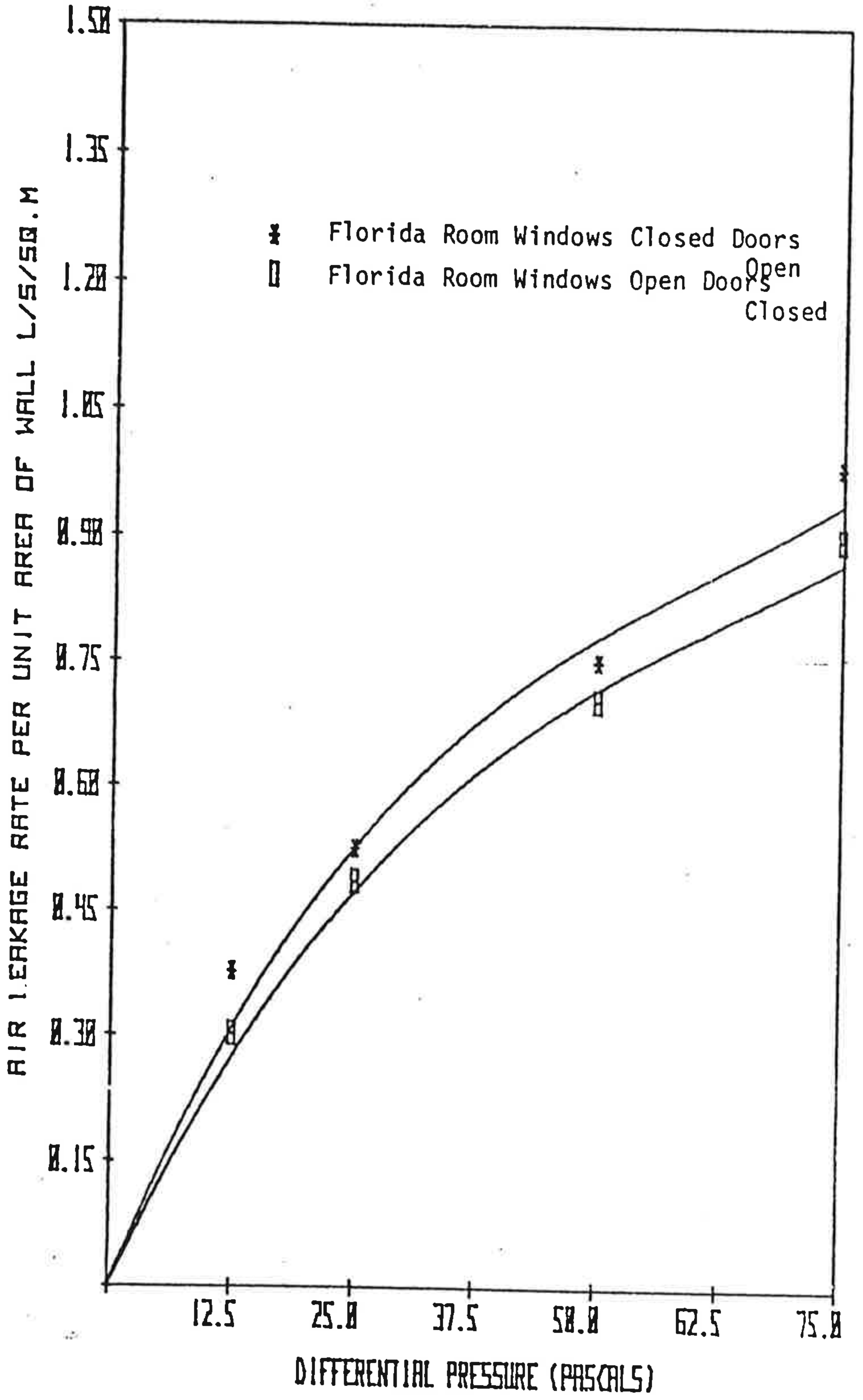

FIGURE 12 - AIR LEAKAGE RATE PER UNIT AREA OF APARTMENT ENCLOSURE, BEFORE TREATMENT. APARTMENT 1408.

