

Roof wind pressures for rectangular low rise buildings using MS1553, EC1-1-4, BS6399-2 and IS875-3

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Abstract: - This paper compares the maximum roof pressures of the low rise rectangular plan building using four major codes (MS 1553-2002, EC 1991-1-4:2005, IS 875-3-1987 and BS 6399-2:1997) on the general and local area of different roof types considering buildings with non-dominant opening, dominant opening and canopies. Two codes used to determine the wind pressures in Malaysia are MS 1553-2002 and BS 6399-2:1997. Eurocodes (EC1-1-4) has been included in the context of its necessary introduction in Malaysia. IS 875-3-1987 is another code from tropical zone namely India. The maximum recommended wind speed in MS 1553-2002 namely 33.5 m/s has been used as the reference for the numerical comparison. The major differences in the codes include averaging time for wind speed, reference height of buildings, and values of pressure coefficients. The study examines the conservativeness or not of the codes if used in the Malaysian context, even though they have been developed for a different wind climate and region. The results of the study are reported.

Keywords: - averaging time, pressure, rectangular building, roof, wind speed.

I. INTRODUCTION

The roofing is a very critical element for the safety of buildings and historically it has suffered severely during the strong wind events. Generally, roof systems have performed well under normal conditions of load. Their performance under extreme wind loads has been disastrous, the predominant failure mode being uplift [1][2][3][4][5]. The wind codes being used in Malaysia are MS 1553-2002 [6] and BS 6399-2 [7]. The introduction of Eurocodes for structural design in Malaysia necessitates examination of EC1-1-4 [8]. IS 875-3 [9] is the wind code used in India which has tropical climate with cyclones in Zone 2. Comparative study of these codes will highlight similarities and differences in approaches, idea regarding the values of terrain multipliers, pressure coefficients and pressures and conservativeness or not if used in the Malaysian context, even though they have been developed for a different wind climate and region.

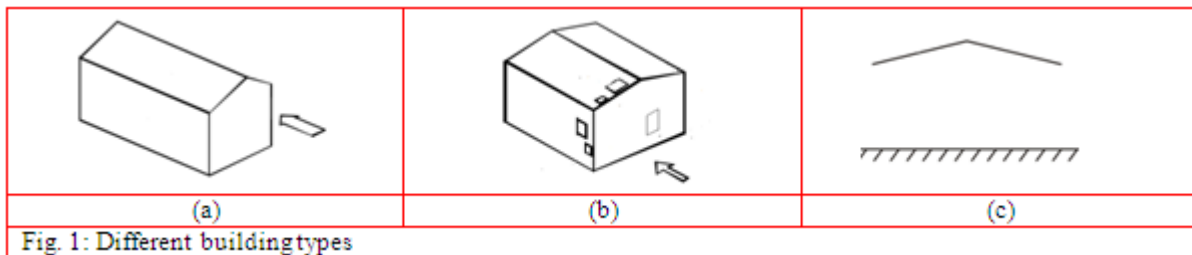
II. LITERATURE REVIEW

2.1 Introduction

The wind speeds in MS 1553-2002 [6], IS 875-3-1987 [9], BS 6399-2-1997 [7] and EC1-1-4-2005 [8] are based on 3-second gusts, 3 second gusts, 10 minute mean and hourly means respectively. The reference heights for calculation of pressures on the whole or part of a building are different in different codes.

2.2 Building Types

Rectangular plan buildings may have different roof types like mono-slope, pitched (gabled or hipped), canopy (pitched or troughed), saw tooth (single or multi span) and circular arch roofs. All these building types are further classified based on percentage openings into non-dominant and dominant opening and open (canopy type). All of them have been considered in the study. Fig. 1 shows the different of building types; case a is non-dominant opening building, case b is dominant opening building and case c is a building with canopy roof.



2.3 Reference height

For calculation and comparison of wind pressures in different codes, MS 1553-2002 is used as the reference. The reference heights are calculated based on roof pitch of 10 degree and average roof height to width of the building ratio of 1.0. Buildings with average roof heights 3, 5, 10 and 15m is considered in this study. In MS 1553-2002, IS 875, EC1-1-4 and BS 6399 the reference height for roofs of non-dominant and dominant opening buildings, at which the wind speed, is determined is the average height of the roof, eaves height and for the latter two the height of the ridge respectively. For canopies, MS 1553-2002 defines the reference height for the roofs as the average height of the roofs. IS 875 and EC1-1-4 defined the reference height of the roofs as eaves height for the pitched and troughed canopies and ridge height for the mono-slope canopies whereas BS 6399 defines the reference height of the canopies at the ridge height. Fig. 2 shows the reference height as per different codes for duo-pitch roofs; Case a for EC1-1-4; case b for MS 1553-2002; case c for IS 875 and case d for BS 6399.

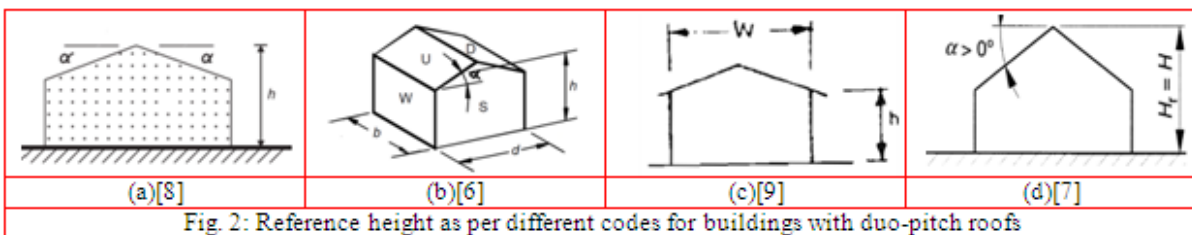


Fig. 2: Reference height as per different codes for buildings with duo-pitch roofs

2.4 Number of terrain categories (TC)

EC1-1-4:2005 specifies 5 terrain categories (0, I, II, III and IV) whereas MS 1553-2002 and IS 875-3-1987 specify only 4 (I, II, III and IV). BS 6399-2:1997 defines three categories of terrains namely sea, country and town.

2.5 External pressure coefficients

MS1553-2002, IS 875-3-1987, BS 6399-2-1997 and EC1-1-4-2005 define the external coefficient of wind pressures for several zones on the roof. The value of external wind pressure coefficient is influenced by roof type, roof slope, wind direction and the ratio of height to width of the buildings. Local and general external coefficients are given in EC1-1-4 and IS 875-3-1987 whereas BS 6399-2-1997 and MS 1553-2002 don't provide the separate values for local and general areas, but different local pressure factor (k_1) for roof edge areas and general areas are provided in MS 1553-2002. External pressure coefficients are same for buildings with non-dominant and dominant openings. Monoslope roof is not separately discussed in MS1553-2002. For circular arch roofs, no provisions are provided for BS 6399-2-1997.

2.6 Internal pressure coefficients

Internal pressure coefficients are same for the buildings irrespective of the roof type. MS 1553-2002 defines the C_{pi} values for two cases namely (1) where openings are shut and permeability dominates, and (2) openings are assumed. IS 875-3-1987 defines four conditions for internal pressure coefficients based on the degree of permeability. EC1-1-4:2005 also considers two cases (1) when the total area of openings on at least two sides is more than 30% of the area of that side, and (2) when the total area of openings is less than 30% of the area of that side. The latter case is further classified into 2 namely (1) buildings with dominant face and (2) buildings without dominant face. The provisions in BS 6399-2 are identical to EC1-1-4 with respect to internal pressure, and can be taken as +0.2 or -0.3.

