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# NIST/TTU Cooperative Agreement -Windstorm Mitigation Initiative: Further Experiments on Generic Low Buildings

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BLWT-SS21-2003 / September 2003



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#### ACKNOWLEDGEMENTS

The current testing program to provide a generic low building database was initiated by Dr. Emil Simiu of the National Institute of Standards and Technology and Dr. Kishor Mehta of Texas Tech University and is guided by an advisory committee. The cooperation of Drs. Simiu and Mehta, as well as the members of the advisory committee, is greatly appreciated.

Acknowledgment is also made of the contributions by various members of the technical staff of the Laboratory, particularly: Messrs. Alex Shilyuk, Rick Allen, Stan Norman and Gerry Dafoe who carried out the experimental phases of the study. The pressure models were constructed by members of the University Machine Shop.

#### **SUMMARY**

This study is part of the NIST/TTU Cooperative Agreement – Windstorm Mitigation Initiative, jointly sponsored by the National Bureau of Standards and Technology and Texas Tech University. It forms part of a larger scope of generic low building testing and analysis.

The first part of the UWO Experimental wind tunnel work on 5 generic model configurations is reported in [1]. The current test program consists of a total of 6 different model or model variations. A detailed summary of the test parameters is included in the report.

1. A generic building model, 200'x100' in plan dimensions with a gable roof slope of 1:24, was tested at two different heights, in two upstream exposures, in simulated 1:200 scale winds.

2. The same generic building model as in item 1, with an addition of 3' high parapets at the roof edges, was tested at two different heights, in two upstream exposures, in simulated 1:200 scale winds.

3. The same generic building model as in item 1 was tested at two different heights, in two upstream exposures, in simulated 1:100 scale winds. Based on the length scale, the equivalent full scale building dimensions are 100'x50'.

4. The same generic building model as in item 3, with an additional module 75' in length, was tested at two different heights, in two upstream exposures, in simulated 1:100 scale winds. The overall dimensions of the model are 175'x50'.

5. A generic building model, 187.5'x120' in plan dimensions with a gable roof slope of 1:12, was tested at five different heights, in two upstream exposures, in simulated 1:100 scale winds.

6. A generic building model, 125'x80' in plan dimensions with a gable roof slope of 6:12, was tested at four different heights, in two upstream exposures, in simulated 1:100 scale winds. Internal pressures were measured for this model.

Details of the test parameters and procedures are provided in this report, together with general data checks to ensure that the data are consistent with current and previous generic model test results.

The data from the above tests form part of the overall generic low building database and will be made available to the public using a standardized archival system described in [1]. Some of the data, along with accepted data from other facilities, will also be used as a benchmark for certification of further wind tunnel facilities contributing to the low building database.

## 1 INTRODUCTION

As part of the "NIST/TTU Cooperative Agreement - Windstorm Mitigation Initiative", a testing program was initiated to create a low building database for the purpose of providing time series of wind load data for public access. The data may be used in the dynamic design of low buildings. A first phase was carried out [1] that included the following generic building models:

- 125'x80', 4 heights, 1:12 roof slope, 2 exposures
- 125'x80', 4 heights, 1/4:12 roof slope, 2 exposures
- 125'x80', 4 heights, 3:12 roof slope, 2 exposures
- 250'x160', 4 heights, 1:12 roof slope, 2 exposures
- 62.5'x40', 4 heights, 1:12 roof slope, 2 exposures

In addition, as part of the quality control program, three models of the TTU full scale building were also tested:

• 45'x30'x13', 1:48 roof slope, 2 exposures (3 models)

The three models included a 1:50 scale model primarily for local point pressure measurements, a 1:100 scale model primarily for structural load evaluation and a test of the 1:100 scale model built by Colorado State University (CSU). Details for the above generic model tests and the tests of the TTU Building models are reported elsewhere [1].

Part of the current experimental program is an extension to the Phase 1 testing (Tests 5 and 6 below) and part of the study is an extension to the first generic model testing commissioned by NIST in 1999 [2] (Tests 1 to 4 below).

The current testing program has a total of 6 different model or model variations:

- Test 1. 200'x100', 2 heights, 1:24 roof slope, 2 exposures, 1:200 scale
- Test 2. 200'x100', 2 heights, 1:24 roof slope, 2 exposures, 1:200 scale (with 3' parapets)
- Test 3. 100'x50', 2 heights, 1:24 roof slope, 2 exposures, 1:100 scale
- Test 4. 175'x50', 2 heights, 1:24 roof slope, 2 exposures, 1:100 scale
- Test 5. 187.5'x120', 5 heights, 1:12 roof slope, 2 exposures, 1:100 scale
- Test 6. 125'x80', 4 heights, 6:12 roof slope, 2 exposures, 1:100 scale

Details of the model variations are described in Section 2.2.

This report provides basic information on the test parameters used in these wind tunnel tests and describes the data quality control checks undertaken.

The data from all of the tests described above form part of the overall generic low building database. Some of the data, along with accepted data from other facilities, will also be used as benchmarks for certification of further wind tunnel facilities contributing to the low building database.

Detailed time series of all the pressure data are available through the standard archival system developed within the TTU/NIST Cooperative Agreement [1].

### 2 GENERIC MODEL TESTS

#### 2.1 The modelling of the wind

#### 2.1.1 Terrain modelling

The basic tool used is the Laboratory's boundary layer wind tunnel. The tunnel is designed with a long test section, which allows extended models of upwind terrain to be placed in front of the model of the building under test. The wind flow then develops characteristics which are similar to the wind over the different terrain conditions.

Two typical terrain cases were used; namely, the open and suburban exposures, defined as having roughness length,  $z_o$ , of 0.03 m and 0.3 m respectively. Simulated winds at two different scales, 1:100 and 1:200, were used in the current set of experiments. For both terrain cases and for both scale simulations, three 5-foot high spires were placed at the entrance of the wind tunnel as well as a 1.25-foot high barrier across the wind tunnel immediately downstream of the spires. These two devices produce the large scale wind gusts in the wind tunnel. Various heights of roughness elements were used along the 100-foot wind tunnel section to provide mixing of the wind gusts and generate the boundary layer characteristics for the two terrain conditions in two different length scales.

Note that the required roughness elements tend to be higher compared to the building height in model scale than in full scale. For this reason, it is unrealistic to continue these roughness elements right up to the model. In practice, smaller roughness elements are used close to the model and some distortion of flow turbulence modelling at low heights is accepted in order to maintain better overall flow homogeneity over the model. Views of the 1:200 simulation in the wind tunnel is shown in Figure 1. Similarly, Figure 2 shows the simulation of the 1:100 scale wind in the wind tunnel.

#### 2.1.2 Characteristics of the modelled wind

The simulation of the typical open and suburban exposures at the site of the building model was based on the wind characteristics described by ESDU 82026 [3], 83045 [4] and 74031[5] for mean wind speed profile, turbulence intensity and wind spectrum respectively. Figures 3 and 4 present 1:200 scale vertical profiles of the mean speed and of the intensity of the longitudinal component of turbulence for the open country and suburban terrains, respectively. The profiles were measured without any building model present at a location 18" (model scale) upstream of the center of the turntable; approximately at the leading edges of the models. Similarly, Figures 5 and 6 show the wind characteristics in 1:100 scale. The target characteristics determined using ESDU are superimposed. Based on the comparison of turbulence intensities, the simulated exposures match the target roughness lengths,  $z_0$ , of 0.03 m and 0.3 m for open and suburban exposures respectively.

Figures 7, 8 and 9 show the normalized longitudinal, lateral and vertical wind spectra respectively, measured in open exposure at 32' (full scale) above ground. At this height,  $\sigma_v / \sigma_u = 0.68$  and  $\sigma_w / \sigma_u = 0.4$  where u, v and w denote the longitudinal, lateral and vertical directions respectively.

The longitudinal turbulence scale is shown to have a mismatch by about a factor of two based on the shift in the high frequency end of the spectra. This level of mismatch is likely to be inconsequential for local pressures. The scale mismatch would be expected to have more importance for area or frame loads where the spatial correlation of the loads are important; however, even here a factor of two in scale is moderated dramatically when translated into an area integral (see Surry [6] for example). Typically, the order of error associated with a scale mismatch of a factor of two should be in the 5 to 10% range.

#### 2.2 The Measurements of Local Pressures

#### 2.2.1 Model instrumentation

A total of 6 different model or model variations have been tested. Table 1 summarizes the model and test parameters.

The model used in Tests 1 to 3 and the basic module used in Test 4 was the same model used in a previous experimental program for NIST [2]. Additional pressure taps were instrumented on the model to provide complete coverage on the entire building. In the current tests, the total number of pressure taps is 625 for Tests 1 to 3. Figure 10 shows the tap layout for Tests 1 and 2, while Figure 11 shows the tap layout of Test 3. Test 4 used the basic building module in Tests 1 to 3 with an extension of 75'. This extended model has overall dimensions of 175'x50', instrumented with a total of 864 active taps. The tap layout for Test 4 is shown in Figure 12. Views of the models used in Test 1 to Test 4 are shown in Figures 13 to 16.

The models used in Tests 5 and 6 follow a series of generic models that have been tested in Phase 1 of the TTU-NIST initiative [1]. Phase 1 tests included buildings of 125'x80' of various building heights at 1:12, 1/4:12 and 3:12 roof slopes. They also included twice-sized (250'x160') and half-sized (62.5'x40') models at 1:12 roof slope. The Test 5 model is an intermediate sized model (187.5'x120') for further investigation into the interpolation of the pressure information in the generic low building database. This model has 694 pressure taps. Figure 17 shows the pressure tap layout of the Test 5 model. Views of the model in the wind tunnel are shown in Figure 18.

The Test 6 model has the basic plan dimensions of 125'x80' but with a larger roof slope of 6:12. This provides the upper limit of roof slope tested within this program to date. Internal pressures due to distributed leakage were measured on this model. The distributed leakage is about 0.1% of the total wall areas, represented by 84 - 1/16" (model scale) diameter holes distributed over the wall areas. As the building height is reduced, the leakage openings are also reduced, maintaining the approximate leakage ratio. In order to be able to measure the dynamic internal pressures, the interior volume of the model is exaggerated approximately following on the volumetric scaling.

$$\lambda_{\text{vol}} = \frac{\lambda_L^3}{\lambda_{\text{vel}}^2} \approx \frac{(1/100)^3}{(1/4)^2} = \frac{1}{62500}$$

The actual model internal volume, including the volume of the model and the sealed chamber extended below the turntable, was 6.36  $\text{ft}^3$  for the 6:12 roof slope model. The model volumes required for the 6:12 model are 3.52  $\text{ft}^3$  and 8  $\text{ft}^3$  for the 12 ft and 40 ft building heights respectively. Using the total available volume, the model volume is approximately correct for a 30 ft high building. This same volume is used for all testing for simplicity.

There are a total number of 704 pressure taps on the model including three (3) pressure taps connected to the interior volume of the model.

Diagrams showing the pressure tap locations for Test 6 are shown in Figure 19. Close-up views of the modelled internal volume are shown in Figure 20. Views of the models are shown in Figure 21. The tap layout and tap nomenclature for all tests are included in Appendix A for reference.

#### 2.2.2 Wind tunnel measurements

A high speed solid state pressure scanning system was used to take the pressure measurements. Measurements were taken at 37 wind angles over the range of  $180^{\circ}$  at  $5^{\circ}$  increments. For Tests 1 to 4, the tested angles are between  $0^{\circ}$  and  $180^{\circ}$ . For Tests 5 and 6, the tested angles are between  $180^{\circ}$  and  $360^{\circ}$  (see Figures 10, 11, 12, 17 and 19 for the definition of wind angles).

Tests 1 and 2 were carried out in a 1:200 wind simulation. The reference speed in the wind tunnel was nominally 60 ft/sec. Pressures were sampled at 400 samples per second for 60 seconds. Based on a full-scale roof height wind speed of 84 mph, the sampled data are equivalent to about 6 samples per second for 1.0 hour in full scale for the open exposure tests and equivalent to about 8 samples per second for 0.81 hours in full scale for the suburban exposure tests.

Tests 3 and 4 were carried out in a 1:100 wind simulation. The reference speed was nominally 60 ft/sec. Pressures were sampled at 400 samples per second for 120 seconds. Again based on a full-scale roof height wind speed of 84 mph, the sampled data are equivalent to about 14 samples per second for 0.93 hours in full scale for the open exposure tests and equivalent to about 19 samples per second for 0.70 hours in full scale for the suburban exposure tests. All of the samples were stored.