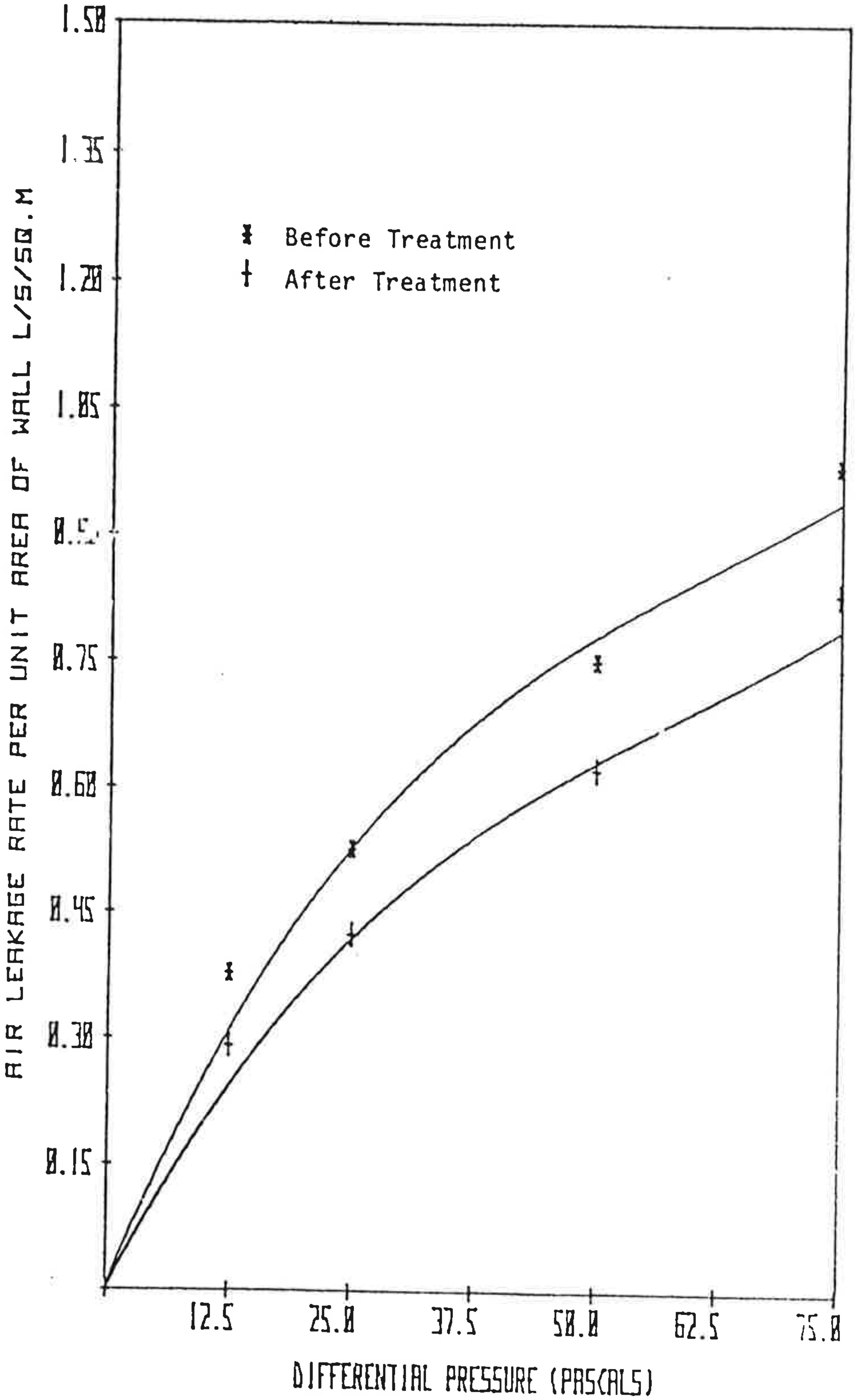

FIGURE 13 - AIR LEAKAGE RATE PER UNIT AREA OF APARTMENT ENCLOSURE, BEFORE AND AFTER TREATMENT. APARTMENT 1408.