2.7 Net pressures coefficients

MS1553-2002, IS 875-3-1987, BS 6399-2-1997 and EC1-1-4 provide the net pressure coefficients of canopies taking into account the combined effect of wind acting on both the upper and lower surfaces of the

canopies for all wind directions. The effect of partial closures is accounted by using solidity ratio. “0” represent to goods or materials stored under the roof block less than 50% or empty, and “1” represents the goods or materials stored under the roof block more than 75% or fully blocked.

2.8 Wind pressure on the roofs

Determination of roof pressures as per MS 1553-2002, IS 875-3-1987, EC1-1-4-2005 and BS 6399-2-1997 have been discussed in [10].

III. OBJECTIVE OF STUDY

The main objective is to evaluate and compare the roofs pressures for rectangular plan buildings with average roof height not greater than 15m under different conditions using the MS 1553-2002 Simplified procedure, EC1-1-4; BS 6399-2-1997 Standard procedure and IS 875-3-1987. The sub objectives are to compare the maximum positive and negative net pressures of the different types of roofs using different codes.

IV. METHODOLOGY

A comparison of the codes requires the wind speed to be converted to the averaging time used in different codes (since 3 second winds speeds have been tabulated in MS 1553-2002 for Malaysia). The roof pressures for different roof types and building permeability or openings condition have been compared. Since the reference heights in EC1-1-4, BS 6399-2-1997 and IS 875-3-1987 are different, those values corresponding to the average roof heights assumed for MS 1553-2002 have been evaluated for use in the respective codes. The wind speeds at the reference height are used to evaluate the pressures on the roof using the pressure coefficients. Using the basic wind speed of 33.5 m/s, and appropriate values for other parameters, the design wind pressures are calculated. Considering external pressure and internal pressure towards the roof as positive, three cases of total pressure can be evaluated (Fig. 3). The value of the terrain height multiplier varies with height (z) and the terrain category. The critical positive (case b) and negative pressures (case c) in Fig. 3 have been evaluated for different height and terrain categories for different roof types and building conditions. Using wind speed of 33.5 m/s converted to the corresponding averaging time, the values of roof pressures as per MS1553-2002; EC1-1-4:2005, BS 6399-2-1997 and IS 875-3-1987 are evaluated and compared.

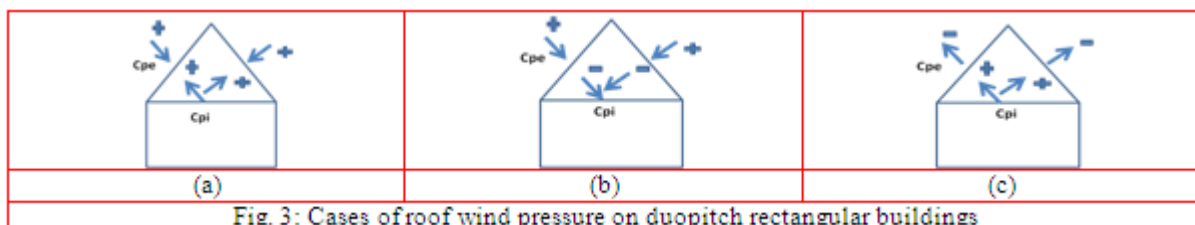


Fig. 3: Cases of roof wind pressure on duopitch rectangular buildings

V. RESULTS AND DISCUSSION

5.1 General

The analysis has been done considering the maximum 3 second basic wind speed in Malaysia, which is 33.5m/s. The corresponding 10 minute mean wind and mean hourly wind speeds are calculated with conversion factors (0.697 and 0.658) obtained from the Durst curves available in ASCE 7-10 as 23.4 m/s and 22.0 m/s respectively [11].

5.2 Comparison of roof pressures

The maximum negative and positive pressures on general and local areas of buildings with non-dominant and dominant openings and canopies for all types of roofs as per MS 1553-2002, EC1-1-4:2005, IS 875-3-1987 and BS 6399-2-1997 have been calculated. The maximum negative and positive pressures on general and local areas for all types of roofs as per MS 1553-2002, EC1-1-4:2005, IS 875-3-1987 and BS 6399-2-1997 for the different terrains indicate increasing trend of values with increasing height and decreasing trend from TC 1 to TC 4, as expected [12] [13] [14]. To determine the conservativeness or not of the different codes if used in Malaysia, all pressures determined using different codes have divided by the corresponding pressures determined using MS 1553-2002. Tables 1, 2, 3, 4, 5 and 6 show the ratio of pressures for duo-pitch, mono-slope, circular arch, flat, multi span duo-pitch and multi span saw-tooth roofs respectively on buildings with non-dominant openings and Tables 7, 8, 9, 10, 11 and 12 show the ratio of pressures for duo-pitch, mono-slope, circular arch, flat, multi span duo-pitch and multi span saw-tooth roofs respectively on buildings with dominant openings and Tables 13, 14 and 15 show the ratio of pressures for duo-pitch troughed roof, duo-pitch ridged roof and mono-slope canopy roofs respectively for all terrain categories for different codes.

Table 1: Ratio of pressures on duo-pitch roofs on buildings with non-dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.20 | 1.02 | 0.89 | 1.15 | 1.25 | | 1.13 | 1.33 | 1.15 | 1.04 | 1.03 | 0.90 |
| 5 | 1.19 | 0.90 | 0.91 | 1.17 | 1.09 | | 1.16 | 1.33 | 1.38 | 1.04 | 1.03 | 1.22 |
| 10 | 1.19 | 0.79 | 0.93 | 1.18 | 0.90 | | 1.25 | 1.09 | 1.40 | 1.06 | 1.03 | 1.64 |
| 15 | 1.20 | 0.79 | 0.93 | 1.19 | 0.89 | | 1.26 | 1.06 | 1.36 | 1.30 | 1.03 | 1.91 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.07 | 0.86 | 0.72 | 1.02 | 1.06 | | 1.01 | 1.13 | 0.93 | 0.93 | 0.87 | 0.73 |
| 5 | 1.06 | 0.76 | 0.74 | 1.05 | 0.92 | | 1.03 | 1.13 | 1.12 | 0.93 | 0.87 | 0.99 |
| 10 | 1.06 | 0.67 | 0.75 | 1.05 | 0.76 | | 1.12 | 0.92 | 1.14 | 0.95 | 0.87 | 1.34 |
| 15 | 1.07 | 0.67 | 0.76 | 1.06 | 0.76 | | 1.12 | 0.89 | 1.10 | 1.16 | 0.87 | 1.56 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.95 | 1.65 | 1.44 | 1.86 | 2.03 | | 1.84 | 2.16 | 1.87 | 1.69 | 1.67 | 1.47 |
| 5 | 1.93 | 1.47 | 1.47 | 1.91 | 1.77 | | 1.88 | 2.16 | 2.24 | 1.69 | 1.67 | 1.98 |
| 10 | 1.94 | 1.29 | 1.51 | 1.92 | 1.47 | | 2.04 | 1.76 | 2.28 | 1.73 | 1.67 | 2.67 |
| 15 | 1.95 | 1.28 | 1.52 | 1.94 | 1.45 | | 2.05 | 1.72 | 2.21 | 2.12 | 1.67 | 3.11 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.29 | 0.99 | 1.21 | 1.24 | 1.21 | | 1.22 | 1.29 | 1.57 | 1.12 | 1.00 | 1.23 |
| 5 | 1.28 | 0.88 | 1.24 | 1.27 | 1.06 | | 1.25 | 1.29 | 1.89 | 1.12 | 1.00 | 1.67 |
| 10 | 1.29 | 0.77 | 1.27 | 1.28 | 0.88 | | 1.35 | 1.05 | 1.92 | 1.15 | 1.00 | 2.25 |
| 15 | 1.29 | 0.77 | 1.28 | 1.29 | 0.86 | | 1.36 | 1.02 | 1.86 | 1.41 | 1.00 | 2.62 |