For Tests 5 and 6, parameters used for other generic model tests in Phase 1 of the current test program [1] were used. The upper level reference speed is nominally 45 ft/sec. Pressures were sampled at 500 samples per second for 100 seconds. Based on a full scale wind speed of 84 mph at 33 ft, the sampled data are equivalent to about 22 samples per second for 0.64 hours in full scale for the open exposure tests and equivalent to about 26 samples per second for 0.53 hours in full scale for the suburban exposure tests.

All instrumented taps were measured essentially instantaneously. The measurements taken within the sampling cycle have a maximum time lag of 15/16 of the sampling rate. In the case of sampling at 500 Hz, the maximum time lag is approximately 15/16x0.002 seconds = 1.875 milliseconds. The data are corrected for the time lag by linear interpolation of the data within the same sample cycle.

The model and testing parameters are summarized in data sheets in Appendix B.

In addition, the maximum, minimum, mean and rms pressure from these time histories were calculated and reviewed as a data quality check.

#### 2.2.3 Aerodynamic data

All the time series files were stored in an archive to be accessible by electronic means. The raw data were referenced to the dynamic pressures taken at an upper reference level in the wind tunnel. Conversion factors, specific to the ratio of the roof height to reference height dynamic pressures resulting from the wind simulation in the wind tunnel, are required to convert these aerodynamic data to roof height reference.

The roof height referenced pressure coefficients are defined using the following expression:

$$C_{\rho_H} = C_{\rho_{ref}} \left( \frac{V_{ref}}{V_H} \right)^2$$

where  $\left(\frac{V_{\text{ref}}}{V_{H}}\right)^2$  is obtained from the wind tunnel experiments and is the ratio of the dynamic pressure at

the reference height in the wind tunnel where upper level wind speed is taken (subscript ref) and the dynamic pressure at roof (eave) height (subscript H). Because of high turbulence near roof height, the measurements taken at this level have large variability. Further discussion of the uncertainties and variability of this factor and wind tunnel testing on low buildings can be found in Ho, et al. [1] and Kopp, et al. [7] respectively.

The pressure coefficients presented in this report are referenced to the mean roof height dynamic pressure. Table 2 summarizes the factors used for re-referencing the pressure coefficients to roof height dynamic pressures.

The aerodynamic data and related information are available in the standard archive developed for this project. The tap layout and tap nomenclature for the respective tests are included in Appendix A for reference.

The maximum and minimum pressure coefficients included in this report have been Lieblein-fitted and are more statistically stable quantities than the measured peaks. This involves dividing the record into 10 parts, using the Lieblein BLUE formulation [8] with the 10 individual peaks to estimate the mode and dispersion of the Type I extreme value distribution, and using these to obtain the "best" expected peak for the entire record.

## **3 DATA QUALITY CHECKS**

#### 3.1 General

General checks have been carried out to ensure consistency of the current data with other data sets. In some cases, data from similar tests were used for comparison. All wind tunnel experiments are expected to have inherent uncertainties; further discussion on the topic of experimental uncertainties can be found in Kopp, et al. [7].

#### 3.2 Overall data checks

For an isolated low building, the pressure variations on the building are directly related to the energy in the incident wind. The total fluctuating energy measured on the building will vary with wind direction because of the detailed aerodynamics but Holmes [9] has suggested that the variation can be expected to be slow. Thus, the calculation of the overall sum of variances at all point measurements and its variation with wind direction offers a simple way of checking the overall data consistency.

$$E_{\text{var}}(\alpha) = \sum_{\text{all taps}} \sigma_{C_{\rho}}^{2}(\alpha)$$

An alternative measure is the sum of mean square values about zero over all pressure taps. This is related to the total energy rather than just the fluctuating energy from the mean inherent in the above expression.

$$E_{\text{mean square}}(\alpha) = \sum_{\text{all taps}} \left[ \overline{C_{\rho}^{2}(\alpha, t)} \right] = \sum_{\text{all taps}} \left[ \sigma_{C_{\rho}}^{2}(\alpha) + \overline{C}_{\rho}^{2}(\alpha) \right]$$

The sum of variances and the sum of mean square values were calculated for all data sets and their variations with wind direction are shown in Appendix C.

The sum of mean square values are seen to be slightly less variable than the sum of variances. As far as the variation with wind direction is concerned, it was found that most of the data sets appear to be well behaved. In a few occasions, the sum of variances indicates large variation with wind direction whereas the sum of mean squares shows a much smoother behaviour. Nevertheless, data sets showing a large change in the variance summation have been examined; however, no clear reason for the deviation is obvious. Since equal weighting is given to each tap, some of the variability may be due to the non-uniform tap resolution. The figures in Appendix C can be used as a guide for a general level of reliability of the data within the data sets.

#### 3.3 Comparison between 1997 NIST data set and the current data set

The model used for Tests 1 to 4 was the same model used in the 1997 NIST experiments. It was shown in the report of the 1997 experiments [2] that the simulation of the open exposure had much higher turbulence intensity than suggested by ESDU. The simulation of turbulence intensity in suburban exposure is much closer to that suggested by the ESDU documents. Figures 22 and 23 are excerpted from the 1997 report [2].

Appendix D shows the comparisons of pressure coefficients referenced to roof height mean dynamic pressures from both the earlier and the current Test 1. It is shown that the mean pressure coefficients match very well. The peak pressure coefficients are higher from the earlier tests. The good agreement in the mean coefficients suggests that there is no systematic or procedural error in the two tests. The differences in the peak coefficients reflect the difference in the turbulence intensity in the wind simulation. Specifically, the differences in the data set for the open exposure are much larger because the turbulence intensities in the earlier tests are much higher for the open exposure when compared to the target ESDU value.

#### 3.4 Comparison between the cases with and without the parapets

Tests 1 and 2 are identical except for the 3' parapet around the roof edges in Test 2. Appendix E shows the comparison of pressure coefficients from the two tests.

The comparison shows that the data from the two sets are consistent except for the pressure taps close to the edges and corners of the roof; e.g. Taps 1901, 1902 and 2001, as well as other taps along the roof edges. Positive pressures are observed for some wind directions; e.g. Taps 1901 to 1915.

#### 3.5 Comparison of data from different length scale simulation

Tests 1 and 2 were carried out in simulated 1:200 winds in the wind tunnel. Tests 3 and 4 used the same model but with simulated 1:100 winds in the wind tunnel. In both cases, the simulated winds model appropriate open and suburban exposures defined by full scale roughness lengths.

For roof taps, because the same model was used for tests at both scales, the tap locations relative to roof height match between the 32' tall building in 1:200 scale (Test 1) and the 16' tall building in the 1:100 scale (Test 3). It is generally expected that the aerodynamic data on a building roof is a function of the ratio of distance from the edge over the building height. Appendices F and G compare the pressure coefficients for similar tap locations relative to roof height tested at the two scales. It is generally shown that the data collapse quite well, suggesting the effect of length scale on local pressures are not significant. Further comparison of other generic low building test data are available in Ho, et al. [10,11].

For wall taps, the comparison is carried out based on the relative locations of the pressure taps to the building height for the two buildings with similar heights; 20 ft building in 1:200 scale and 16 ft building in 1:100 scale. There are no matching rings of taps on the buildings but the second line of taps for the 1:200 test is selected to compare with the third line of taps in the 1:100 scale building. The results for open exposure are very similar but the results for the suburban exposure show larger differences with the 1:100 results generally higher. This may be a result of the increased difficulty in maintaining the simulations down to the surface in the suburban case (see Figures 4 and 6).

#### 3.6 Comparison of data from generic model tests on different size buildings

In addition to Test 5 of the current experiments, a number of different sized generic building models have been tested. Comparisons of the pressure coefficients from the other generic building model tested can be found in Ho, et al. [10,11]. An excerpt of the data from Ho, et al. is shown in Figures 24 and 25 with examples of data from the current intermediate-sized building superimposed. The comparison is based on the pressure coefficients as a function of the building height.

It can be seen that data from the current intermediate-sized building are similar to the data from the other three different sizes when compared in this form. It shows consistency among the different data sets. Further suggestions for the extrapolation of the aerodynamic data on low buildings can be found in Chen, et al. [12,13] and is beyond the scope of this experimental program.

# 3.7 Comparison of data from generic model tests on buildings with different roof slopes

Figures 26 and 27 show differences in pressure coefficients obtained for buildings with different roof slopes. As expected, the roof pressures on the 6:12 roof slope are positive while the roof pressures at the leading edge of the roof are negative for the other roof slopes. Except for the low roof slope cases, the normalizing parameter of x/H, does not work well for larger roof slope buildings.

#### REFERENCES

- [1] T.C.E. Ho and D. Surry. Wind tunnel testing of low buildings for the NIST/TTU aerodynamic database. Alan G. Davenport Wind Engineering Group, The University of Western Ontario, London, Ontario, Canada. BLWT-SS20-2003.
- [2] J. Lin and D. Surry. Simultaneous time series of pressures on the envelope of two large low-rise buildings. The Boundary Layer Wind Tunnel Laboratory, The University of Western Ontario, London, Ontario, Canada. BLWT-SS7-1997.
- [3] Engineering Science Data Unit. Strong winds in the atmosphere boundary layer. Part 1: Mean-hourly wind speeds. Data Item 82026. 1982.
- [4] Engineering Science Data Unit. Strong winds in the atmosphere boundary layer. Part 2: Discrete gust speeds. Data Item 83045. 1983.
- [5] Engineering Science Data Unit. Characteristics of atmospheric turbulence near the ground. Data Item 74031. 1974.
- [6] D. Surry. Consequences of distortions in the flow including mismatching scales and intensities of turbulence. *Wind Tunnel Modelling For Civil Engineering Applications*. Cambridge University Press. 1982.
- [7] G.A. Kopp, D. Surry and R.J. Martinuzzi. The NIST aerodynamic database for wind loads on low buildings: Part 4. Measurement uncertainties in the UWO experiments. Under preparation, 2003.
- [8] J. Lieblein. Efficient methods of extreme-value methodology. National Bureau of Standards, Washington, D.C., Report No. NBSIR 74-602. October 1974.
- [9] J. Holmes. Emerging issues in wind engineering. *Proceedings of the 11<sup>th</sup> International Conference on Wind Engineering*. Lubbock, Texas. June 2-5, 2003.
- [10] T.C.E. Ho, D. Surry, D. Morrish and G.A. Kopp. The NIST aerodynamic database for wind loads on low buildings: Part 1. Basic aerodynamic data and archiving. Submitted to the Journal of Wind Engineering and Industrial Aerodynamics. 2003.
- [11] T.C.E. Ho, C. Mans, D. Surry and G.A. Kopp. The NIST aerodynamic database for wind loads on low buildings: Part 2. Local Loads. Submitted to the Journal of Wind Engineering and Industrial Aerodynamics. 2003.
- [12] Y. Chen, G.A. Kopp and D. Surry. Prediction of pressure coefficients on roofs of low buildings using artificial neural networks. *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 91, pp. 423-441, 2003.
- [13] Y. Chen, G.A. Kopp and D. Surry. Interpolation of pressure time series in an aerodynamic database for low buildings. *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 91, pp.737-765, 2003.

# **TEST CONFIGURATIONS** TABLE 1

Test	Plan Dimension:	Heights	Roof Slope	Length Scale	Remarks
٦	200'x100'	20', 32'	1:24	1:200	
2	200'x100'	20', 32'	1:24	1:200	With 3' parapet on all roof edges
3	100'x50'	12', 16'	1:24	1:100	
4	150'x50'	12', 16'	1:24	1:100	
5	187.5'x120'	12', 16', 18', 24', 40'	1:12	1:100	
9	125'x80'	12', 18', 24', 40'	6:12	1:100	Internal pressure measurements (see note 3 below

Notes:

1. Tests 1 to 3 used the same model.

Test 4 used the same model as 1 to 3 with a 50' extension.
Test 6 included internal pressure measurements due to distributed leakage.