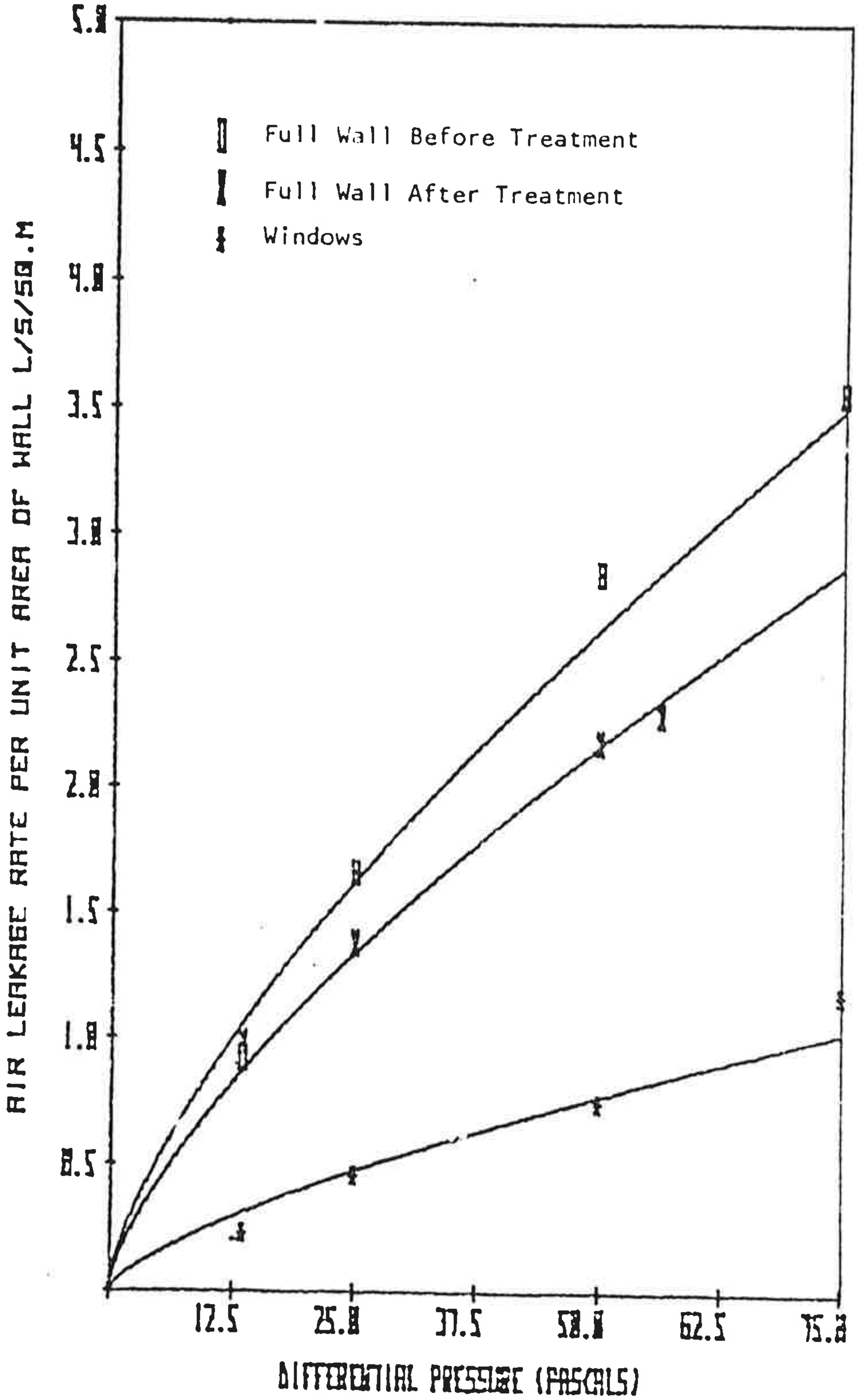

FIGURE 14 - FLORIDA ROOM AIR LEAKAGE RATE PER UNIT AREA OF EXTERIOR WALL. APARTMENT 1408