Table 2: Ratio of pressures on mono-slope roofs on buildings with non-dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.21 | 0.42 | 0.90 | 1.16 | 0.52 | | 1.13 | 0.55 | 1.17 | 1.04 | 0.43 | 0.92 |
| 5 | 1.20 | 0.38 | 0.91 | 1.19 | 0.45 | | 1.18 | 0.55 | 1.39 | 1.04 | 0.43 | 1.23 |
| 10 | 1.20 | 0.33 | 0.93 | 1.20 | 0.38 | | 1.27 | 0.45 | 1.42 | 1.09 | 0.43 | 1.67 |
| 15 | 1.21 | 0.33 | 0.94 | 1.21 | 0.37 | | 1.28 | 0.43 | 1.37 | 1.33 | 0.43 | 1.93 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.23 | 0.86 | 0.93 | 1.18 | 1.06 | | 1.15 | 1.13 | 1.20 | 1.06 | 0.87 | 0.95 |
| 5 | 1.21 | 0.76 | 0.94 | 1.21 | 0.92 | | 1.20 | 1.13 | 1.44 | 1.06 | 0.87 | 1.28 |
| 10 | 1.22 | 0.67 | 0.97 | 1.22 | 0.76 | | 1.29 | 0.92 | 1.47 | 1.11 | 0.87 | 1.72 |
| 15 | 1.23 | 0.66 | 0.97 | 1.22 | 0.75 | | 1.30 | 0.88 | 1.42 | 1.35 | 0.87 | 2.00 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.96 | 0.69 | 1.46 | 1.89 | 0.85 | | 1.84 | 0.90 | 1.89 | 1.69 | 0.70 | 1.50 |
| 5 | 1.94 | 0.61 | 1.48 | 1.93 | 0.74 | | 1.91 | 0.90 | 2.26 | 1.69 | 0.70 | 2.01 |
| 10 | 1.95 | 0.54 | 1.52 | 1.95 | 0.61 | | 2.07 | 0.74 | 2.30 | 1.77 | 0.70 | 2.71 |
| 15 | 1.96 | 0.53 | 1.53 | 1.96 | 0.60 | | 2.08 | 0.70 | 2.23 | 2.16 | 0.70 | 3.14 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.81 | 0.87 | 1.21 | 1.74 | 1.07 | | 1.70 | 1.14 | 1.57 | 1.56 | 0.88 | 1.23 |
| 5 | 1.79 | 0.77 | 1.25 | 1.78 | 0.93 | | 1.77 | 1.14 | 1.90 | 1.56 | 0.88 | 1.69 |
| 10 | 1.80 | 0.68 | 1.28 | 1.80 | 0.77 | | 1.91 | 0.93 | 1.94 | 1.63 | 0.88 | 2.27 |
| 15 | 1.81 | 0.67 | 1.28 | 1.81 | 0.75 | | 1.92 | 0.89 | 1.87 | 1.99 | 0.88 | 2.65 |

Table 3: Ratio of pressures on circular arch roofs on buildings with non-dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|-----|------|------|-----|------|------|-----|------|------|-----|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.73 | 1.47 | | 1.65 | 1.81 | | 1.64 | 1.92 | | 1.50 | 1.48 | |
| 5 | 1.71 | 1.31 | | 1.70 | 1.58 | | 1.67 | 1.92 | | 1.50 | 1.48 | |
| 10 | 1.72 | 1.15 | | 1.71 | 1.31 | | 1.81 | 1.57 | | 1.54 | 1.48 | |
| 15 | 1.73 | 1.14 | | 1.72 | 1.29 | | 1.82 | 1.52 | | 1.88 | 1.48 | |

| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
|--|------|------|--|------|------|--|------|------|--|------|------|--|
| 3 | 0.58 | 0.58 | | 0.55 | 0.72 | | 0.55 | 0.77 | | 0.50 | 0.59 | |
| 5 | 0.57 | 0.52 | | 0.57 | 0.63 | | 0.56 | 0.77 | | 0.50 | 0.59 | |
| 10 | 0.58 | 0.46 | | 0.57 | 0.52 | | 0.61 | 0.63 | | 0.52 | 0.59 | |
| 15 | 0.58 | 0.45 | | 0.58 | 0.51 | | 0.61 | 0.61 | | 0.63 | 0.59 | |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 2.60 | 2.20 | | 2.48 | 2.71 | | 2.45 | 2.88 | | 2.25 | 2.23 | |
| 5 | 2.57 | 1.96 | | 2.54 | 2.36 | | 2.50 | 2.88 | | 2.25 | 2.23 | |
| 10 | 2.59 | 1.72 | | 2.56 | 1.96 | | 2.72 | 2.35 | | 2.31 | 2.23 | |
| 15 | 2.60 | 1.71 | | 2.59 | 1.93 | | 2.74 | 2.29 | | 2.82 | 2.23 | |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 0.98 | 0.99 | | 0.93 | 1.21 | | 0.92 | 1.29 | | 0.85 | 1.00 | |
| 5 | 0.97 | 0.88 | | 0.96 | 1.06 | | 0.94 | 1.29 | | 0.85 | 1.00 | |
| 10 | 0.97 | 0.77 | | 0.97 | 0.88 | | 1.02 | 1.05 | | 0.87 | 1.00 | |
| 15 | 0.98 | 0.77 | | 0.97 | 0.86 | | 1.03 | 1.02 | | 1.06 | 1.00 | |