# TABLE 2FACTORS FOR RE-REFERENCING PRESSURE COEFFICIENTS TO ROOF<br/>HEIGHT DYNAMIC PRESSURES

Test	Building	Exposure 1	Exposure 2
	Height (It)	Open	Suburban
1 and 2	20	2.86	4.56
	32	2.46	3.82
3 and 4	12	2.98	5.37
	16	2.7	4.84
5 and 6	12	2.98	5.37
	16	2.7	4.84
	18	2.58	4.67
	24	2.37	4.22
	40	2.04	3.53



**EXPOSURE 1** 



#### **EXPOSURE 2**

#### FIGURE 1 VIEWS OF THE 1:200 MODEL IN THE WIND TUNNEL



**EXPOSURE 1** 



#### **EXPOSURE 2**

#### FIGURE 2 VIEWS OF THE 1:100 MODELS IN THE WIND TUNNEL



















































-100 ft-

+

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						—5	0 f	t—						
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FIGURE 12 PRESSURE TAP LAYOUT – TEST 4

Continued on the next page

Continued from the last page

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		+	+	+
		+	+	+
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	+	+	+	+
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175 ft





#### FIGURE 13 VIEWS OF THE TEST 1 MODEL IN THE WIND TUNNEL





FIGURE 14 VIEWS OF THE TEST 2 MODEL IN THE WIND TUNNEL





#### FIGURE 15 VIEWS OF THE TEST 3 MODEL IN THE WIND TUNNEL





#### FIGURE 16 VIEWS OF THE TEST 4 MODEL IN THE WIND TUNNEL
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-	+	+	+	+	+	+	+	+	+	+	+	+	+	
F	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ŀ	+	+	+	+	+	+	+	+	+	+	+	+	+	•
ł.	+	+	+	+	+	+	+	+	+	+	+	+	+	+

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FIGURE 18

VIEWS OF THE TEST 5 MODEL IN THE WIND TUNNEL



FIGURE 19 PRESSURE TAP LAYOUT – TEST 6

125



## FIGURE 20 VIEW OF THE EXAGGERATED INTERNAL VOLUME CHAMBER



## FIGURE 21 VIEWS OF MODEL FOR TEST 6



FIGURE 22 WIND SPEED AND TURBULENCE INTENSITY PROFILES FROM THE 1997 NIST EXPERIMENTS – OPEN EXPOSURE (AFTER [2])



#### FIGURE 23 WIND SPEED AND TURBULENCE INTENSITY PROFILES FROM THE 1997 NIST EXPERIMENTS – SUBURBAN EXPOSURE (AFTER [2])



COMPARISON OF MEAN PRESSURE COEFFICIENTS, OBTAINED AT MIDSPAN FOR MODELS OF VARYING DIMENSIONS IN OPEN COUNTRY TERRAIN FIGURE 24





COMPARISON OF MEAN PRESSURE COEFFICIENTS, OBTAINED AT MIDSPAN FOR MODELS OF VARYING ROOF SLOPE FOR H=24FT IN OPEN COUNTRY TERRAIN FIGURE 26



# PRESSURE TAP LAYOUT AND NOMENCLATURE

## Tests 1 and 2

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<u> </u>				·				
+ [3+ 13+	1213 1213	1515 1515	+22 +9	+ 108 +	1015	+00 +00	+16 +	+8
H2 1313 1314 1315 H2 1313 1314 1315 H1 1310 1309 1308 H + + + + + + + + + + + + + + + + + + +	02 1303 1304 1305 1 1216 1215 1214	* 1206 1205 1204 • + + + + + + + + + + + + + + + + + + +	14 1115 1116 1201 13 1112 1111 1110 13 1112 1111 1110	+ + + + 104 1105 1106 1107 + + + +	03 1102 1101 1015 + + + + 010 1011 1012 1013	+ + + + + + + 009 1008 1007 1006 + + + + + + + + + + + + + + + + 1001 1003 1003	915 914 913 912	+ + + +

<b></b>	_	
3905	3906	+06 3303+60 3304+02
3904	3903	+3302 +334
181+	3812	+38+38+
3810	3809	+88+80+88+
1085	3802	+38+3804
1405	1404	+02+02+1403+
<u>8</u> +	1407	+1409+1408+
55+	1414	+ = + = + = + = +
1416	1201	+32+53+52+
-1200 1200	1508	+32++
1210	1211	+27+22+22+
1604	1603	+35+66+
1605	1606	+160+160+
1614	1613	+161 +161 +161 +
1615	1616	+102+02+02+
80+	1707	+ 20+ 20+ 20+ 40+
1709	1710	+12+22+22+
<u>68</u> +	1801	+171+171++
68+	804	+ 6 + 8 + 6 +

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3701	3702	3703	3704	3705	3706	3707	3708	3709	3710	3711	3712	3713	3714	3715
3601 +	3602	3603 +	3604	3605	3606 +	3607	3608	3609	3610	3611 +	3612	3613	3614	<del>3</del> 615
3201 +	3502 +	3203 +	3504	3505 4	3506 +	3507	3508	3209 +	3510	3511 354	3512 4	3513 4+	3514	3515 3515
3401	3402	3403	3404	3405	3406	3407	3408	3409	3410	3411	3412	3413 +	3414	3415
3301	3302 +	3303 +	3304 +	3305 +	3306 +	3307 +	3308	4066	3310 +	3311 +	3312 +	3313 +	3314 +	3315 +
3201	3202	3203 4	3204 +	3205 +	3206 +	3207	3208	3509 +	3210	32II	-13 3515	<b>4</b>	3214	3215
<b>+</b> ₩	<b>+</b> 8	<b>+</b> 8	<b>+</b> ₩	<b>4</b> 92	<b>+</b> 8	3107	38	+60jg	+ <sup>0</sup> 3	+⊞	<b>+</b> 8	+ <sup>60</sup>	<del>3</del> 14	+ <mark>918</mark>
+100	+8	+8	+ 80 80	+902	+000	3004	308	+60	+010 3010	+100	+8	+ <sup>61</sup>	<del>3</del> 014	+92
+62	+62	+62	<b>5</b> 904	5905 54	5306	5907	5908	+6062	+0162	+1162	-515 5915	<b>5</b> 913	<b>5</b> 914	+52
<b>+</b> 80	<b>+</b> 88	+683	<b>5804</b>	5805 5805	<del>5</del> 80 <del>(</del>	5807	5808	<b>580</b>	5810 5810	+118	+618	+82	<b>5814</b>	+582
570+	5702 2702	5703	2704	2705	2706	2707	2708	2709	2710	57 <u>1</u>	2712	5713	2714	+8
<b>5</b> 60+	-5602	<del>5</del> 603	<del>2</del> 604	<del>2</del> 605	<del>5</del> 606	2607	5608	<del>5</del> 609	+919	<b>5611</b>	<b>5</b> 612	<b>5</b> 613	<b>5614</b>	+592
<b>5</b> 20+	52 <b>0</b> +	53 <mark>0+</mark>	5504	5202 5202	5206 52	5507	5208	<b>5</b> 203+	5210	+Ę	5215 5215	+82	<b>5</b> 514	+52
540+	5405 54 <b>0</b> +	5403 54 <b>0</b> 3	5404	5405	5406 54	2407	2408	540 <del>0</del>	5410	54II	5415 5415	5413 5413	5414 5414	<del>5</del> 412
+105	5305 53 <b>6</b> +	<b>5</b> 30 <b>+</b>	<b>+</b> 5304	5305 +	5306	5307 +	2308	530 <del>4</del>	<b>5</b> 310	53I1	5315 5315	+8	5314	+923
+102	5205 550+	5503 550 <b>+</b>	5204	5505 2205	5506 5206	2207	2208	5509	5510 5510	<b>5211</b>	5515	<b>+</b> 613	5514 5514	+52
<b>+</b> 5	<b>+</b> 605	<b>-10</b>	+10 5104	5105 +	<del>5</del> 106	2107	2108	<b>5109</b>	<b>-1</b> 0	+⊞	<b>+</b> 2115	+E	511 <b>4</b>	+9
+1002	+80	+8	<b>5004</b>	<del>5</del> 02+	+90	2007 2004	2008	+600	+0102	+1102	<b>5012</b>	+613	2014 2014	+502
+6	+8	+8	+8	+8	+8	+6	908	+6	+06	+6	+8	+6	+16	+96

							č									
4013	4006	4005	3914	3913	+106	<del>8</del> 12	+88	<b>8</b> 04	+ 716	115 715	+802	+ 107	+9 919	+9 612	-	+8
4012	4007	4004	3915	3912	205	814	608		100	14	602	706	ē	614		ŝ
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
4011	4008	4003	3916	3911	<b>-</b> 66	813	+8	<mark>+</mark> 86	<b>+</b> 8	<b>1</b> 24	<b>1</b> 2	102	<b>1</b> 25	<b>-</b> 19		+8
4010	4009	4002	4001	3910	26	읞	18	804	803	10	Ē	704	703	612		3
3716	3616	3516 4	3416 +	3316 +	3216 +	9] <b>[</b>	<del>ا</del> %	5916 +	<mark>ا</mark> ر ک	5716 •	<b>5</b> 616	÷۲	5416	<del>1</del>		<del>ب</del>
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# Test 3

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+ + + + + + + + + + + + + + + + + + +	311 1310 1309 1308	+ + + + + + + + + + + + + + + + + + + +	+ + + + + + + + + 1214	+ + + + + + + + 08 1209 1210 1211	+ + + + + + + + + + 07 1206 1206	14 1115 1116 1201	+ + + + + + + + + + + + + + + + + + +	+ + + + + + + + + + + + + + + + + + +	+ + + + + + + + 101 1016	+ + + + + + 010 1012 1013	+ + + + + + + 009 1008 1007 1006	+ + + + + + + 916 1001 1002 1003	+ + + + +	+ + + + and and and

-3 <sup>90</sup>	++308 3908 3908 3908 3908 3908
3904	+88+330 380+330+333 380+330+333 380+33
	+85+814+38+
-1981 -1981 	+3804 3804 3804 3804 3804 3804 3804 3804
1000 +	98+88+88+98+
5 <mark>4</mark> 4	1404 1402 1402 1403 1404 1403 1404 1404 1404 1404 1404
¥+	140 + 40 + 40 + 40 + 40 + 40 + 40 + 40 +
<u>۲</u> +	<u>4</u> + <u>6</u> + <u>6</u> + <u>6</u> + <u>6</u> +
≝+	+20+20+20+20+20
<u>6</u> 6+	+22+22+22+22
≌+	
<u>§</u> +	+151+151+152+153
<u>8</u> +	1609 + 031 1609 + 031 +
<u>5</u> +	+66+61+65+65+
1615 +	1021 1701 1702 1702 1703 1704 1705 1705
<u>_</u> *	1705 +120 +1205 +1
60 <mark>+</mark>	02+12+02+02+
803 1802 + +	804 1801 865 1716 805 1716 807 1715 +++++++++++++++++++++++++++++++++++

3701 3701	3702 3702	3703 +	3704 3704	3705 +	3706 4	+ 3707	3708	3709 4	37 <u>10</u>	3711 +	3712 3712	3713	3714 3714	+
3601 +	3602 4+	3603 +	3604 +	3605 +	3606 +	3607	3608	3609 +	3610 +	3611 +	3612 4	3613 3613	3614 3614	+20
3501 +	3502 +	3203 +	3504	3205 +	3506 +	3507	3508	3509 +	3510 +	3511 +	3512 4	3513 +	3514 +	+ <sup>4</sup>
3401	3402 +	3403	3404	3405	3406 +	+ 3407	3408	3409 +	3410	34 <u>11</u>	3412	34[3 ++	3414	+
3301 +	3302 +	3303 +	330 <b>4</b> +	3305 +	3306 +	3307	3308	3309 +	3310 +	33II +	3312 +	3313 +	33 <b>14</b> +	+**
3201 +	3202 4+	3203 +	3204	3205 +	3206 +	3207	3208	3209 +	3210 3210	3211 3211	3212 3212	3213 +	3214 +	+
+寢	+88	+8	+8	+88	+8	+6	38	+68	+≣	+≣	+ <sup>21</sup>	+ <sup>EE</sup>	+ <mark>11</mark>	+
+	+8	+8	+8	+8	+ខ្ល	+60	-8	+8	+ह	+	+210	+8	+ <del>1</del>	+
+6	+62	+66	+80	+62	+88	<del>5</del> 907	5908	+66	+62	+60	5315 5315	+ <sup>61</sup>	5 <mark>14</mark>	+
+	+88	+	+8	+88	+జ్	+60	88	+88	+ಹ	+	+ <sup>21</sup> 5812	<del>5</del> 813	5814 5814	+
570H	2702 2702	+503	570 <b>4</b> +	5705	5706	2707	2708	+502	5710	+	2712	5713	2714 2714	+
+100	2602 2602	<del>5</del> 603		+92	+999	<del>26</del> 07	5608	<del>5</del> 603	+99	+192		<del>5</del> 613		+2
+50	+202	+8	+50	+92	+%	+	508	+62	+8	+152	5512	5 <mark>213</mark> +	5514 2514	+
+5	5405 5405	5 <b>4</b> 03 5 <b>4</b> 03	+8	+8	5 <sup>40</sup>	5407	2408	+65	+	+3	5412	5413 5413	-414 5414	+
+82	+2305	+88	+ 200	+58	+ಜ್ಞ	5307	2308	+88	+8	+2	+82	+ <sup>61</sup>	+5314	+
+20	+202	+82	+ 200	+502	+%	<del>22</del> 07	2208	+622	+ខ្ល	+2	+ <sup>235</sup>	+82	+55	+
+8	+8	+8	+8	+88	+8	+ 501 5104	2108	+8	+8	+	+2115	+ <mark>5113</mark>	+17	+
+	+ + 902 2002	+ + +	+ 904 2004	+ 905 2005	+ 906 2006	+ + 907 2007	908 2008	+ 909 2009	+ 910 2010	+ 5011	+ +	+ 913 2013	+ +	+20