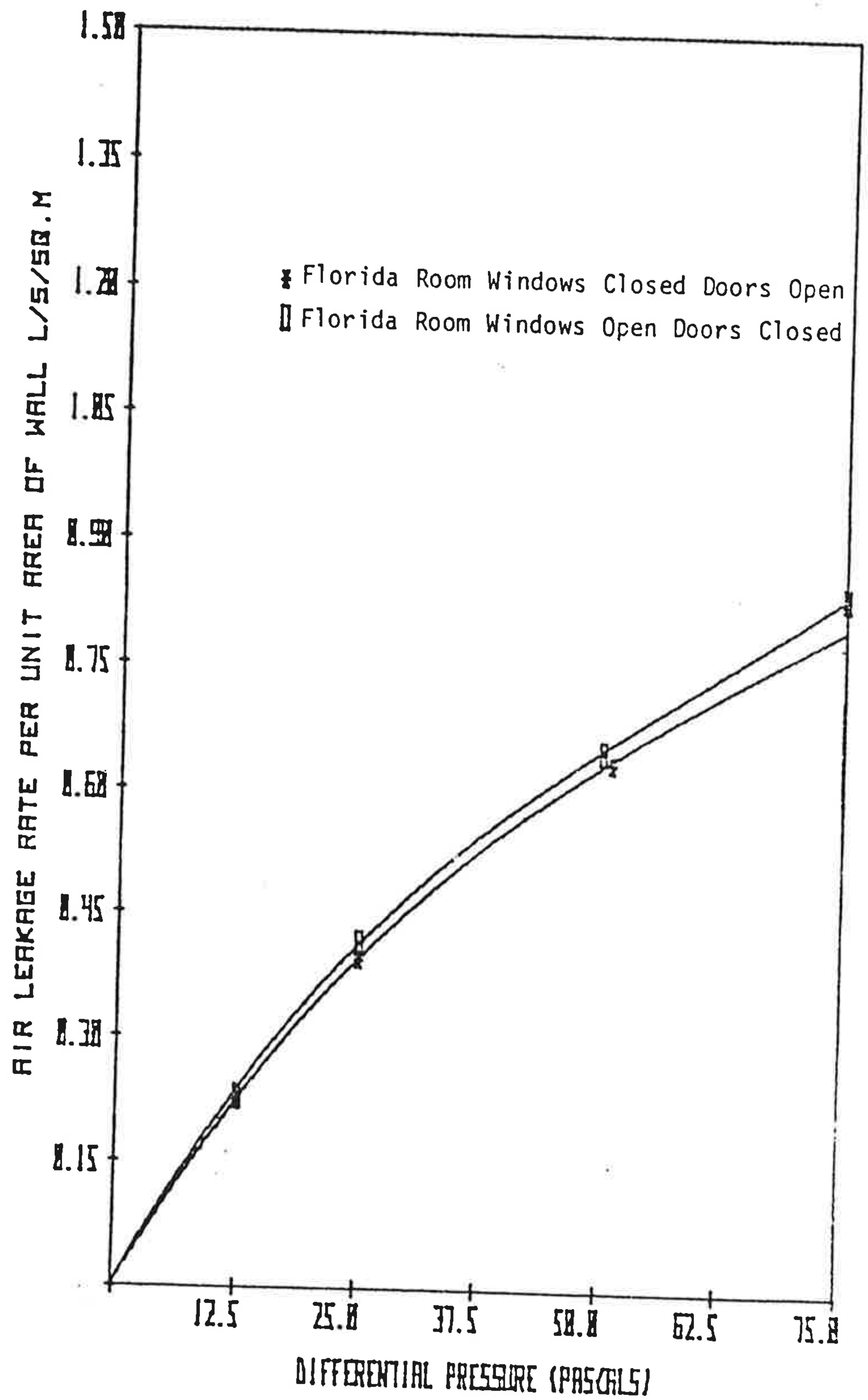

FIGURE 15 - AIR LEAKAGE RATE PER UNIT AREA OF APARTMENT ENCLOSURE BEFORE TREATMENT. APARTMENT 2505