Table 4: Ratio of pressures on flat roofs on buildings with non-dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 0.64 | 0.42 | 0.40 | 0.61 | 0.52 | | 0.61 | 0.55 | 0.52 | 0.56 | 0.43 | 0.40 |
| 5 | 0.63 | 0.38 | 0.41 | 0.62 | 0.45 | | 0.61 | 0.55 | 0.62 | 0.56 | 0.43 | 0.55 |
| 10 | 0.64 | 0.33 | 0.42 | 0.63 | 0.38 | | 0.66 | 0.45 | 0.63 | 0.56 | 0.43 | 0.74 |
| 15 | 0.64 | 0.33 | 0.42 | 0.64 | 0.38 | | 0.67 | 0.45 | 0.61 | 0.69 | 0.43 | 0.86 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 0.83 | 0.86 | 0.50 | 0.79 | 1.06 | | 0.80 | 1.13 | 0.65 | 0.73 | 0.87 | 0.51 |
| 5 | 0.83 | 0.76 | 0.52 | 0.81 | 0.92 | | 0.80 | 1.13 | 0.78 | 0.73 | 0.87 | 0.69 |
| 10 | 0.83 | 0.67 | 0.53 | 0.82 | 0.76 | | 0.87 | 0.92 | 0.80 | 0.73 | 0.87 | 0.93 |
| 15 | 0.84 | 0.68 | 0.53 | 0.83 | 0.76 | | 0.87 | 0.91 | 0.77 | 0.90 | 0.87 | 1.09 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.04 | 0.69 | 0.65 | 0.99 | 0.85 | | 0.99 | 0.90 | 0.84 | 0.91 | 0.70 | 0.65 |
| 5 | 1.03 | 0.61 | 0.67 | 1.01 | 0.74 | | 0.99 | 0.90 | 1.01 | 0.91 | 0.70 | 0.89 |
| 10 | 1.04 | 0.54 | 0.68 | 1.02 | 0.61 | | 1.08 | 0.74 | 1.03 | 0.91 | 0.70 | 1.20 |
| 15 | 1.04 | 0.54 | 0.69 | 1.03 | 0.61 | | 1.09 | 0.73 | 1.00 | 1.12 | 0.70 | 1.40 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.03 | 0.87 | 0.85 | 0.98 | 1.07 | | 0.98 | 1.14 | 1.10 | 0.90 | 0.88 | 0.85 |
| 5 | 1.02 | 0.77 | 0.87 | 1.01 | 0.93 | | 0.98 | 1.14 | 1.32 | 0.90 | 0.88 | 1.16 |
| 10 | 1.03 | 0.68 | 0.89 | 1.02 | 0.77 | | 1.07 | 0.93 | 1.34 | 0.90 | 0.88 | 1.56 |
| 15 | 1.03 | 0.68 | 0.89 | 1.02 | 0.77 | | 1.08 | 0.92 | 1.30 | 1.11 | 0.88 | 1.83 |

Table 5: Ratio of pressures on multi span duo-pitch roofs on buildings with non-dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.20 | 0.68 | 0.89 | 1.15 | 0.83 | | 1.13 | 0.89 | 1.15 | 1.04 | 0.69 | 0.90 |
| 5 | 1.19 | 0.60 | 0.91 | 1.17 | 0.73 | | 1.16 | 0.89 | 1.38 | 1.04 | 0.69 | 1.22 |
| 10 | 1.19 | 0.53 | 0.93 | 1.18 | 0.60 | | 1.25 | 0.72 | 1.40 | 1.06 | 0.69 | 1.64 |
| 15 | 1.20 | 0.53 | 0.93 | 1.19 | 0.59 | | 1.26 | 0.70 | 1.36 | 1.30 | 0.69 | 1.91 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.11 | 0.79 | 0.84 | 1.06 | 0.97 | | 1.05 | 1.03 | 1.09 | 0.97 | 0.80 | 0.85 |
| 5 | 1.10 | 0.70 | 0.86 | 1.09 | 0.84 | | 1.07 | 1.03 | 1.30 | 0.97 | 0.80 | 1.15 |
| 10 | 1.11 | 0.61 | 0.88 | 1.10 | 0.70 | | 1.16 | 0.84 | 1.33 | 0.99 | 0.80 | 1.55 |
| 15 | 1.11 | 0.61 | 0.88 | 1.11 | 0.69 | | 1.17 | 0.82 | 1.29 | 1.21 | 0.80 | 1.81 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.95 | 1.10 | 1.44 | 1.86 | 1.35 | | 1.84 | 1.44 | 1.87 | 1.69 | 1.11 | 1.47 |

| | | | | | | | | | | | | |
|---|------|------|------|------|------|--|------|------|------|------|------|------|
| 5 | 1.93 | 0.98 | 1.47 | 1.91 | 1.18 | | 1.88 | 1.44 | 2.24 | 1.69 | 1.11 | 1.98 |
| 10 | 1.94 | 0.86 | 1.51 | 1.92 | 0.98 | | 2.04 | 1.18 | 2.28 | 1.73 | 1.11 | 2.67 |
| 15 | 1.95 | 0.86 | 1.52 | 1.94 | 0.97 | | 2.05 | 1.14 | 2.21 | 2.12 | 1.11 | 3.11 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.80 | 0.93 | 1.55 | 1.72 | 1.14 | | 1.70 | 1.21 | 2.00 | 1.56 | 0.94 | 1.57 |
| 5 | 1.78 | 0.82 | 1.58 | 1.76 | 1.00 | | 1.73 | 1.21 | 2.40 | 1.56 | 0.94 | 2.12 |
| 10 | 1.79 | 0.72 | 1.62 | 1.78 | 0.82 | | 1.88 | 0.99 | 2.44 | 1.60 | 0.94 | 2.86 |
| 15 | 1.80 | 0.72 | 1.63 | 1.79 | 0.81 | | 1.89 | 0.96 | 2.37 | 1.95 | 0.94 | 3.33 |

Table 6: Ratio of pressures on multi span saw-tooth roofs on buildings with non-dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.21 | 0.93 | 0.24 | 1.16 | 1.15 | | 1.13 | 1.22 | 0.32 | 1.04 | 0.94 | 0.25 |
| 5 | 1.20 | 0.83 | 0.25 | 1.19 | 1.00 | | 1.18 | 1.22 | 0.38 | 1.04 | 0.94 | 0.34 |
| 10 | 1.20 | 0.73 | 0.25 | 1.20 | 0.83 | | 1.27 | 1.00 | 0.39 | 1.09 | 0.94 | 0.45 |
| 15 | 1.21 | 0.72 | 0.26 | 1.21 | 0.81 | | 1.28 | 0.95 | 0.37 | 1.33 | 0.94 | 0.53 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.12 | 0.79 | 0.85 | 1.08 | 0.97 | | 1.05 | 1.03 | 1.10 | 0.97 | 0.80 | 0.87 |
| 5 | 1.11 | 0.70 | 0.86 | 1.10 | 0.84 | | 1.09 | 1.03 | 1.32 | 0.97 | 0.80 | 1.17 |
| 10 | 1.12 | 0.61 | 0.88 | 1.11 | 0.70 | | 1.18 | 0.84 | 1.34 | 1.01 | 0.80 | 1.58 |
| 15 | 1.12 | 0.61 | 0.89 | 1.12 | 0.68 | | 1.19 | 0.80 | 1.30 | 1.23 | 0.80 | 1.83 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.96 | 1.51 | 0.40 | 1.89 | 1.86 | | 1.84 | 1.98 | 0.52 | 1.69 | 1.53 | 0.41 |
| 5 | 1.94 | 1.35 | 0.40 | 1.93 | 1.63 | | 1.91 | 1.98 | 0.62 | 1.69 | 1.53 | 0.55 |
| 10 | 1.95 | 1.18 | 0.41 | 1.95 | 1.35 | | 2.07 | 1.62 | 0.63 | 1.77 | 1.53 | 0.74 |
| 15 | 1.96 | 1.17 | 0.42 | 1.96 | 1.31 | | 2.08 | 1.55 | 0.61 | 2.16 | 1.53 | 0.86 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.81 | 0.70 | 1.56 | 1.74 | 0.86 | | 1.70 | 0.91 | 2.03 | 1.56 | 0.70 | 1.61 |
| 5 | 1.79 | 0.62 | 1.59 | 1.78 | 0.75 | | 1.77 | 0.91 | 2.42 | 1.56 | 0.70 | 2.15 |
| 10 | 1.80 | 0.54 | 1.63 | 1.80 | 0.62 | | 1.91 | 0.74 | 2.47 | 1.63 | 0.70 | 2.90 |
| 15 | 1.81 | 0.54 | 1.64 | 1.81 | 0.60 | | 1.92 | 0.71 | 2.39 | 1.99 | 0.70 | 3.37 |