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+00 400 400 400 400 400 400 400 400 400	406 4006	
400 400 4003 4003 4004 4004 4003	+ <sup>4</sup>	
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+ <sup>22</sup> + <sup>22</sup> + <sup>22</sup> + <sup>24</sup> + <sup>24</sup>	'  +₽	
+32+27+22+62	+8	
+25 26 7+ 75 75 75 75 75	+2	
74 70 + 70 + 70 + 70 + 70 + 70 + 70 + 70	 + <sup>99</sup>	
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609 610 611 61+ 5216	+ଞ	
+2+5+6+6+8	+09	
60+60+60+20+	י  + <u>%</u>	
27+27+23+23+	+8	



## Test 4



Continued on the next page

175 ft-

Continued from the last page

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3904 + 3903	3905 3905	3901	3816
3812 3812	3813	3814	3815
3810 3809	+80 <del>4</del>	3807	+90 <del>8</del> +
3802 +3802	3803	3804	3802
1405 + 1404	1403	1402	<mark>+</mark> 登+
1406 + 1407	14 <sup>04</sup>	1409	<mark>+</mark> ≅+
1412 1414 +	1413 1413	1412	+ <u>₹</u> +
1416 1501 +	150+	1503	+150+
1509 1508	1507	1506	+52+
1510 1511	151+	1513	+ <u>5</u> +
1604 1603	+091	1516	+ <sup>5</sup> 2+
1605 + 1606	160 <del>1</del>	1608	+99+
1613 1613	1612 1612	1611	+ <sup>2</sup> 9+
1615 + 1616	<b>+</b> ₽	1702	<sup>1703</sup>
1708 + 1707	1706	1705	<b>+</b> <u>6</u> +
1709 1710	<b>+</b> Ē+	1712	+ <u>1</u> 3
803 1802 + + 804 1801	805 1716	806 1715	807 1714 +

						-50	ft	;						•
3701	3702	3703	3704	3705	3706 +	3707	3708	3709	3710	3711 4+	3712	3713	3714	4 175
3601	3602	3603	3604	3605 4	3606	3607	3608	3609	3610 +	3611 +	3612	3613 +	3614	+ ₽
3501	3502	3503	3504	3505	3506	3507	3508	3509	3510 4	3511 4	3512	3513	3514	+ 515
3401	3402	3403	3404	3405	3406	3407	3408	3409	3410 +	3411 +	3412 3412	3413	3414 3414	+₽2
3301	3302 +	3303 +	3304	3305 +	3306 +	3307	3308	3309 +	3310 +	3311 +	3312 +	3313 +	3314 +	+55 2155
3201	3202 +	3503 +	3204	3205	3206 +	3207	3208	3209	3210 4	3211 3211	3212 3212	3213 4	3214 3214	+c 51c
<b>+</b> ≣	3105 3105	<del>3</del> 103	310 <b>4</b>	3105 +	3106 4	3107	88	310 <del>4</del>	+9	+≣	+입	+≘	<b>+</b> ₽	+
<b>100</b>	<b>+</b> 005	+8	<b>304</b>	<del>3</del> 002	<b>+</b> %	4 <sup>2</sup> 004	800	+600	+00	<b>+</b> 100	-2015 3015	<b>+</b> 610	301 <b>4</b>	+ie
2901	<del>5</del> 905	<b>5</b> 903	590 <b>4</b>	5902 5302	+8	2907	5908	+6062	+0162	<b>+</b> 62	-515 5915	+62	591 <b>4</b>	+ <sup>6</sup>
5801	5805 5805	5803 5803	580 <b>4</b>	5802 5802	<b>+</b> 880	2807	88	<b>+</b> 608	+018	<del>4</del> 81	5815 5815	+83	5814 5814	+ <sup>4</sup>
2701	2702	2703 +	2704	2705 2705	2706	2707	2708	2709	+5210	<del>4</del> 4	2712	2713	2714	+g
2601	2602	5603	2604	2605 2605	<del>5</del> 606	2607	2608	<del>2</del> 609	<del>2</del> 610	<del>4</del>	2612 2612	<del>5</del> 613	2614	+92
5501	5205 5205	5203+	550 <b>4</b>	5202 5204	5206 +	2507	528	520 <del>4</del>	5510+	5511	5215 5215	5313 5313	551 <b>4</b>	+ v
5401	2402	2403	2404	2405	2406	2407	2408	2409	5410 5410	5411 5411	2412 2412	5413	5414 5414	+545
5301	5302 +	5303 +	5304	5305 +	5306 +	2307	2308	5309	+8	+ 5311	5315 5315	<mark>5313</mark>	53 <b>14</b>	+ *
5201	5205 5505	503 +	5204	5505 74	520 <b>6</b> +	2207	2208	<del>5</del> 209	+0125	<del>5</del> 211	5515 5515	5513 5513	5514 5514	+ 1 2
5101	5105 +	5103 5103	510 <b>4</b>	5105 +	<b>5</b> 106	2107	5188	<del>1</del> 09+	<b>+</b> 10	+Ę	<del>1</del> 15	+Ella	5114 5114	+12
+ +	+ 902 2002	+ + +	+ 904 2004	+ + 9052005	+ +	+ 907 2007	908 2008	+ + +	+ +	+ 911 2011	+ +	+ +	+ + 1914 2014	1 <mark>4</mark> 15 2015





Test 5

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5805	ε <u>μ</u> ε	4510	9025	1415	107S	5077	5610	9167	1092	6061	sizs	¥0£¥	See	912
5803	2122	4515	2025	1122	5616	9077	56092	12312	5602	0169	1195	EUEF	5200	512
+	. <u>+</u>	+	+	+	+	_+	+	_ +	+	+	+	+		
5804	шz	4513	807S	0177	5615	2077	8092	\$314	5603	1164	5210	4305	2052	<b>\$1</b> 3
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## **APPENDIX B**

# SUMMARY DATA SHEETS

# TESTS 1 and 2 – GENERIC MODEL (200'x100', 1:24 ROOF SLOPE, WITH AND WITHOUT PARAPET)

Building dimensions		200' x 100' x two different eave heights; 1:24 roof slope gable roof				
Model scale		1:200				
Number of pressure taps		625 external taps				
Sampling frequency		400 Hz				
Sampling period		60 seconds				
Reference wind tunnel speed		60 fps, nominal (see note)				
Test angles		Every 5° between 0 $^{\circ}$ and 180 $^{\circ}$ (inclusive)				
Upstream exposure		1	2			
Exposure description		Open country	Suburban			
Patio of roof to reference wind speed	H=20'	0.591	0.468			
Ratio of fool to reference wind speed	H=32'	0.638	0.512			
Nominal roof height wind speed, V <sub>Hm</sub> , in fps (see note)	H=20'	35	28			
• ` ` ´	H=32'	38	31			
Full scale mean wind speed at roof heig	ht (fps)	V	, H			
Equivalent full scale sampling frequenc	y (Hz)	$rac{2 V_{Hm}}{V_{H}}$				
Equivalent full scale sampling duration (s	econds)	12000 V <sub>Hm</sub> V <sub>H</sub>				
Test file identifications:						
No poropot	H=20'	Q11	Q12			
no paraper	H=32'	Q21	Q22			
With Q' a super st	H=20'	R11	R12			
with 3 parapet	H=32'	R21	R22			

Note:

Actual wind speeds are within 5% of 60 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 60 fps has been used.

#### TEST 3 – GENERIC MODEL (100'x50', 1:24 ROOF SLOPE)

Building dimensions		100' x 50' x two different eave heights; 1:24 roof slope gable roof			
Model scale		1:100			
Number of pressure taps		625 external taps			
Sampling frequency		400 Hz			
Sampling period		120 seconds			
Reference wind tunnel speed		60 fps, nominal (see note)			
Test angles		Every 5° between 0° and 180° (inclusive)			
Upstream exposure		1	2		
Exposure description		Open country	Suburban		
Ratio of roof to reference wind speed	H=12'	0.579	0.432		
Ratio of fool to reference wind speed	H=16'	0.609	0.455		
Nominal roof height wind speed, V <sub>Hm</sub> , in fps (see note 1)	H=12'	35	26		
	H=16'	37	27		
Full scale mean wind speed at roof heigl	nt (fps)	V <sub>H</sub>			
Equivalent full scale sampling frequency	y (Hz)	$\frac{4 V_{Hm}}{V_H}$			
Equivalent full scale sampling duration (se	econds)	12000 V <sub>Hm</sub> V <sub>H</sub>			
Test file identifications:					
	H=12'	T11	T12		
	H=16'	T21	T22		

Note:

Actual wind speeds are within 5% of 60 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 60 fps has been used.

#### TEST 4 – GENERIC MODEL (175'x50', 1:24 ROOF SLOPE)

Building dimensions		175' x 50' x two different eave heights; 1:24 roof slope gable roof			
Model scale		1:100			
Number of pressure taps		864 external taps			
Sampling frequency		400 Hz			
Sampling period		120 seconds			
Reference wind tunnel speed		60 fps, nominal (see note)			
Test angles		Every 5° between 0° and 180° (inclusive)			
Upstream exposure		1	2		
Exposure description		Open country	Suburban		
Ratio of roof to reference wind speed	H=12'	0.579	0.432		
	H=16'	0.609	0.455		
Nominal roof height wind speed, V <sub>Hm</sub> , in fps (see note)	H=12'	35	26		
	H=16'	37	27		
Full scale mean wind speed at roof heigl	nt (fps)	V	, H		
Equivalent full scale sampling frequency	y (Hz)	$\frac{4 V_{Hm}}{V_{H}}$			
Equivalent full scale sampling duration (se	econds)	$\frac{12000 V_{Hm}}{V_H}$			
Test file identifications:					
	H=12'	V11	V12		
	H=16'	V21	V22		

Note:

Actual wind speeds are within 5% of 60 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 60 fps has been used.

### TEST 5 – GENERIC MODEL (187.5'x120', 1:12 ROOF SLOPE)

Building dimensions	187.5' x 120' x five different eave heights; 1:12 roof slope gable roof					
Model scale		1:100				
Number of pressure taps		694 external taps				
Sampling frequency	500 Hz					
Sampling period	100 seconds					
Reference wind tunnel speed		45 fps, nominal (see note 1)				
Test angles		Every 5° from 270° to 360° and from 0° to 90° (inclusive)				
Upstream exposure		1	2			
Exposure description		Open country	Suburban			
	H=12'	0.579	0.432			
	H=16'	0.609	0.455			
Ratio of roof to reference wind speed	H=18'	0.623	0.463			
	H=24'	0.650	0.487			
	H=40'	0.700	0.532			
	H=12'	26	19			
Nominal roof beight wind speed V(, in	H=16'	27	21			
fra (and not)	H=18'	28	21			
ips (see note)	H=24'	29	22			
	H=40'	32	24			
Full scale mean wind speed at roof heig	ht (fps)	V	, H			
Equivalent full scale sampling frequency	y (Hz)	$\frac{5 V_H}{V_{Hm}}$				
Equivalent full scale sampling duration (se	econds)	10000 V <sub>Hm</sub> V <sub>H</sub>				
Test file identifications:						
	H=12'	P11	P12			
	H=16'	P21	P22			
No leakage or dominant openings	H=18'	P31	P32			
	H=24'	P41	P42			
	H=40'	P51	P52			

#### Note:

Actual wind speeds are within 5% of 45 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 45 fps has been used.