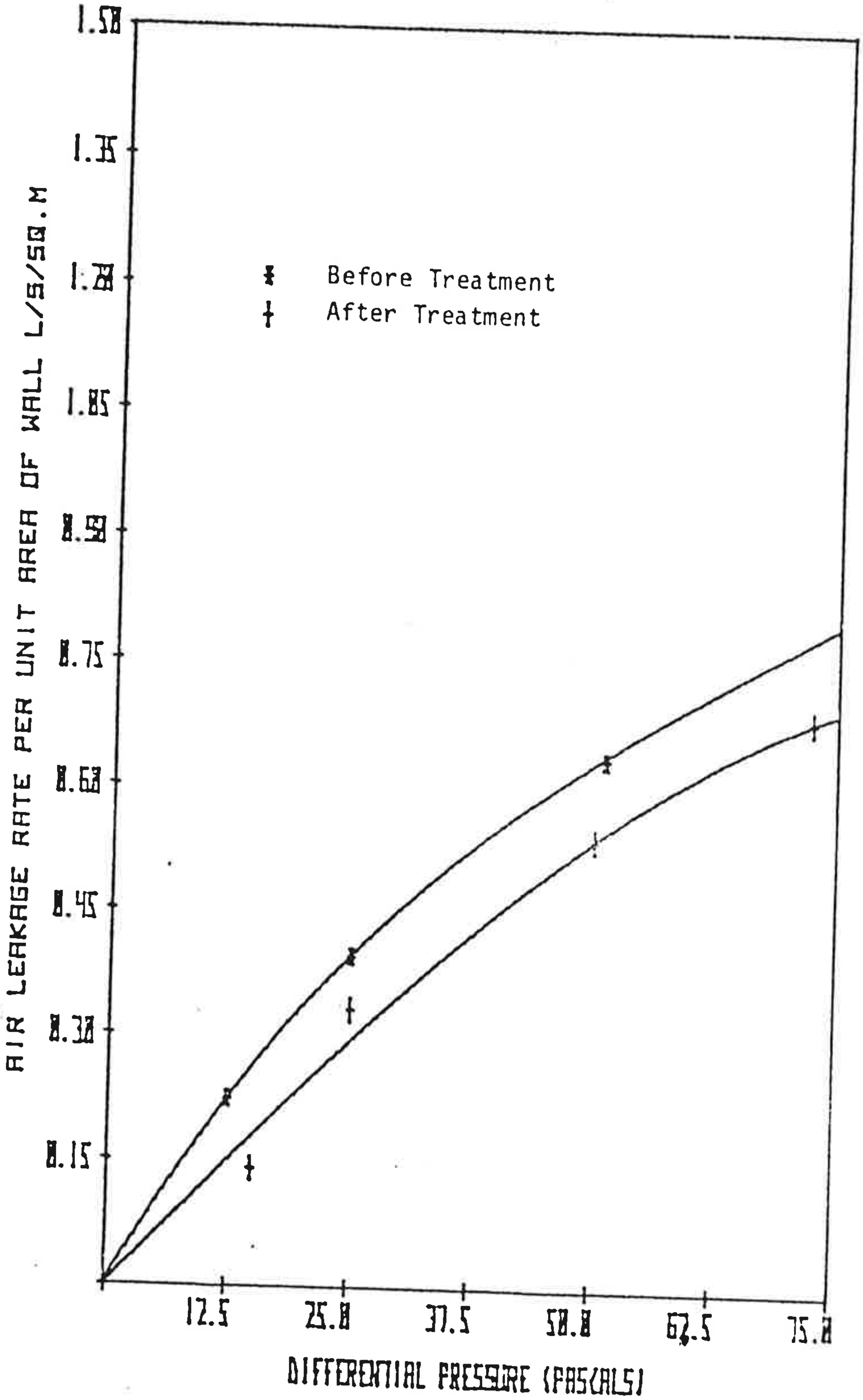

FIGURE 16 - AIR LEAKAGE RATE PER UNIT AREA OF APARTMENT ENCLOSURE BEFORE AND AFTER TREATMENT. APARTMENT 2505.