Table 7: Ratio of pressures on duo-pitch roofs on buildings with dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.41 | 0.63 | 1.34 | 1.35 | 0.77 | | 1.33 | 0.82 | 1.74 | 1.22 | 0.64 | 1.37 |
| 5 | 1.40 | 0.56 | 1.37 | 1.38 | 0.68 | | 1.36 | 0.82 | 2.08 | 1.22 | 0.64 | 1.84 |
| 10 | 1.40 | 0.49 | 1.40 | 1.39 | 0.56 | | 1.48 | 0.67 | 2.12 | 1.25 | 0.64 | 2.49 |
| 15 | 1.41 | 0.49 | 1.41 | 1.40 | 0.55 | | 1.49 | 0.65 | 2.06 | 1.53 | 0.64 | 2.90 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.34 | 0.87 | 1.04 | 1.28 | 1.08 | | 1.27 | 1.14 | 1.35 | 1.16 | 0.88 | 1.06 |
| 5 | 1.32 | 0.78 | 1.06 | 1.31 | 0.94 | | 1.29 | 1.14 | 1.61 | 1.16 | 0.88 | 1.42 |
| 10 | 1.33 | 0.68 | 1.09 | 1.32 | 0.78 | | 1.40 | 0.93 | 1.64 | 1.19 | 0.88 | 1.92 |
| 15 | 1.34 | 0.68 | 1.09 | 1.33 | 0.77 | | 1.41 | 0.91 | 1.59 | 1.46 | 0.88 | 2.24 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.97 | 0.88 | 1.88 | 1.89 | 1.08 | | 1.87 | 1.15 | 2.44 | 1.71 | 0.89 | 1.91 |
| 5 | 1.95 | 0.78 | 1.92 | 1.94 | 0.95 | | 1.90 | 1.15 | 2.92 | 1.71 | 0.89 | 2.58 |
| 10 | 1.97 | 0.69 | 1.97 | 1.95 | 0.78 | | 2.07 | 0.94 | 2.97 | 1.75 | 0.89 | 3.48 |
| 15 | 1.98 | 0.68 | 1.98 | 1.97 | 0.77 | | 2.08 | 0.91 | 2.88 | 2.15 | 0.89 | 4.05 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.94 | 0.94 | 1.68 | 1.85 | 1.16 | | 1.83 | 1.24 | 2.18 | 1.68 | 0.95 | 1.71 |
| 5 | 1.92 | 0.84 | 1.72 | 1.90 | 1.01 | | 1.87 | 1.24 | 2.61 | 1.68 | 0.95 | 2.30 |
| 10 | 1.93 | 0.74 | 1.76 | 1.92 | 0.84 | | 2.03 | 1.01 | 2.66 | 1.72 | 0.95 | 3.11 |

| | | | | | | | | | | | | |
|----|------|------|------|------|------|--|------|------|------|------|------|------|
| 15 | 1.94 | 0.73 | 1.77 | 1.93 | 0.83 | | 2.04 | 0.98 | 2.57 | 2.11 | 0.95 | 3.63 |
|----|------|------|------|------|------|--|------|------|------|------|------|------|

Table 8: Ratio of pressures on mono-slope roofs on buildings with dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.42 | 0.44 | 1.36 | 1.37 | 0.54 | | 1.33 | 0.58 | 1.76 | 1.22 | 0.45 | 1.39 |
| 5 | 1.41 | 0.39 | 1.38 | 1.40 | 0.47 | | 1.39 | 0.58 | 2.11 | 1.22 | 0.45 | 1.87 |
| 10 | 1.42 | 0.34 | 1.41 | 1.41 | 0.39 | | 1.50 | 0.47 | 2.14 | 1.28 | 0.45 | 2.52 |
| 15 | 1.42 | 0.34 | 1.42 | 1.42 | 0.38 | | 1.51 | 0.45 | 2.08 | 1.56 | 0.45 | 2.92 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.35 | 0.87 | 1.05 | 1.30 | 1.08 | | 1.27 | 1.14 | 1.36 | 1.16 | 0.88 | 1.08 |
| 5 | 1.34 | 0.78 | 1.07 | 1.33 | 0.94 | | 1.32 | 1.14 | 1.63 | 1.16 | 0.88 | 1.44 |
| 10 | 1.34 | 0.68 | 1.09 | 1.34 | 0.78 | | 1.42 | 0.93 | 1.66 | 1.22 | 0.88 | 1.95 |
| 15 | 1.35 | 0.67 | 1.10 | 1.35 | 0.76 | | 1.43 | 0.89 | 1.61 | 1.48 | 0.88 | 2.26 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.99 | 0.62 | 1.90 | 1.91 | 0.76 | | 1.87 | 0.81 | 2.47 | 1.71 | 0.62 | 1.95 |
| 5 | 1.97 | 0.55 | 1.94 | 1.96 | 0.66 | | 1.94 | 0.81 | 2.95 | 1.71 | 0.62 | 2.61 |
| 10 | 1.98 | 0.48 | 1.98 | 1.97 | 0.55 | | 2.10 | 0.66 | 3.00 | 1.79 | 0.62 | 3.53 |
| 15 | 1.99 | 0.47 | 1.99 | 1.99 | 0.53 | | 2.11 | 0.63 | 2.91 | 2.19 | 0.62 | 4.09 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.96 | 0.89 | 1.10 | 1.88 | 1.10 | | 1.83 | 1.17 | 1.42 | 1.68 | 0.90 | 1.12 |
| 5 | 1.94 | 0.79 | 1.13 | 1.92 | 0.96 | | 1.91 | 1.17 | 1.72 | 1.68 | 0.90 | 1.53 |
| 10 | 1.95 | 0.70 | 1.16 | 1.94 | 0.79 | | 2.06 | 0.95 | 1.75 | 1.76 | 0.90 | 2.05 |
| 15 | 1.96 | 0.69 | 1.16 | 1.95 | 0.77 | | 2.07 | 0.91 | 1.69 | 2.15 | 0.90 | 2.40 |