## TEST 6 - GENERIC MODEL (125'x80', 6:12 ROOF SLOPE)

Building dimensions	125' x 80' x four different eave heights; 6:12 roof slope gable roof					
Model scale	1:100					
Number of pressure taps	701 external taps + 3 internal taps					
Sampling frequency	500 Hz					
Sampling period	100 seconds					
Reference wind tunnel speed	45 fps, nominal (see note 1)					
Test angles	Every 5° from 270° to 360° and from 0° to 90° (inclusive)					
Upstream exposure		1 2				
Exposure description		Open country	Suburban			
· · ·	H=12'	0.579	0.432			
Datia of reaf to reference wind encod	H=18'	0.623	0.463			
Ratio of roof to reference wind speed	H=24'	0.650	0.487			
	H=40'	0.700	0.532			
	H=12'	26	19			
Nominal roof height wind speed, V <sub>Hm</sub> , in	H=18'	28	21			
fps (see note)	H=24'	29	22			
	H=40'	32	24			
Full scale mean wind speed at roof heig	ht (fps)	V	, H			
Equivalent full scale sampling frequenc	y (Hz)	$\frac{5 V_H}{V_{Hm}}$				
Equivalent full scale sampling duration (s	econds)	10000 V <sub>Hm</sub> V <sub>H</sub>				
Test file identifications:						
	H=12'	Y11	Y12			
	H=18'	Y21	Y22			
Distributed leakage	H=24'	Y31	Y32			
	H=40'	Y41	Y42			

#### Note:

Actual wind speeds are within 5% of 45 fps at reference level. Pressure coefficients have been normalized based on actual wind tunnel speeds. For the determination of time scaling, nominal wind speed of 45 fps has been used.

# SUM OF MEAN SQUARES AND SUM OF VARIANCES FOR ALL TESTS









Test 2, 32ft Bld, open exposure





Test 3, 16ft Bld, open exposure







Test 4, 12ft Bld, open exposure



Test 4, 16ft Bld, open exposure










Test 5, 40ft Bld, open exposure



Test 6, 12ft Bld, open exposure



Test 6, 18ft Bld, open exposure





## **APPENDIX D**

## COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 AND 1997 NIST DATA SET

- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20', 32'

## 32 ft Building – Open Exposure



408	416		219		99 90
	9	801	515		
	414		5		614
405	E H		213	SOS	613
04	412	504 504	212 212	600 604	612
	E				15
			210		ê10
2 0 120 150 180 2 0 120 150 180 2 0 0 120 150 180 2 0 0 0 120 150 180		<u> </u>			

INIST 2003 - 32ft Bid Open Country - No Parapet
 NIST (Lin & Surry) - 32ft Building - Open Country

	802	9	88	100		1002
		<u></u>				
	208	714		8 4	806	
		<u></u>		81		914
						8 3 3 3 3 3 3
						6 6 7
irection 0 120 150 180						5
wind di 4 0 30 60 9						

INST 2003 - 32ft Bid Open Country - No Parapet
 INST (Lin & Surry) - 32ft Building - Open Country

		1010	1102	110	1202	1210	1302
				1109	1201	1209	
		1008	1016	1108	1116	1208	1316
		1007	1015	1107	1115	1207	1215
		1006	1014	1106	111	1206	1214
		1005	1013	1105		1205	1213
		1004	1012	1104	1112	1204	1212
wind direction 0 30 60 90 120 150 180			1011	1103	=	1203	1121
4	assure coefficient	φ φ bud	 	 	 	 . r 1	· · · · · · · · · · · · · · · · · · ·

INST 2003 - 32ft Bid Open Country - No Parapet
 INST (Lin & Surry) - 32ft Building - Open Country

	1310		1410	1502	1510	1603
			1409	1501	1509	1602
			1408	1416	1508	1516
	1307		1407	1415	1507	1515
	1306		1406	1414	1506	1514
			1405	1413	1505	1513
			1404	1412	1504	1512
0 30 60 90 120 150 180			1403	1111		121

INST 2003 - 32ft Bid Open Country - No Parapet
 NIST (Lin & Surry) - 32ft Building - Open Country

					166
		1702	1802		1910
		1701	1801		
		11008	91/1	1810	11908
		1615	1715	1807	1990 1990
		1914	1111		1906
		1706		1805	1906
wind direction 0 30 60 90 120 150 180 4 1 1	6 6 6 6 7 1 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1612	111	1804	الم

INST 2003 - 32ft Bid Open Country - No Parapet
 INST (Lin & Surry) - 32ft Building - Open Country

	2003	2011	2103	2111		2211
	2002	2010	2102	2110	2202	2210
	2001	2009	2101	2100	2201	2200
	1916	2008	2016	5 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	2116	2208
	1915	2007	2015	2107 22107	2115	2207
	بر المراجع الم المراجع المراجع	2006	2014		2114	2206
		2005	2013	2105	213 213	500
wind direction 0 30 60 90 120 150 180	2 6 6 7 1912	2004	2012	2104	2112	2204

INST 2003 - 32ft Bid Open Country - No Parapet
 INST (Lin & Surry) - 32ft Building - Open Country

		3303	331	2403	2411	2503	
		2302	2310	2402	2410	2502	2510
		2301	5308	2401	2409	2501	5608
		2216		2316	2408	2416	2508
		2215	2307	2315	2407	2415	2507
		2214		2314		2414	2506
		2213	302	2313	502	2413	
wind direction 0 30 60 90 120 150 180 4 1 1 1 1	2 	8 2212	2304	2312	2404	2412	2504

INST 2003 - 32ft Bid Open Country - No Parapet
 NIST (Lin & Surry) - 32ft Building - Open Country

	5803	2611	5012 5012	11/2	2804	2812
	2602	2610	2702	2710	3803	331
	2801	560	2701	2708	2802	2810
	2516	500	2616	2708	2801	2809
	5215	2607	2615	2707	2716	
	2514	5000	2614	2706	2714	23007
	2513		2613	2705	2713	5000
wind direction 0 30 60 90 120 150 180	2 2 2 2 2 2 2 2 2 2 2 2 2 2	2804	2612	5704	2712	2805

INST 2003 - 32ft Bid Open Country - No Parapet
 INST (Lin & Surry) - 32ft Building - Open Country



E

------ NIST 2003 - 32tt Bld Open Country - No Parapet ------- NIST (Lin & Surry) - 32tt Building - Open Country

-	3204	3212	
	3203	3211	
+	3202	3210	
+	3201	3300	
	33	3208	3216
	3115	3207	3215
	314	3506	3214
wind direction 0 30 60 90 120 150 180		3202	3213

—— NIST 2003 - 32ft Bid Open Country - No Parapet …… NIST (Lin & Surry) - 32ft Building - Open Country



			8	210		
		412	201	5 5 5 5 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7		615
	406	414		S14	606 506 506 506	614
		413		513 513		613
	404	415	201	512 512	904	612 612
			203			
			205	910 910 910		
0 30 60 90 120 150 180	2 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6					

----- NIST 2003 - 32ft Bid Suburban - No Parapet ------ NIST (Lin & Surry) - 32ft Building - Suburban

		216	808		910 10	1002
		212 212	807	815	606	1001
	900	714	808	814	806	916
			805		607	<u>9</u> 15
	100	212 V	804	812	906	914
	80L		803	8 1	904	913
			803	810	603	812
wind direction 0 30 60 90 120 150 180			801	608	902	911

------ NIST 2003 - 32ft Bid Suburban - No Parapet ------- NIST (Lin & Surry) - 32ft Building - Suburban

	1010	1102	110	1202	1210	
	1009		1109		1209	1301
	1008	1016	1108		1208	1216
	1007		1107	1115	1207	1215
	1006	1014	1106	1114	1206	1214
	1005	1013	1105	1113	1205	1213
	1004	1012	1104	1111 1111	1204	1212
wind direction 0 30 60 90 120 150 181 0 20 20 20 120 150 181 0 20 20 20 20 120 150 181 0 20 20 20 20 20 150 181 0 20 20 20 20 20 20 20 20 20 20 20 20 20		1011	1103	E E	1203	EZ

Sep. 24, 2003

----- NIST 2003 - 32ft Bld Suburban - No Parapet ------- NIST (Lin & Surry) - 32ft Building - Suburban

1310	1 402	1410		
	1001			1602
	1316	1416		1516
	1315	1415	1907	1515
	1314	1416	1506	1514
	1313	1405		1913
1304	1312	1404	1504	1512
wind direction a 60 90 120 150 481 a 60 90 120 150 481 a 60 90 120 150 481 a 1303		1403		1131

----- NIST 2003 - 32ft Bld Suburban - No Parapet ------ NIST (Lin & Surry) - 32ft Building - Suburban



----- NIST (Lin & Surry) - 32ft Building - Suburban

2003	2011	2103	2111	2203	
2002	2010		2110	A WWW 22202	2210
2001	2009	A Contraction of the second se	2108	M. M. W. Szor	2209
1916	2008	2016	2108	2116	2208
	2007	2015 2015	2107	2115 2115	And the second s
1914	2006	2014	2106	2114	2206
1913	2005	2013		213	2205 2205
wind direction 2 0 0 120 150 180 2 0 0 120 150 180 4 0 0 0 0 120 150 180 6 0 120 150 180 1912	2004	2012	Archevision and a second and as second and a	2112	22204

------ NIST 2003 - 32ft Bid Suburban - No Parapet ------- NIST (Lin & Surry) - 32ft Building - Suburban

	303	2311	2403	22411	2503	2511 2511
		2310	2402	2410	2502	2510
		2309	1001	2409	When the second	2509 2509
	2216	2308	2316	2408	2416	2508
	2215	2307	2315 2315	2407	2415	2507
	2214	2306	2314	2406	2414	2506
	2213	2305	2313	2405	2413	2505
wind direction 0 30 60 90 120 150 180	2 	2304	2312	2404	2412	2504

INST 2003 - 32ft Bid Suburban - No Parapet
 INST (Lin & Surry) - 32ft Building - Suburban

-	2603	2611	Store	11.12 2000	2804	2812
-	Contraction of the second	2610	2022	2710 2710	2803	2811 2811
+	2601	2609			2802	2810
+	2516	2608	2616	2708	2801	2809
+ + + + +	2515	2090		2707	2716	2808
	2514	2600 2600	2614	2706	2714	2807
	2513	2000		2705	2713	2806
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1 1 1 1 1	6 2512	2604	2612	2704	2712	2806

----- NIST 2003 - 32ft Bid Suburban - No Parapet ------ NIST (Lin & Surry) - 32ft Building - Suburban

	2904	10 2912	22 3003 3004		22 2303	3112
						3
	2301	2809		3008	3101	308
	2816	2308 2308	2916			3108
	2815	2907	2915		2015	3107
	<u>بن بن ب</u>	2908	2914	3000	2014	300
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1	2 2 2 2 2 2 2 3 3 2 6 1 3 2 6 1 3 2 6 1 3 1 1 1 1 1 1 1 1 1 1 1 1 1	5002	2913	3005	3013	3]05
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Sep. 24, 2003

—— NIST 2003 - 32ft Bid Suburban - No Parapet ------- NIST (Lin & Surry) - 32ft Building - Suburban



—— NIST 2003 - 32ft Bld Suburban - No Parapet
…… NIST (Lin & Surry) - 32ft Building - Suburban

## 20 ft Building – Open Exposure



Sep. 24, 2003

------ NISI 2003 - 2011 Bid Open Country - No Parapet ------ NIST (Lin & Surry) - 20ft Building - Open Country

		200		601		- 19		402				81
		505		514		<u>610</u>		704		7/14		810
		204		- <u>5</u> 13		609		403		713		608 803
		······································										
		203		£ 12		909		702		72		806
		416		510		605		401		<u>F</u>		805
		415		200		604		614		410		804
		414		208				613		60/		803
etion 120 150 180		413		202		602		612		90		8802
wind dire 30 60 90												
0 <del>1</del>	ארפ כספננוכופונ קריא סייס לעריא אריך איי	- <del>ا ب ،</del> - م م bues	<u>  z; / š ; ;</u>	∔╊ ╄	<u></u> 1;&	-∔-∔ ∔-	<u> </u>		<u>; 1                                   </u>		┊╌╝┦┚╶┊──┊	

----- NIST 2003 - 20ft Bid Open Country - No Parapet ------- NIST (Lin & Surry) - 20ft Building - Open Country

		60.	1001	1011	1105	1115	1209
		906	8	1010	1104	1114	1208
		304	8 15	1009	1103	1113	1207
		608	914	1008	1102	112	1206
		66		1007	1101	Ξ	1205
			612	1006	1016		1204
			806 	1003	1013		1201
wind direction 0 30 60 90 120 150 180	2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	9 8 9	806	1002	1012	1106	1116