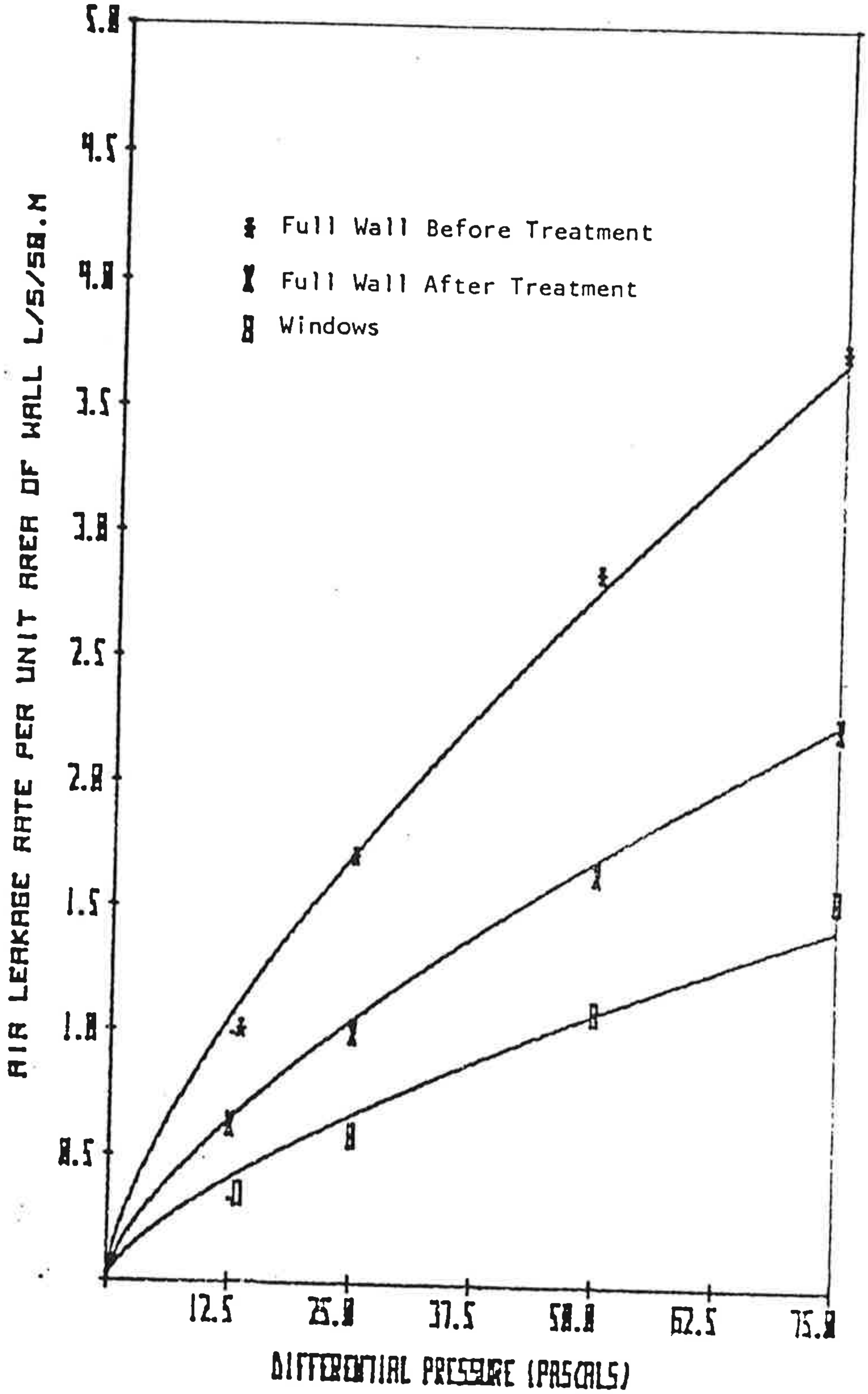

FIGURE 17 - FLORIDA ROOM AIR LEAKAGE RATE PER UNIT AREA OF EXTERIOR WALL. APARTMENT 2505

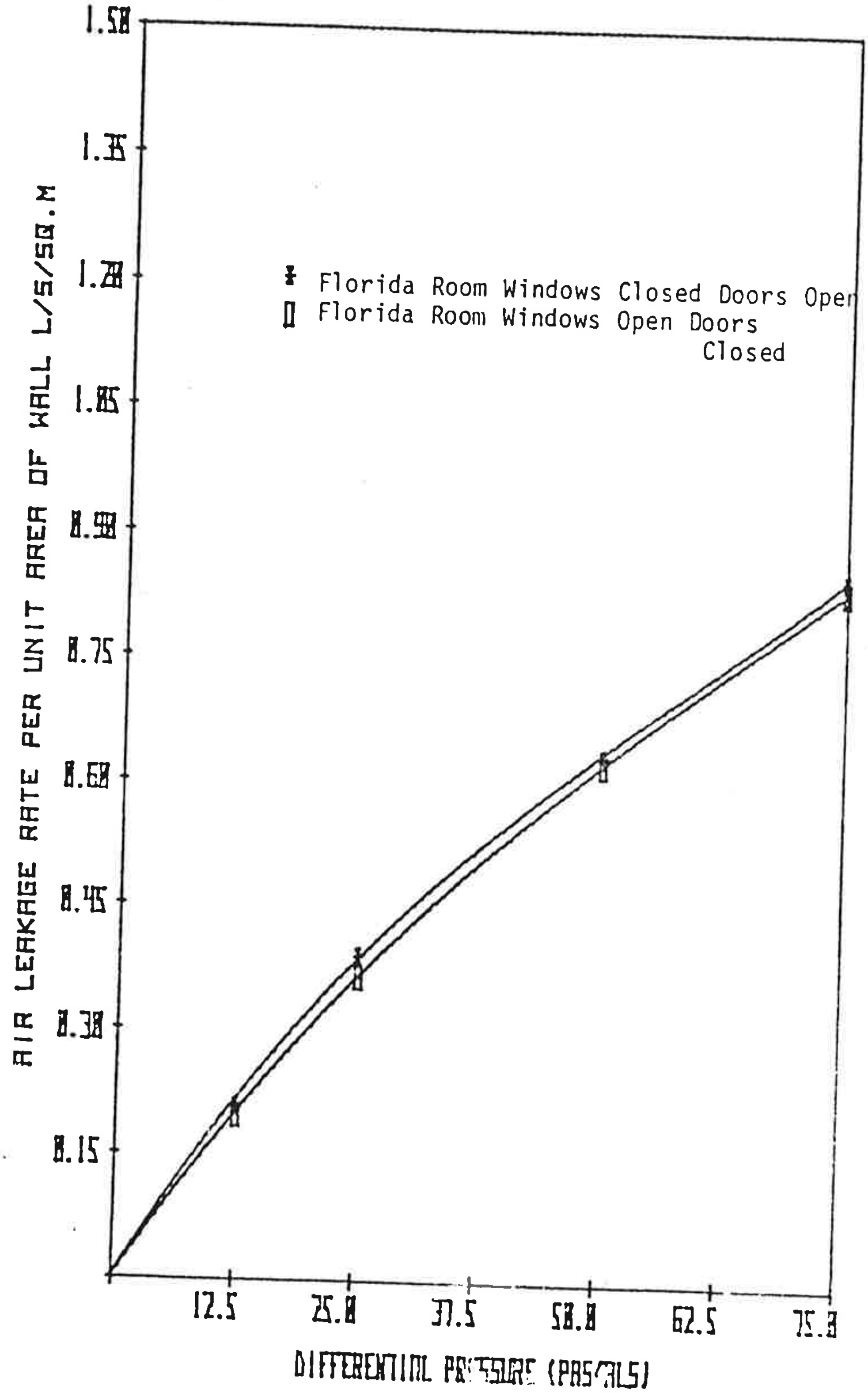

FIGURE 18 - AIR LEAKAGE PER UNIT