Table 9: Ratio of pressures on circular arch roofs on buildings with dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|-----|------|------|-----|------|------|-----|------|------|-----|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.83 | 1.14 | | 1.75 | 1.40 | | 1.73 | 1.49 | | 1.59 | 1.15 | |
| 5 | 1.81 | 1.02 | | 1.79 | 1.23 | | 1.76 | 1.49 | | 1.59 | 1.15 | |
| 10 | 1.82 | 0.89 | | 1.81 | 1.02 | | 1.91 | 1.22 | | 1.62 | 1.15 | |
| 15 | 1.83 | 0.89 | | 1.82 | 1.00 | | 1.93 | 1.19 | | 1.99 | 1.15 | |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 0.74 | 0.62 | | 0.71 | 0.76 | | 0.70 | 0.81 | | 0.64 | 0.62 | |
| 5 | 0.73 | 0.55 | | 0.73 | 0.66 | | 0.71 | 0.81 | | 0.64 | 0.62 | |
| 10 | 0.74 | 0.48 | | 0.73 | 0.55 | | 0.77 | 0.66 | | 0.66 | 0.62 | |
| 15 | 0.74 | 0.48 | | 0.74 | 0.54 | | 0.78 | 0.64 | | 0.80 | 0.62 | |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 2.35 | 1.47 | | 2.25 | 1.81 | | 2.22 | 1.92 | | 2.04 | 1.48 | |
| 5 | 2.33 | 1.31 | | 2.30 | 1.58 | | 2.27 | 1.92 | | 2.04 | 1.48 | |
| 10 | 2.34 | 1.15 | | 2.32 | 1.31 | | 2.46 | 1.57 | | 2.09 | 1.48 | |
| 15 | 2.35 | 1.14 | | 2.34 | 1.29 | | 2.48 | 1.52 | | 2.56 | 1.48 | |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.20 | 1.00 | | 1.15 | 1.23 | | 1.13 | 1.30 | | 1.04 | 1.01 | |
| 5 | 1.19 | 0.89 | | 1.17 | 1.07 | | 1.16 | 1.30 | | 1.04 | 1.01 | |
| 10 | 1.19 | 0.78 | | 1.18 | 0.89 | | 1.25 | 1.06 | | 1.06 | 1.01 | |
| 15 | 1.20 | 0.77 | | 1.19 | 0.87 | | 1.26 | 1.03 | | 1.30 | 1.01 | |

Table 10: Ratio of pressures on flat roofs on buildings with dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 3.26 | 1.03 | 2.27 | 3.10 | 1.26 | | 3.11 | 1.34 | 2.94 | 2.86 | 1.04 | 2.28 |
| 5 | 3.23 | 0.91 | 2.33 | 3.18 | 1.10 | | 3.11 | 1.34 | 3.52 | 2.86 | 1.04 | 3.10 |

| | | | | | | | | | | | | |
|--|------|------|------|------|------|--|------|------|------|------|------|------|
| 10 | 3.25 | 0.80 | 2.38 | 3.21 | 0.91 | | 3.39 | 1.10 | 3.59 | 2.86 | 1.04 | 4.19 |
| 15 | 3.27 | 0.81 | 2.40 | 3.24 | 0.91 | | 3.42 | 1.09 | 3.48 | 3.51 | 1.04 | 4.90 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.19 | 0.87 | 0.65 | 1.13 | 1.08 | | 1.13 | 1.14 | 0.84 | 1.04 | 0.88 | 0.65 |
| 5 | 1.18 | 0.78 | 0.66 | 1.16 | 0.94 | | 1.13 | 1.14 | 1.00 | 1.04 | 0.88 | 0.88 |
| 10 | 1.18 | 0.68 | 0.68 | 1.17 | 0.78 | | 1.23 | 0.93 | 1.02 | 1.04 | 0.88 | 1.19 |
| 15 | 1.19 | 0.69 | 0.68 | 1.18 | 0.78 | | 1.24 | 0.92 | 0.99 | 1.28 | 0.88 | 1.39 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 3.26 | 1.03 | 2.27 | 3.10 | 1.26 | | 3.11 | 1.34 | 2.94 | 2.86 | 1.04 | 2.28 |
| 5 | 3.23 | 0.91 | 2.33 | 3.18 | 1.10 | | 3.11 | 1.34 | 3.52 | 2.86 | 1.04 | 3.10 |
| 10 | 3.25 | 0.80 | 2.38 | 3.21 | 0.91 | | 3.39 | 1.10 | 3.59 | 2.86 | 1.04 | 4.19 |
| 15 | 3.27 | 0.81 | 2.40 | 3.24 | 0.91 | | 3.42 | 1.09 | 3.48 | 3.51 | 1.04 | 4.90 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.53 | 0.84 | 1.05 | 1.45 | 1.03 | | 1.46 | 1.10 | 1.35 | 1.34 | 0.85 | 1.05 |
| 5 | 1.51 | 0.75 | 1.07 | 1.49 | 0.90 | | 1.46 | 1.10 | 1.62 | 1.34 | 0.85 | 1.43 |
| 10 | 1.52 | 0.66 | 1.10 | 1.50 | 0.75 | | 1.59 | 0.90 | 1.65 | 1.34 | 0.85 | 1.93 |
| 15 | 1.53 | 0.66 | 1.10 | 1.52 | 0.75 | | 1.60 | 0.89 | 1.60 | 1.64 | 0.85 | 2.26 |

Table 11: Ratio of pressures on multi span duo-pitch roofs on buildings with dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.41 | 0.63 | 1.34 | 1.35 | 0.77 | | 1.33 | 0.82 | 1.74 | 1.22 | 0.64 | 1.37 |
| 5 | 1.40 | 0.56 | 1.37 | 1.38 | 0.68 | | 1.36 | 0.82 | 2.08 | 1.22 | 0.64 | 1.84 |
| 10 | 1.40 | 0.49 | 1.40 | 1.39 | 0.56 | | 1.48 | 0.67 | 2.12 | 1.25 | 0.64 | 2.49 |
| 15 | 1.41 | 0.49 | 1.41 | 1.40 | 0.55 | | 1.49 | 0.65 | 2.06 | 1.53 | 0.64 | 2.90 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.23 | 0.80 | 0.95 | 1.18 | 0.99 | | 1.16 | 1.05 | 1.24 | 1.07 | 0.81 | 0.97 |
| 5 | 1.22 | 0.71 | 0.98 | 1.21 | 0.86 | | 1.19 | 1.05 | 1.48 | 1.07 | 0.81 | 1.31 |
| 10 | 1.23 | 0.63 | 1.00 | 1.22 | 0.71 | | 1.29 | 0.86 | 1.51 | 1.09 | 0.81 | 1.77 |
| 15 | 1.23 | 0.62 | 1.00 | 1.23 | 0.71 | | 1.30 | 0.83 | 1.46 | 1.34 | 0.81 | 2.06 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.97 | 0.88 | 1.88 | 1.89 | 1.08 | | 1.87 | 1.15 | 2.44 | 1.71 | 0.89 | 1.91 |
| 5 | 1.95 | 0.78 | 1.92 | 1.94 | 0.95 | | 1.90 | 1.15 | 2.92 | 1.71 | 0.89 | 2.58 |
| 10 | 1.97 | 0.69 | 1.97 | 1.95 | 0.78 | | 2.07 | 0.94 | 2.97 | 1.75 | 0.89 | 3.48 |
| 15 | 1.98 | 0.68 | 1.98 | 1.97 | 0.77 | | 2.08 | 0.91 | 2.88 | 2.15 | 0.89 | 4.05 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.94 | 0.94 | 1.68 | 1.85 | 1.16 | | 1.83 | 1.24 | 2.18 | 1.68 | 0.95 | 1.71 |
| 5 | 1.92 | 0.84 | 1.72 | 1.90 | 1.01 | | 1.87 | 1.24 | 2.61 | 1.68 | 0.95 | 2.30 |
| 10 | 1.93 | 0.74 | 1.76 | 1.92 | 0.84 | | 2.03 | 1.01 | 2.66 | 1.72 | 0.95 | 3.11 |
| 15 | 1.94 | 0.73 | 1.77 | 1.93 | 0.83 | | 2.04 | 0.98 | 2.57 | 2.11 | 0.95 | 3.63 |