INST 2003 - 20ft Bid Open Country - No Parapet
 INST (Lin & Surry) - 20ft Building - Open Country

	1303	1313	1408	1502	1512	1607
	1302	1312	1407	1501	1511	1606
	1301	1311	1404	1414	1508	1603
	1216	1310	1403	1413	1507	1602
	1215	1309	1402	1412	1506	1516
	1214	1308	1401	1411	1505	1515
	121	1305	1315	1410	1504	1514
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1	5-6- 		1314	1409		1513

INST 2003 - 20ft Bid Open Country - No Parapet
 NIST (Lin & Surry) - 20ft Building - Open Country
				1913	2005
1616	1710	1804	11904	المحتدين ال المحتدين المحتدين الم	2004
1613	1707			1911	2003
1912	1706	11/16		مان الم	2002
	1105	SILL			2001
<b>16</b> 10	1704	1114		1908	
	1408 1408 1408 1408 1408 1408 1408 1408	113		1907	1915
wind direction 2 0 30 60 90 120 150 180 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		1112		1908 1908	1914

------ NIST 2003 - 20ft Bld Open Country - No Parapet ------- NIST (Lin & Surry) - 20ft Building - Open Country

	2013	2105	213 213	2205	5213	23005
	2012	23 Od	2112	2204	2212	2304
	برین میں	5103	2111	2200		2300 2300
	2010	2102	210	2202	2210	2302
		2101	2109	2201	2209	2301
	2008	2016	2108	2316 2316		2216
	2007	2015	2107	2115		2215
wind direction 0 30 60 90 120 150 180 4	6 6 8 8 2006	2014	2106	214	2200	2214

-

INST 2003 - 20ft Bid Open Country - No Parapet
INST (Lin & Surry) - 20ft Building - Open Country

	313	2405	2413	2505	2513	2605
	2312	2404	3412	2504	5212	2604
	2311	 2403	2911	2503	2311	2603
	2310	2402	2410	2502	5510	2602
		2401	2409	5201	52	2601
	2308	2316	2408	2416	2508	2316
	2307	2315	2407	2415 2415	2507	2315
wind direction 0 30 60 90 120 150 180		2314	2406	2414	5506	2514

.

INIST 2003 - 20ft Bid Open Country - No Parapet
INIST (Lin & Surry) - 20ft Building - Open Country

		2613	2705	- 2713	2806	2814	2906
		2612	2704	2712	2805		2905
		2611	2703	2711	2804	2812	2904
		2610	2702	2710	5803	2811	2903
		5609	5701	2709	2802	2810	2902
		5608	2616	2708	2801	580	2901
		2607	2615	2707	 2716	5808	2816
wind direction 0 30 60 90 120 150 180 4	4 2 0 2 4		2614	2706	2714	2807	2815

INST 2003 - 20ft Bid Open Country - No Parapet
NIST (Lin & Surry) - 20ft Building - Open Country

		2914	3006	3014	3106	 3114	3206
		5913	3005	3013	3105	3113	3205
		2912	3004	3012	3104	3112	3204
		5911	3003	391	3103	311	3203
		5910	3602	3010	3102	3110	3202
		2909	3001	3008	3101	8	3201
		5908	2916	3008	3016	88	3116
wind direction 0 30 60 90 120 150 180	2 0 0 2 4	-6	2915	3007	3015	3107	3115

------ NIST 2003 - 20ft Bid Open Country - No Parapet ------- NIST (Lin & Surry) - 20ft Building - Open Country

Sep. 24, 2003

pressure coefficient



----- NIST 2003 - 20ft Bid Open Country - No Parapet ------ NIST (LIn & Surry) - 20ft Building - Open Country

## 20 ft Building – Suburban Exposure

	A Contraction of the second se	300	214	308	A Constant	402		412
		203 203	513	307		401 101		
Hole Hole Hole Hole Hole Hole Hole Hole		202 	313	306		316	A A A A A A A A A A A A A A A A A A A	410
Long Long		201	53	305		315		
			308	302		312		909
			307	301		311		405
				216		310		404
wind direction 2 2 2 2 4 4 5 5 6 9 150 180 180 180 180 180 180 180 18			302 100	315		300		403

Sep. 24, 2003

----- NIST 2003 - 20ft Bld Suburban - No Parapet ------- NIST (Lin & Surry) - 20ft Building - Suburban

	214	e(10	101	714	8
504	11 213 213			33	
	512 512	900 100 100 100 100 100 100 100 100 100	202	712	908
416	210				
415		6004	5 614		
mind direction mind direction	200	in the second se			802

—— NIST 2003 - 20ft Bid Suburban - No Parapet …… NIST (Lin & Surry) - 20ft Building - Suburban

• • • •		907		1001		1011		1105	1115		1209
-		906	Contraction of the second	<u>9</u> 16	And the second	1010		1104	1114		1208
-		904		312 312		1009	And a second sec	1103	1113		1207
-		903		914		1008		1102	1112	A Carlor Contraction of the cont	1206
-		605		<u>9</u> 13		1007		1101			1,205
		814		912		1006		1016	110		1204
)		813		806 		1003		1013	1107		1201
wind direction 0 30 60 90 120 150 18	and the coefficient					1002		1012	1106	A Contraction of the second se	1116

— NIST 2003 - 20ft Bid Suburban - No Parapet …… NIST (Lin & Surry) - 20ft Building - Suburban

	1313	1108	1502	1512	200 - 1607
			1501		
		1404	1414		
1316		1408	1413	1507	1602
1215	1300 11300	1402	1412	1506	
151 121 121 121 121	1308				1515
En State	1305 1.1305	1315	1110 1110	And the second sec	151
wind direction 0 30 60 90 120 150 18( 0 0 0 10 120 150 18( 0 0 0 0 0 0 0 120 150 18( 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1304	1314	1100		1513

•

—— NIST 2003 - 20ft Bid Suburban - No Parapet ------ NIST (Lin & Surry) - 20ft Building - Suburban

1041			1908 		2005
1616	OIL1		Line and the second sec	KA Contraction of the second s	2004
1613			1903	1911	2003
1912	90,1	1116		WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW	2002
1191	Soll			1909	
	And the second s	1114	1810	1908	M
	Sol -		1807	1907	control of the second s
wind direction wind direction 0 30 60 90 120 150 180 0 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2				1906	

Sep. 24, 2003

------- NIST (Lin & Surry) - 20ft Building - Suburban

2013	2105	2113	2205	2213	23055
2012	2 5 5 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	2112 2112	2204	22 22 22 22	2304
2011	2 103		203	2211	2303
2010	2102	2110 2110	WWW. Z202	2210	2302
2008		2109	Land Contraction	<u>مجمع المجمع المحمة المحمة محمة المحمة المحمة محمة المحمة ا لمحمة المحمة المحم</u>	A A A A A A A A A A A A A A A A A A A
2008	2016	2108	2116		2216
2007	2015	2107	2115 2215	2207	2215
0 30 60 90 120 150 180	2014	2	2114	2206	2214

INST 2003 - 20ft Bid Suburban - No Parapet
INST (Lin & Surry) - 20ft Building - Suburban

		2313	2405				2513	Mary Control of Contro
		2312	2404		2412	2504	2512	2604
		231	2403		2411	2503	5511	2603
		2310	2402		2410	The manual is a second	5510	2602
			V V V		2409	When we want the second s	5509	AND 2501
		2308	2316		2408	2416	2508	2516
		2307	2315		2407	2415	2507	2515
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1	2 month		2314	and the second s	2406	2314	5506	2514

INST 2003 - 20ft Bid Suburban - No Parapet
INST (Lin & Surry) - 20ft Building - Suburban

	5613	2705	2713	2806	2814	2306
	2612	2704	2712	2805	2913 2913	
	2611	2703	2711	2804	2812	2904
	2610	2702	2710	2803	581 581 581 582 582 582 582 582 582 582 582	
	5609	A 2701	5409	2802	2810	2902
	5608	2616	508	2801	5900	
	2607	2615	2707	2716 2716 2716		
wind direction 0 30 60 90 120 150 180 0 0 0 0 0 0 0 0 0 0 0 0 0	8	2614	2706	2714	2807	2815

pressure coefficient

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INST 2003 - 20ft Bid Suburban - No Parapet
NIST (Lin & Surry) - 20ft Building - Suburban

2 <b>3</b> 14	900E	3014	3106		3206
2	3005	3013	3105	3113	3205
2912	3004	3012	3104		3204
2911		3011	3103	3111	3203
2910	3002	3010	3102		3202
2808	1000 House	3000		3109	And the second s
2008	2916		3016	3108	3116
wind direction wind direction 0 30 60 90 120 150 190 0 0 0 0 0 0 120 150 190 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2915		3015	3107	A V V V

INST 2003 - 20ft Bid Suburban - No Parapet
INST (Lin & Surry) - 20ft Building - Suburban



INST 2003 - 20ft Bid Suburban - No Parapet
NIST (Lin & Surry) - 20ft Building - Suburban

## COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 (WITHOUT PARAPET) AND TEST 2 (WITH 3' PARAPETS)

- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20', 32'
- Test 1: without parapets; Test 2: with parapets

## 32 ft Building – Open Exposure



Sep. 24, 2003

INST 2003 - 32ft Bid Open Country - No Parapet
NIST 2003 - 32ft Bid Open Country - Parapet

			809	416	208	<u>.</u>	80    	616
-	3		407	415	207	22	607	615
- - - -			406	414	208	20 4	900	614
-			405	413	202		605	<u>6</u> 13
-	7		404	412	204	512	604	612
	3		403		20		603	61
			402	410	202	210	602	<u>6</u> 10
wind direction 0 30 60 90 120 150 180		600 910260	5.6 		501	88		609

1001
916 816
<u> </u>
914
8 13
83
5

INST 2003 - 32ft Bid Open Country - No Parapet
NIST 2003 - 32ft Bid Open Country - Parapet



	1310	1402		1502	1510	1603
	1309	1401	-1		1500	
	1308	1316	1408	116	1508	1516
	1307	1315	1407	1415	1507	1515
	1306	1314	1406	1414	1506	1214
	1305		1405	1413	1505	
	1304	1312	1404	11	1504	151
wind direction 0 30 60 90 120 150 180 0 20 0 120 150 180 0 20 0 120 150 180			1403		1503	

Sep. 24, 2003

INST 2003 - 32ft Bid Open Country - No Parapet
INST 2003 - 32ft Bid Open Country - Parapet

	1703	111	1803		1911
16i0	1702	1710	1802		
1609	1701	1709	1801		1909
1608	1616	1708		1810	1908
1607	1615	1707	1715	1807	
100 100	1614	1706	N		
100 100	1613	1705	1713		1906 1905
wind direction 0 30 60 90 120 150 180 2 0 0 120 150 180 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1612	1704			1904

Sep. 24, 2003

INST 2003 - 32ft Bid Open Country - No Parapet
NIST 2003 - 32ft Bid Open Country - Parapet

	2003	2011	2103	211	22003	150 F
	2002	2010	2102	2110	2202	2210
	2001	2009	2101	108 1308	2201	2200
	1916	2008	2016	3108	2116	2208
	- 1915 	2007	2015	2107	2115	2207
		2006	2014	23066	2114	2206
	1913 1913	2005	2013	2]05	3113	2205
wind direction 0 30 60 90 120 150 18(	6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	2004	2012	2104	2112	2204

Init of the control of the cont

	5303	2311		2411	2503	2511
	5302	2310		5410	2502	2510
	5301	2309		5409	2501	2509
	5216	5308	WWW BALL	508	2416	2508
	5315	2307	2315	2407	2415	2507
	2214	2306	3314	500	2414	2506
	2213	2305		5405	2413	2505
wind direction 0 30 60 90 120 150 180	2212	2304		2404	2412	2504

----- NIST 2003 - 32ft Bid Open Country - No Parapet ------- NIST 2003 - 32ft Bid Open Country - Parapet

		5803	2611	5703	5	5804	2812
		5903	2610	2702	2710		2811
			2¢03	2701	5109	2802	2810
			2608	2616	2708	2801	2809
			2607	2615	2707	2716	2808
		2514	2606	2614	5706	2714	2807
		2513	2605	2613	2705	2713	2806
wind direction 0 30 60 90 120 150 180 4	4 2 0 2		2604	5612	2704	242	2805

INST 2003 - 32ft Bld Open Country - No Parapet
NIST 2003 - 32ft Bld Open Country - Parapet