AREA OF APARTMENT ENCLOSURE BEFORE TREATMENT. APARTMENT 3302

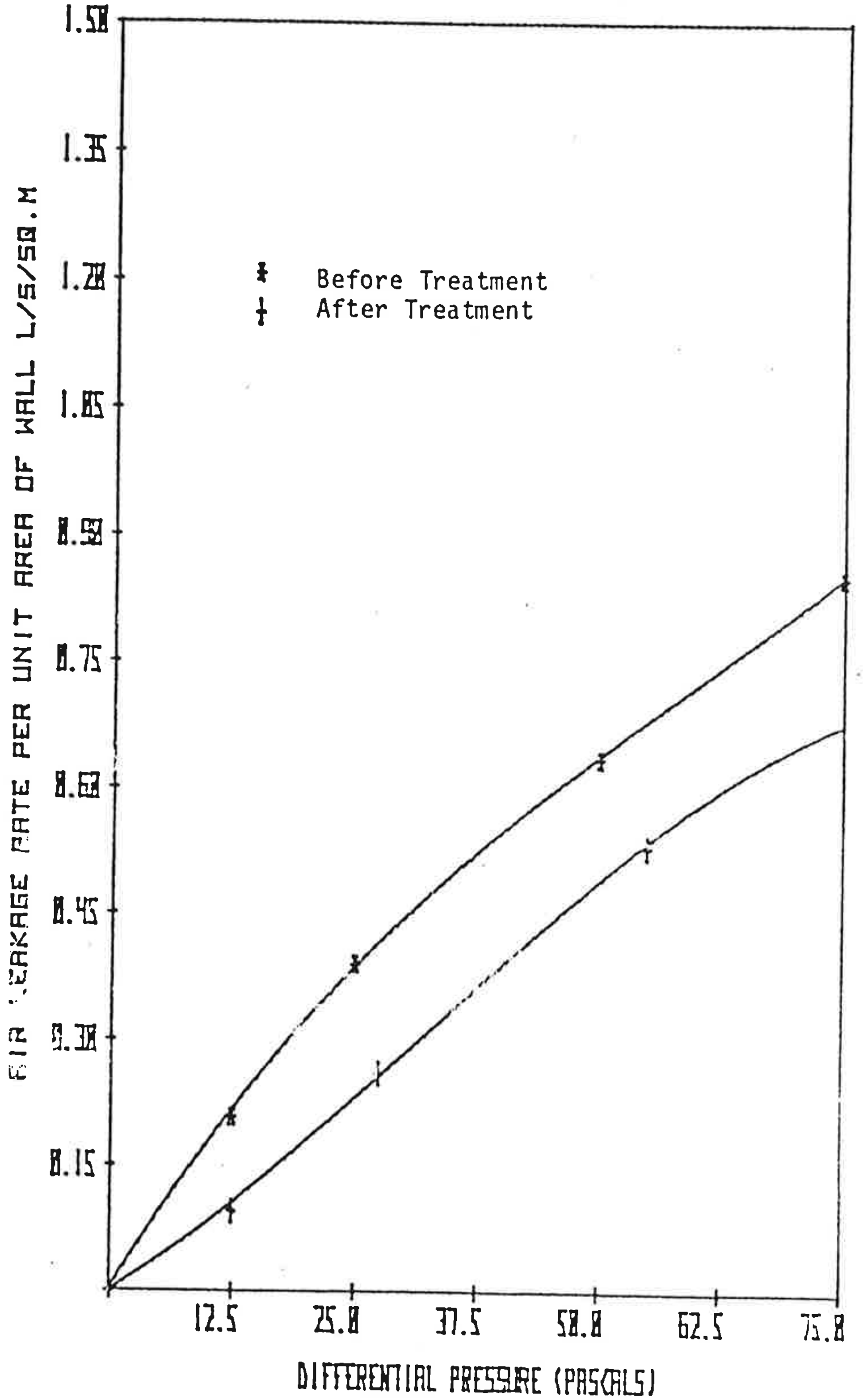

FIGURE 19 - AIR LEAKAGE PER UNIT AREA OF APARTMENT ENCLOSURE BEFORE AND AFTER TREATMENT. APARTMENT 3302.