Table 12: Ratio of pressures on multi span saw-tooth roofs on buildings with dominant openings for different codes

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|--|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.42 | 0.82 | 0.87 | 1.37 | 1.01 | | 1.33 | 1.07 | 1.13 | 1.22 | 0.83 | 0.90 |
| 5 | 1.41 | 0.73 | 0.89 | 1.40 | 0.88 | | 1.39 | 1.07 | 1.35 | 1.22 | 0.83 | 1.20 |
| 10 | 1.42 | 0.64 | 0.91 | 1.41 | 0.73 | | 1.50 | 0.87 | 1.38 | 1.28 | 0.83 | 1.62 |
| 15 | 1.42 | 0.63 | 0.92 | 1.42 | 0.71 | | 1.51 | 0.84 | 1.33 | 1.56 | 0.83 | 1.88 |
| maximum negative pressures on the critical areas of roof | | | | | | | | | | | | |
| 3 | 1.24 | 0.80 | 0.96 | 1.19 | 0.99 | | 1.16 | 1.05 | 1.25 | 1.07 | 0.81 | 0.99 |
| 5 | 1.23 | 0.71 | 0.98 | 1.22 | 0.86 | | 1.21 | 1.05 | 1.50 | 1.07 | 0.81 | 1.33 |
| 10 | 1.24 | 0.63 | 1.00 | 1.23 | 0.71 | | 1.31 | 0.86 | 1.52 | 1.12 | 0.81 | 1.79 |

| | | | | | | | | | | | | |
|---|------|------|------|------|------|--|------|------|------|------|------|------|
| 15 | 1.24 | 0.62 | 1.01 | 1.24 | 0.70 | | 1.32 | 0.82 | 1.47 | 1.36 | 0.81 | 2.08 |
| maximum positive pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.99 | 1.15 | 1.22 | 1.91 | 1.41 | | 1.87 | 1.50 | 1.59 | 1.71 | 1.16 | 1.26 |
| 5 | 1.97 | 1.02 | 1.24 | 1.96 | 1.23 | | 1.94 | 1.50 | 1.90 | 1.71 | 1.16 | 1.68 |
| 10 | 1.98 | 0.89 | 1.27 | 1.97 | 1.02 | | 2.10 | 1.22 | 1.93 | 1.79 | 1.16 | 2.27 |
| 15 | 1.99 | 0.88 | 1.28 | 1.99 | 0.99 | | 2.11 | 1.17 | 1.87 | 2.19 | 1.16 | 2.63 |
| maximum negative pressures on the general areas of roof | | | | | | | | | | | | |
| 3 | 1.96 | 0.73 | 1.70 | 1.88 | 0.90 | | 1.83 | 0.96 | 2.21 | 1.68 | 0.74 | 1.75 |
| 5 | 1.94 | 0.65 | 1.73 | 1.92 | 0.79 | | 1.91 | 0.96 | 2.64 | 1.68 | 0.74 | 2.34 |
| 10 | 1.95 | 0.57 | 1.77 | 1.94 | 0.65 | | 2.06 | 0.78 | 2.68 | 1.76 | 0.74 | 3.16 |
| 15 | 1.96 | 0.57 | 1.78 | 1.95 | 0.64 | | 2.07 | 0.75 | 2.60 | 2.15 | 0.74 | 3.66 |

Table 13: Ratio of pressures on trough duo-pitch canopy roofs

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|---|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive wind pressures for empty under | | | | | | | | | | | | |
| 3 | 1.46 | 1.34 | 1.27 | 1.39 | 1.65 | | 1.38 | 1.75 | 1.65 | 1.26 | 1.35 | 1.30 |
| 5 | 1.44 | 1.19 | 1.30 | 1.43 | 1.44 | | 1.40 | 1.75 | 1.98 | 1.26 | 1.35 | 1.75 |
| 10 | 1.45 | 1.05 | 1.33 | 1.44 | 1.20 | | 1.52 | 1.45 | 2.01 | 1.29 | 1.35 | 2.36 |
| 15 | 1.46 | 1.06 | 1.34 | 1.45 | 1.19 | | 1.53 | 1.43 | 1.95 | 1.58 | 1.35 | 2.75 |
| maximum negative wind pressures for empty under | | | | | | | | | | | | |
| 3 | 1.37 | 1.26 | 1.20 | 1.31 | 1.55 | | 1.29 | 1.65 | 1.55 | 1.19 | 1.27 | 1.22 |
| 5 | 1.35 | 1.12 | 1.23 | 1.34 | 1.35 | | 1.32 | 1.65 | 1.86 | 1.19 | 1.27 | 1.64 |
| 10 | 1.36 | 0.99 | 1.25 | 1.35 | 1.13 | | 1.43 | 1.36 | 1.90 | 1.22 | 1.27 | 2.22 |
| 15 | 1.37 | 0.99 | 1.26 | 1.36 | 1.12 | | 1.44 | 1.34 | 1.84 | 1.49 | 1.27 | 2.59 |
| maximum negative wind pressures for block under | | | | | | | | | | | | |
| 3 | 1.62 | 1.05 | 1.42 | 1.55 | 1.29 | | 1.53 | 1.37 | 1.84 | 1.40 | 1.06 | 1.44 |
| 5 | 1.60 | 0.93 | 1.45 | 1.59 | 1.12 | | 1.56 | 1.37 | 2.20 | 1.40 | 1.06 | 1.94 |
| 10 | 1.61 | 0.82 | 1.48 | 1.60 | 0.94 | | 1.69 | 1.13 | 2.24 | 1.44 | 1.06 | 2.62 |
| 15 | 1.62 | 0.83 | 1.49 | 1.61 | 0.93 | | 1.70 | 1.12 | 2.17 | 1.76 | 1.06 | 3.05 |

Table 14: Ratio of pressures on ridge duo-pitch canopy roofs

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|---|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive wind pressures for empty under | | | | | | | | | | | | |
| 3 | 1.40 | 1.31 | 1.25 | 1.32 | 1.61 | | 1.35 | 1.71 | 1.61 | 1.24 | 1.32 | 1.27 |
| 5 | 1.38 | 1.16 | 1.27 | 1.36 | 1.40 | | 1.32 | 1.71 | 1.93 | 1.24 | 1.32 | 1.71 |
| 10 | 1.39 | 1.01 | 1.30 | 1.37 | 1.15 | | 1.44 | 1.38 | 1.97 | 1.21 | 1.32 | 2.31 |
| 15 | 1.40 | 1.02 | 1.31 | 1.39 | 1.16 | | 1.45 | 1.37 | 1.91 | 1.48 | 1.32 | 2.69 |
| maximum negative wind pressures for empty under | | | | | | | | | | | | |
| 3 | 1.68 | 1.57 | 1.50 | 1.59 | 1.94 | | 1.62 | 2.06 | 1.94 | 1.49 | 1.59 | 1.52 |
| 5 | 1.66 | 1.40 | 1.53 | 1.63 | 1.69 | | 1.58 | 2.06 | 2.33 | 1.49 | 1.59 | 2.05 |
| 10 | 1.68 | 1.22 | 1.57 | 1.65 | 1.39 | | 1.73 | 1.66 | 2.37 | 1.45 | 1.59 | 2.77 |
| 15 | 1.69 | 1.23 | 1.58 | 1.67 | 1.39 | | 1.75 | 1.64 | 2.30 | 1.79 | 1.59 | 3.23 |
| maximum negative wind pressures for block under | | | | | | | | | | | | |
| 3 | 0.99 | 1.27 | 0.81 | 0.94 | 1.56 | | 0.96 | 1.66 | 1.05 | 0.88 | 1.28 | 0.82 |
| 5 | 0.99 | 1.13 | 0.82 | 0.97 | 1.36 | | 0.94 | 1.66 | 1.25 | 0.88 | 1.28 | 1.11 |
| 10 | 0.99 | 0.99 | 0.84 | 0.98 | 1.12 | | 1.03 | 1.34 | 1.28 | 0.86 | 1.28 | 1.49 |
| 15 | 1.00 | 0.99 | 0.85 | 0.99 | 1.12 | | 1.04 | 1.33 | 1.24 | 1.06 | 1.28 | 1.74 |