		5904	2912	3004	3012	3304	3112
		5903	2911	3003	301	3303	3111
		2902	2910	3005	3010	3102	3110
		500	5300	3001	600 600 600 600 600 600 600 600 600 600	301	3109
			7908	2916	3008	3016	3108
			2907	2915	300	3015	3107
		2814	7906 7906	2914	300	3014	3106
wind direction 0 30 60 90 120 150 180	2 0 2 4	8 9	2905	5913		3013	3105

INST 2003 - 32ft Bid Open Country - No Parapet
INST 2003 - 32ft Bid Open Country - Parapet

	3204	3212	3304	3312	3404	3412
	3203	3211	3303	33	3403	3411
	3202	3210	3302	3310	3402	3410
	3201	3209	3301	3308	3401	3409
	316	3308	3216	3308	3316	3408
	312	3207	3215	3307	3315	3407
	314	3206	3214	3300	3314	3406
wind direction 0 30 60 90 120 150 180	8	3205	3213	3302	3313	3405

INST 2003 - 32ft Bid Open Country - No Parapet
INST 2003 - 32ft Bid Open Country - Parapet

		3504	3512	3604	3612	3704	3712
		3203	3511	3603	3611	3703	311
-		3502	3510	3602	3610		3710
+ + + + + +		3501	3509	3601	3609	IOLE	3308
		3416	3508	3516	3608	3816	3708
		3415	3\$07	3515	3607	3615	3707
		3414	3506	3514	3606	3614	3308
wind direction 0 30 60 90 120 150 18(	2		3505	3513	3605	3813	3705

INST 2003 - 32ft Bld Open Country - No Parapet
INST 2003 - 32ft Bld Open Country - Parapet

-	3804	3812	3904	3912	4004	4012
-	3803	3811	3803		4003	4011
	3802	3810	3902	3910	4002	4010
	3801	3300	3901	3300	401	4009
	3716	3808	3816	3308	3916	4008
	3715	3607	3812	3907	332	4007
	3714	3806	3814	3906	3914	4006
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1 1	5-6- 	3802	3813	3905	3313	4005

INST 2003 - 32ft Bid Open Country - No Parapet
INST 2003 - 32ft Bid Open Country - Parapet



INST 2003 - 32ft Bld Open Country - No Parapet
INST 2003 - 32ft Bld Open Country - Parapet



	/		408		9	Į		8 <u>8</u>		210	88		616
			407		415			207		2 2	20 <u>3</u>		615
			406		414					514			614
			405		413			505		<u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>	602		613
			404		412			504					612
			403					<u> </u>			83		611
	3		402		410		}	205					610
wind direction 0 30 60 90 120 150 180 8	4	4 °	12 401		8	}							609

INST 2003 - 32ft Bid Suburban - No Parapet
NIST 2003 - 32ft Bid Suburban - Parapet
				- Contraction of the second se	80/ 			716		-	808		}		<u>9</u> 01		2		910				1002
											807				815				606		<u>}</u>		1001
											806			-	814		) }	}	 808	5			916
				- F							12			-	<u>ه</u>				 2				
				~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~							8						Ì		0	Ì			916
				704							804				812	-	Jan 1		906				914
				703			· · · · ·				803				81			{ }	904		9 		
				702							802				810			} }	903				
150 180				701		-					801				608				902			<u>61</u>	
wind direction 0 30 60 90 120	0 ~	4	 	2-																			

pressure coefficient

INST 2003 - 32ft Bld Suburban - No Parapet
 INST 2003 - 32ft Bld Suburban - Parapet

	1102	1110	1202	1210	1302
	1101		1201	1209	1301
	1016	8			1216
				1207	
	101				151
	1013				13:3
	1012				
wind direction wind direction 0 00 120 150 180 0 00 120 180 0 00 00 180 0 00 00 00 0 00 00 00 0 00 00 00 0 00 00 00 0 00 0 00 00 0					E

pressure coefficient

Sep. 24, 2003

—— NIST 2003 - 32ft Bid Suburban - No Parapet …… NIST 2003 - 32ft Bid Suburban - Parapet

	1310	1402	1410	<b>15</b> 02	1510	1603
			1409		1509	1602
	1308	1316	1408	1416		1516
	1307	1315	1407		1507	1515
	1306	1314	1406		1506	1514
	1305	1313	1405	1413		1513
	1304		1004	14 14 15 14 15 15 15 15 15 15 15 15 15 15 15 15 15		1512
wind direction 8 0 120 150 180 9 0 120 150 180 9 0 0 120 150 180 9 0 0 0 120 150 180 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-12	2000		<u><u></u></u>		

Sep. 24, 2003

## —— NIST 2003 - 32ft Bid Suburban - No Parapet ------ NIST 2003 - 32ft Bid Suburban - Parapet

pressure coefficient

		161	1703	E.	1803		191
		1610	1702	1710	1802		1910
		1609	1701	60.1	1801		1909
			1010	1108			1908
		1607		1707	1715		1907
			161	1706	1714	1909	1906
		1605		1705			1905
wind direction 0 30 60 90 120 150 18	4 0 4			-1-04	1172	1900	1904

INST 2003 - 32ft Bld Suburban - No Parapet
 INST 2003 - 32ft Bld Suburban - Parapet

		- 5003	2011	5103	2111	2203	2211
	M. Contraction	2002	2010	2102	2110	5202	2210
+		2001		501	5100	5201	2209
			5008	2016	500	2116	2208
		1915	2007	2015	2107	2115	2207
		1914	2006	2014	5106	2114	5208
		<u><u></u></u>	5002	5013	53	313	2205
wind direction 0 30 60 90 120 150 180 8 1 1 1 1 1			2004	2012	2104	5112	2204

pressure coefficient

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----- NIST 2003 - 32ft Bid Suburban - No Parapet ------- NIST 2003 - 32ft Bid Suburban - Parapet

	2303	2311 2311	2403	281 11	2503	231 231
	2302	2310	2402	2410	2502	2510
	2301	5308	2401	3400	2501	2508
	2216	2308 2308	2316		2416	2508
	2215	2307	2315	2407	2415	2607
	2214	5300 5300 5300	2314	2406	2414	5506 25006
	2213		333 5333 5333	2405	5413	
0 30 60 90 120 150 180	2212	2304	2312	2404	2412	2504

INST 2003 - 32ft Bld Suburban - No Parapet
 INST 2003 - 32ft Bld Suburban - Parapet

			5603	561	5703	Ę	2804	2812
+			5602	5610	2702	5/10		2811
+			5901		5201	2308	5802	2810
				2608	2616	2708	5801	2809
			2515	2607	2615	2707	5,16	2808
			2514	2606	2614	2706	2	2807
		·	2\$13	2605	5613	2002	5713	2806
wind direction 0 30 60 90 120 150 180 8 1 1 1 1 1 1	0	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	-16	2604	3912	2704	2712	2805

----- NIST 2003 - 32ft Bid Suburban - No Parapet ------- NIST 2003 - 32ft Bid Suburban - Parapet

-			<b>}</b>	2904		2912	3004	3012	3104	3112
				2903		5311	3903	3011	33	311
				2902			3905	3010	3105	3110
				2901			3001	6000	3301	3109
				2816		2908	2916	3008	3016	3108
				2815		2907	2915	3007	3015	3107
				2814		5308	2914	3000	3014	3106
wind direction 0 30 60 90 120 150 180	4	0		6 2813 1 6 2813 1		5005	5913	3002	3013	3105

— NIST 2003 - 32ft Bid Suburban - No Parapet ...... NIST 2003 - 32ft Bid Suburban - Parapet

	3504	3212	3304	3312	3404	3412
	330	331	3303	33	3403	3411
	330	3210	3302	3310	3402	3410
	3301	3300	3301	3300	3901	3409
	316	3208	3216	3308	3316	3408
	315	3207	3315	3307	3315	3407
	314	3300	3214	3308	3314	3406
wind direction 0 30 60 90 120 150 180 8		3502	3213	3305	3313	3405

INST 2003 - 32ft Bid Suburban - No Parapet
 NIST 2003 - 32ft Bid Suburban - Parapet

		3504	3512	3604	3612	3704	3712
		3503	351		3611	3103	3711
		3502	3510	3602	3610	3702	3710
		3501	3208	3601		3701	6026
		3316	3508	3516	3608	3616	8042
		3415	3507	3515	3607	3615	3707
-		3414	3206	3514	3606	3614	3706
wind direction 0 30 60 90 120 150 180	0 4	3413	3505	3213	3605	3613	3705

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Sep. 24, 2003

pressure coefficient

+	1		3804	3812	3904	3912		4004	4012
+ + + + +	2 	7							
			88		300			40	401
		{	3802	3810	3305	3910		4002	4010
			3801	3809	3901			4001	4009
			3716	3808	3816	3308	3	3916	4008
		<b>\$</b>							
			315	3807	3815	3901			4007
		<u>}</u>	3714	<u>908</u>	3814	900 1		3914	4006
wind direction 60 90 120 150 180			3713	3802	3813	3905		3913	4005
8 0 30	fficient 0 4	coessure coe	<u>1 9</u>						

INST 2003 - 32ft Bid Suburban - No Parapet
 INST 2003 - 32ft Bid Suburban - Parapet

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— NIST 2003 - 32ft Bld Suburban - No Parapet
…… NIST 2003 - 32ft Bld Suburban - Parapet

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## 20 ft Building – Open Exposure



Sep. 24, 2003

----- NIST 2003 - 20ft Bld Open Country - No Parapet ------- NIST 2003 - 20ft Bld Open Country - Parapet

		<u>ශ</u> ී (			405		81
	}		214 214	9 9			810
		504 204				<u>A</u> 13	608
							00
							80
	} }	416	210		<u>6</u>		802
	}		200				804
	}		8		613 13		803
0150180					615	98-	802
wind directit	φ 4 γ		\$				·····

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-			101	1105	1115	1209
	906		1010	104	1114	1208
+		915	1009	1103		1207
+	<u> </u>	9 <mark>14</mark>	1008	1102	1112	1206
		6	1007	1101	Ē	1205
	88		1006		110	1204
	813				1107	1201
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1	812 812	88	1002	1012		1116

.

+		1313	1408	1502	1512	1607
-	1302	1312	1407	1501	<u> </u>	1606
+	301	111	1404	1414	-1508	1603
	1216 1216	1310	1403	113	1507	1602
	1215		1402	1112		1516
	1214		1401		1505	1515
	112	1305		1410	1504	1514
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1	pressure coefficient	1304		1400	1203	1513

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		1701	1111	1805	1905	161 113	2006
+ + + + +		1616	1710	1804	1904	1912	2004
		1613	1207				2003
		1612	1706	1216	1902	1910	2002
		1611					2001
			1704		1810	1308	1916
		1600	1703		1907		1915
wind direction 0 30 60 90 120 150 18 4 1 1 1 1 1	Bescure coefficient	Б-6- 	1702		1906		1914

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	2013		2105	2113		2205	2213	2305
	2012		2104	2112		2204	2212	2304
	2011		2103	2111		2203	2211	5303
	2010		2102	2110		5302	2210	2302
	2009	A A A A A A A A A A A A A A A A A A A	2101	2109	A Contraction of the second se	2201	5200	2301
	5008		2016	2108		2116	5208	2216
	2007		2015	2107		2115	2207	2215
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1	5-6 -8 		2014	5106		2114	2206	2214

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		2313	5405	2413	2505	2513	2605
		2312	2404	2412	2504	2512	2604
		5311	2403	2411	2503	2511	5603
		2310	2402	2410	2502	2510	2602
			2401	2409	2501	5509	2601
		2308	2316	5408	2416	5208	2516
		2307	2315	2407	2415	2507	2515
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1 1 1 1 1	2		2314	2406	2414	5506	2514

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	5613	2705	2713	2806	2814	2906
		2704	2712	2805	2813	2905
		2703	2711	2804	2812	2904
+	2¢10	2702	2710	5803		2903
	560	2701	5/09	5805		2902
	5608		5,08	2801		2901
	2607	2615	2707	2716	5808	2816
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1 1 1		2614	2706	2714	2807	2815

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	2914	3009	3014	3106	3114	3206
	5913	3005	3013	33	31	3205
	2912	3004	3012	3104	312	3204
	531	3003	301	3103		3203
	2910	3002	3010	305	3 10	3202
	5000	3001	3000	3101	300	3201
	2908	2916	3008	3016	3308	 316
wind direction 0 30 60 90 120 150 180 4 1 1 1 1		2915	3007	3915	330	3115