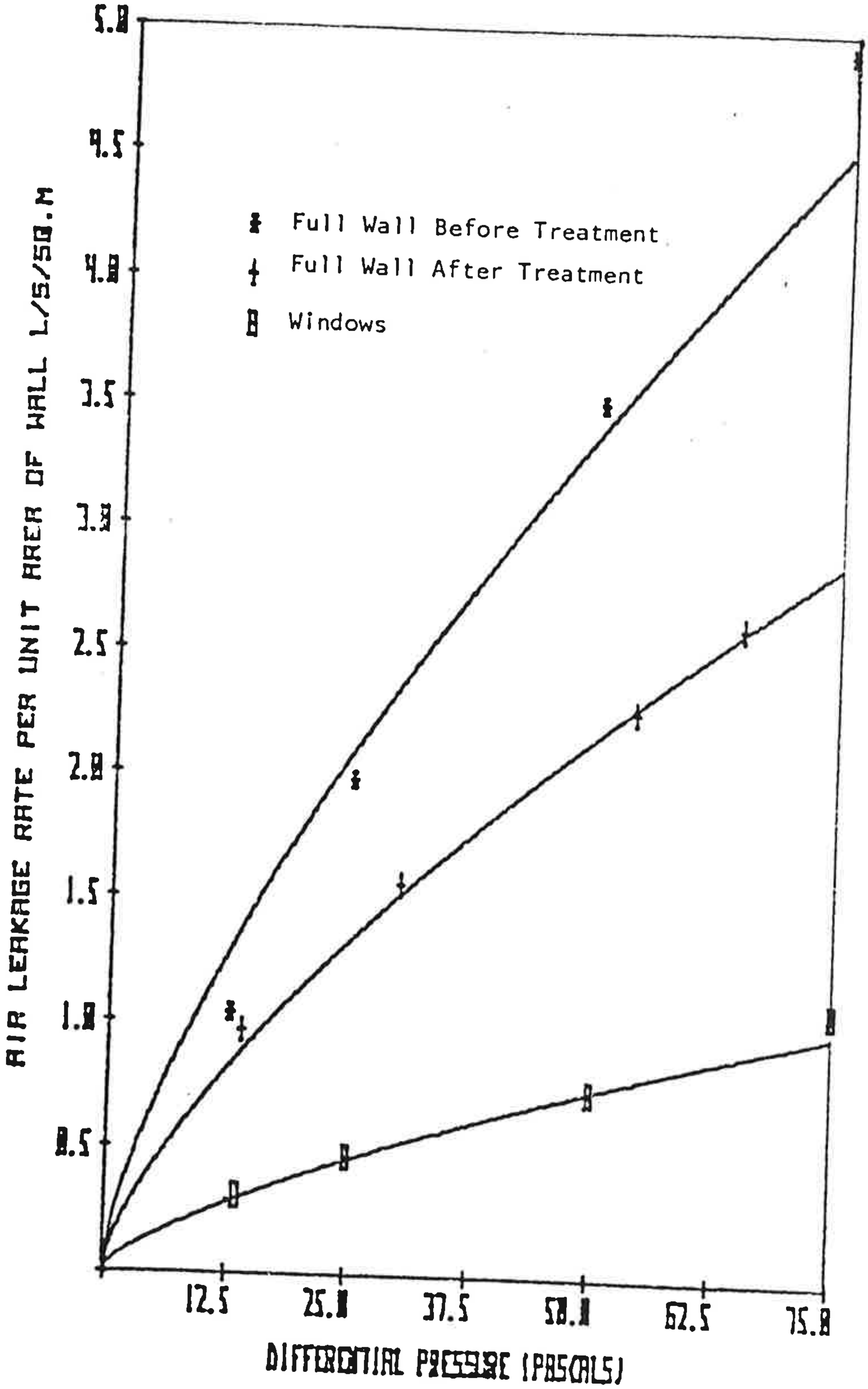

FIGURE 20 - FLORIDA ROOM AIR LEAKAGE RATE PER UNTI AREA OF EXTERIOR WALL. APARTMENT 3302.