Table 15: Ratio of pressures on mono-slope canopy roofs

| H | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | B/M | E/M | I/M | S/M |
|---|------|------|------|------|------|-----|------|------|------|------|------|------|
| | TC1 | | | TC2 | | | TC3 | | | TC4 | | |
| maximum positive wind pressures for empty under | | | | | | | | | | | | |
| 3 | 1.21 | 1.10 | 1.06 | 1.16 | 1.35 | | 1.13 | 1.44 | 1.38 | 1.04 | 1.11 | 1.09 |
| 5 | 1.20 | 0.98 | 1.08 | 1.19 | 1.18 | | 1.18 | 1.44 | 1.65 | 1.04 | 1.11 | 1.46 |

| | | | | | | | | | | | | |
|---|------|------|------|------|------|--|------|------|------|------|------|------|
| 10 | 1.20 | 0.87 | 1.10 | 1.20 | 1.00 | | 1.27 | 1.20 | 1.68 | 1.09 | 1.11 | 1.97 |
| 15 | 1.21 | 0.88 | 1.11 | 1.21 | 0.99 | | 1.28 | 1.19 | 1.62 | 1.33 | 1.11 | 2.28 |
| maximum negative wind pressures for empty under | | | | | | | | | | | | |
| 3 | 1.04 | 0.95 | 0.91 | 1.00 | 1.17 | | 0.98 | 1.24 | 1.19 | 0.90 | 0.96 | 0.94 |
| 5 | 1.03 | 0.85 | 0.93 | 1.03 | 1.02 | | 1.02 | 1.24 | 1.42 | 0.90 | 0.96 | 1.26 |
| 10 | 1.04 | 0.75 | 0.95 | 1.03 | 0.86 | | 1.10 | 1.04 | 1.45 | 0.94 | 0.96 | 1.70 |
| 15 | 1.04 | 0.76 | 0.96 | 1.04 | 0.85 | | 1.11 | 1.03 | 1.40 | 1.15 | 0.96 | 1.97 |
| maximum positive wind pressures for block under | | | | | | | | | | | | |
| 3 | 1.21 | 1.10 | 1.06 | 1.16 | 1.35 | | 1.13 | 1.44 | 1.38 | 1.04 | 1.11 | 1.09 |
| 5 | 1.20 | 0.98 | 1.08 | 1.19 | 1.18 | | 1.18 | 1.44 | 1.65 | 1.04 | 1.11 | 1.46 |
| 10 | 1.20 | 0.87 | 1.10 | 1.20 | 1.00 | | 1.27 | 1.20 | 1.68 | 1.09 | 1.11 | 1.97 |
| 15 | 1.21 | 0.88 | 1.11 | 1.21 | 0.99 | | 1.28 | 1.19 | 1.62 | 1.33 | 1.11 | 2.28 |
| maximum negative wind pressures for block under | | | | | | | | | | | | |
| 3 | 0.67 | 0.77 | 0.57 | 0.65 | 0.95 | | 0.63 | 1.01 | 0.74 | 0.58 | 0.78 | 0.59 |
| 5 | 0.66 | 0.69 | 0.58 | 0.66 | 0.83 | | 0.65 | 1.01 | 0.88 | 0.58 | 0.78 | 0.78 |
| 10 | 0.67 | 0.61 | 0.59 | 0.67 | 0.70 | | 0.71 | 0.85 | 0.90 | 0.60 | 0.78 | 1.06 |
| 15 | 0.67 | 0.62 | 0.60 | 0.67 | 0.70 | | 0.71 | 0.84 | 0.87 | 0.74 | 0.78 | 1.23 |

VI. CONCLUSIONS

6.1 Roof pressure ratios for buildings with non-dominant opening

Ratios for all terrain categories for EC1-1-4-2005 are generally higher than 1.0 for all types of roofing considered except in TC4 for circular arch roof where the lowest ratio of the maximum negative pressure on local area is 0.5 and for general area is 0.85. For IS 875-3-1987 in the case of duo-pitch roofs, the ratios are generally less than 1.0 for TC1 and TC2 but greater than 1.0 for TC3 and TC4. For mono-slope and flat roofs all ratios are less than 1.0. For circular arch roofs, the ratios of the negative pressures are less than 1.0. For multi saw-tooth and multi duo-pitch roofs, all ratios are generally less than 1.0 except for the maximum positive pressure on general areas which are greater than 1.0. For BS 6399-3-1997, all ratios for duo-pitch, mono-pitch and multi duo-pitch roofs are generally greater than 1.0 except for local areas of TC1 where the ratios are less than 1.0. For flat roofs the ratios are generally less than 1.0 except for the ratios of maximum negative pressure on general areas in TC3 and TC4. For circular arch roofs, no provisions are provided. For multi span saw-tooth roofs, the ratios on local areas are generally less than 1.0 except for TC3 and TC4 where the maximum negative pressure ratios on local areas are higher than 1.0.

6.2 Roof pressure ratios for buildings with dominant openings

Ratios for all terrain categories for EC1-1-4-2005 are generally higher than 1.0 for all types of roofing considered except for circular arch roof where the maximum negative pressure ratios on local areas are less than 1, the lowest ratio is about 0.64. For IS 875-3-1987 in the case of multi span duo-pitch, multi span saw-tooth, duo-pitch, mono-slope roofs the ratios are less than 1.0. For flat roofs, all the maximum negative pressure ratios are less than 1. For circular arch roofs, except for maximum negative pressure ratios for local areas, all values are generally greater than 1.0. Ratios for all terrain categories for BS 6399-3-1997 are generally higher than 1.0 for all types of roofing considered except for the maximum negative pressure ratios for local areas in TC1 are less than 1, the minimum ratio is about 0.87.

6.3 Roof pressure ratios for buildings with canopies

Ratios for all terrain categories for EC1-1-4 are generally higher than 1.0 for all types of canopies considered except for mono-slope canopies where the maximum negative pressure ratios for block under are less than 1, the lowest ratio is about 0.58. Ratios for all terrain categories for IS 875-3 are generally higher than 1.0 for all types of canopies considered except for mono-slope canopies where the maximum negative pressure ratios for block and empty under are less than 1, the lowest ratio is about 0.61. Ratios for all terrain categories for BS 6399-3 are generally higher than 1.0 for all types of canopies considered except for mono-slope canopies where the maximum negative pressure ratios for block under are less than 1 for TC1, the lowest ratio is about 0.81.

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