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	3214	3308	3314	90 <mark>6</mark>	3314	3506
	3213	3305	3313	3405	3413	3505
	3212	3304	3312	3404	3412	3504
	3211	3303	3311	3403	3311	3503
	3210	3305	3310	3402	3410	3502
	33	3301	3308	3401	330	3501
	3208	3216	3308	3316	3908	3416
wind direction 0 30 60 90 120 150 180 4 1 1 1 1	φ. φ	3215	3307	3315	3407	3415

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		3514	3606		3614	3706		3807
		3513	3605		3613	3005	3113	3806
		3512	3604		3612	3704	31/2	
		311	3603	E C	3611	\$042		
		3510	3602		3610	3702	3110	
		3203	3601				3709	3802
		3208	3216		3608	3616	3708	3716
wind direction 0 30 60 90 120 150 180	4 0 0		3515		3607	3915		3115

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INST 2003 - 20ft Bld Suburban - No Parapet
 INST 2003 - 20ft Bld Suburban Parapet

		Bill	902		
	41 214 514	<u>م</u>	704	14 714	
	513 513	609 		4 4 4 7 4 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	
	M. 512	999 		112 712	
	210			711	
					8804
wind direction wind direction 0 20 60 90 120 150 180 0 20 0 20 150 180 0 20 0 120 150 180 0 20 0 120 150 180		800 800 800 800 800 800 800 800 800 800			

— NIST 2003 - 20ft Bid Suburban - No Parapet
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	607	1001	1011			1115	
	906	<u></u>	1010	A starting of the start of the	1104	1114	1208
	904	915	1009		1103	1113	1207
· · · ·	803		1008		1102	1112	
-	302	<u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>	1007		1101		1205 1205
-	814		1606	A Construction of the second s	1016	1110	1204
-	8813	606	1003		1013	1107	
wind direction 0 30 60 90 120 150 180	812	608	1002		1012	1106	

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— NIST 2003 - 20ft Bid Suburban - No Parapet ...... NIST 2003 - 20ft Bid Suburban Parapet

pressure coefficient



INST 2003 - 20ft Bid Suburban - No Parapet
 INST 2003 - 20ft Bid Suburban Parapet

				1913	2005
		1710 1710		1912	2004
		1707 1707 1801		1911	2003
The second secon		1716		M 1910	
					Tool
		1704	1810		1916
	and the second s	1713			1915
wind direction wind d					1914

—— NIST 2003 - 20ft Bid Suburban - No Parapet …… NIST 2003 - 20ft Bid Suburban Parapet •

+	2013	2105	2113	2205	2213	2305
	2012	2104	2112	2204	2212	2304
	2011	2103	2111	2203	1122 212	22003
	2010	2102	2110	M 2200 2200	2210 2210	2302
	2000	2101	2109	A A A A A A A A A A A A A A A A A A A	2209	2301
	2008	<u>т</u> М 2016	2108	2116	2200 2200 2200	2216
	2007	2015	2107	2115	2207	2315 2315 2315
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1 1 1	2 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7	WWW 2014	2106	2114	2200 2200 2200	2214

INST 2003 - 20ft Bid Suburban - No Parapet
 INST 2003 - 20ft Bid Suburban Parapet

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2313 2313	2405	2413	2505	2813	2605
2312	2200	2412	2504	2312	
2311 2311		2411	2500	2511	2000
2310	2402	2410	2502	2510	2902
2300	The second second	2409	2501	2809	2601
2308	2316 2316	2408	2316 2316		2516
	2315	2407	2415		2515
wind direction 2 0 30 60 90 120 180 2 0 0 0 120 150 180 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2314	2406	23414 23414	2506	2514

pressure coefficient o 4 v 0 v Sep. 24, 2003

------ NIST 2003 - 20ft Bld Suburban - No Parapet ------- NIST 2003 - 20ft Bld Suburban Parapet

-		5705	2713	2806	2814	23006
		2704	2712	2805	2813	2306
+	۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰	5,03	2711	2804	2812	2904
+		2702	2710	2803	2811	2903
			5400	2802	2810	2902
	2808	2616	2708	2801	5800	WWW 2801
	2807	2615	2707	2716		2816
wind direction 0 30 60 90 120 150 180 4 1 1 1 1 1		5614	2706	2714	2807	2815

INST 2003 - 20ft Bid Suburban - No Parapet
 INST 2003 - 20ft Bid Suburban Parapet

2914	3008	2014	3106	23114	3206
2913		3013	300	3113	3205
2912	2004	3012	3104	3112	3204
	3003	3011	3303	311	3203
2910		3010	3302	3110	3202
		3000		3308	102 3201
	2916	3008	3016	3108	3116
wind direction 2 0 00 120 150 181 2 0 0 0 120 150 181 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2915		3015	3101	3115

pressure coefficient

— NIST 2003 - 20ft Bid Suburban - No Parapet
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		3214		3306		3314		3406	3414	3506
		3213		3305		3313		3405	3113	3505
		3212	2 W With	3304		3312		3404	3312	3504
		3211		3303	······································	331	A Contraction of the second se	3403	331	3503
		3210		3302		3310		3402	3410	3502
		3209		1 3301		3308		3401	3409	3501
		3308		3216		3308		3316	3408	3416
wind direction 0 30 60 90 120 150 180 4 1 1 1 1	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2			3215		3307		3315	3407	3415

----- NIST 2003 - 20ft Bid Suburban - No Parapet ------- NIST 2003 - 20ft Bid Suburban Parapet
	3514					
-	3513	3005		Sorte		3806
	3512	3604	3612	3704	3/12	
	3511		3611		3111	
	3510		3610	3702	3710	
	3209		3900		3709	2086
	3208	3516		3616	3708	316
wind direction 0 30 60 90 120 150 18	Ē-6	3515		3915		3715

INST 2003 - 20ft Bld Suburban - No Parapet
NIST 2003 - 20ft Bld Suburban Parapet

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----- NIST 2003 - 20ft Bld Suburban - No Parapet ------- NIST 2003 - 20ft Bld Suburban Parapet

## COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 (1:200 SCALE) AND TEST 3 (1:100 SCALE) – ROOF TAPS

### Test 1

- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20'

#### Test 3

- Length scale: 1:100
- Model dimensions: 100'x50'
- Roof slope: 1:24
- Building heights: 16'

Note that the tap locations on the roof from the two tests match when normalized by their respective building height.



—— NIST 2003 - 32ft Bid Open Country - No Parapet Roof taps ……… NIST 2003 - 16ft Bid Open Country No Extension Roof taps



—— NIST 2003 - 32th Bld Open Country - No Parapet Roof taps ……… NIST 2003 - 16th Bld Open Country No Extension Roof taps



—— NIST 2003 - 32th Bid Open Country - No Parapet Roof taps ……… NIST 2003 - 16th Bid Open Country No Extension Roof taps



INST 2003 - 32th Bid Open Country - No Parapet Roof taps
IST 2003 - 16th Bid Open Country No Extension Roof taps

	3205	3213	3306	3314	3407	3415
	3204	3212	3305	333	3406	3414
	3203	3211	3304	3312	3402	3413
	3202	3210	3303	3311	3004	3412
	3201	602	3302	3310	303	3411
	315	3208	3301	SS 3300	3402	3410
	3114	3207	3215	3308	3401	3409
wind direction 0 30 60 90 120 150 180	-9 -9 -13 -13 -13 -13 -13 -13 -13 -13 -13 -13	3206	3214	3307	3315	3408

INST 2003 - 32ft Bld Open Country - No Parapet Roof taps
INST 2003 - 16ft Bld Open Country No Extension Roof taps



—— NIST 2003 - 32th Bid Open Country - No Parapet Roof taps ……… NIST 2003 - 16th Bid Open Country No Extension Roof taps

# Suburban Exposure

		5008	2101	3109	2202
	1914	2007	2015	5]08	2201
	1913	2006	2014	2107	2115 2115
	1912	2005	2013	2 000	2114
	1911	2004	2012	2 2 05	2113
	1910		2011	2104	2112
	1909	2002	2010	2103	2111
wind direction a 0 30 60 90 120 150 161 4 4 4 4 		2001	2000	2102	210

INST 2003 - 32ft Bld Suburban - No Parapet Roof taps
IST 2003 - 16ft Bld Suburban No Extension Roof taps

+			2210	5303	2311		2404		2412	2505
			5500		2310		2403		5411	2504
+		A second s	2208	2301	2309		2402		2410	2503
+			2207	2215	5308		2401		5100	2502
		میں میں ایک می ایک میں ایک میں	5200	2214	2307		2915		2408	2501
		میں میں میں میں میں میں میں میں میں میں میں		2213	500		2314	میں بندوین بریک میں الندوین میں میں الم	2407	2415
			2204	2212		بر المراجع الم المراجع المراجع ا المراجع المراجع	5313		2406	2414
wind direction 0 30 60 90 120 150 180 8	4 0		-12 -16		2304		5312		2005	2413

INST 2003 - 32ft Bld Suburban - No Parapet Roof taps
IST 2003 - 16ft Bld Suburban No Extension Roof taps

		2513	5606		2707	5801		580A
		5212		2613	2706	2714		
	<u>بر کرد اور اور اور اور اور اور اور اور اور اور</u>	5511	2604	2612	2705	5713		
	میں اور	2510		2611	2704	2712		
		5509	2602	2610	2703	2711	3805	
	المراجع المراجع المراجع المراجع	2508	2601	5609	2702	2710	2804	
		2507	2515	5608	2701	2709	5803	
wind direction 0 30 60 90 120 150 180	4 0 	12 16 16 16	2514	2607	2615	2708	2802	

INST 2003 - 32ft Bid Suburban - No Parapet Roof taps
IST 2003 - 16ft Bid Suburban No Extension Roof taps

	2902	2910		3104	3112
	2901	2900	33002	3303	3111
	2815	2908		3102	3110
	2814	2907		3101	33
	3813	5906 23006		3012	33
	2812			3014	3107
	2811	2904			300
wind direction 0 30 60 90 120 150 180		2903		3012	300

INST 2003 - 32ft Bld Suburban - No Parapet Roof taps
IST 2003 - 16ft Bld Suburban No Extension Roof taps

-		3205	3213	3306	3314	3407	3415
-		3204	3212	3302	3313	3406	3414
-		3503	331	3304	3312	3405	3413
-		3202	3210	3303	331	3404	3412
		3201	3209	3302	3310	3403	3411
		3115	3208	3301	3308	3402	3410
		314	3207	3215	3308	3401	3409
wind direction 0 30 60 90 120 150 180	4 0 	8 12 16 16 13 113 13 113	3200	3214	3307	3315	3408

INST 2003 - 32ft Bid Suburban - No Parapet Roof taps
IST 2003 - 16ft Bid Suburban No Extension Roof taps

-		3508	3601	89 99 	3102	3710	
		3507	3515	80	3404	3709	
		3200	3514	3607	3615	3708	
		3505	3513	3606	3614	3407	3715
		3504	321	380	3613	3400	3714
		3203	3211	3604	3612	50LE	3713
		3205	3510	3603	3611	3704	3712
wind direction 0 30 60 90 120 150 180		3501	3200	3602	3610	502 502 502 502 502 502 502 502 502 502	3711
8	trie coefficient	-12 -12 -14 buess					-

INST 2003 - 32ft Bld Suburban - No Parapet Roof taps
IST 2003 - 16ft Bld Suburban No Extension Roof taps

## COMPARISON OF PRESSURE COEFFICIENTS BETWEEN TEST 1 (1:200 SCALE) AND TEST 3 (1:100 SCALE) – WALL TAPS

### Test 1

- Length scale: 1:200
- Model dimensions: 200'x100'
- Roof slope: 1:24
- Building heights: 20'

#### Test 3

- Length scale: 1:100
- Model dimensions: 100'x50'
- Roof slope: 1:24
- Building heights: 16'

Comparison were made on the taps from the second line from the top of the Test 1 Building and the third line of taps from the top of the Test 3 Building.

Note that the taps from the two tests were selected based on the location of the taps from ground relative to the building height. The nomenclature follows that of Test 3.

# **Open Exposure**



------ NIST 2003 - 20ft Bld Open Country - 1:200 ------- NIST 2003 - 16ft Bld Open Country - 1:100



----- NIST 2003 - 20ft Bld Open Country - 1:200 ------- NIST 2003 - 16ft Bld Open Country - 1:100

# Suburban Exposure



----- NIST 2003 - 20ft Bid Suburban - 1:200 ------ NIST 2003 - 16ft Bid Suburban - 1:100



----- NIST 2003 - 20ft Bid Suburban - 1:200 ------ NIST 2003 - 16ft Bid Suburban - 1:100