WIND INTENSITY MEASURMENT AND WIND LOADING CODES IN NEPAL

Prof. Dr. Meen B. Poudyal Chhetri [a] and Anil Shakya[b]

[a] *Disaster Preparedness Network, Kathmandu, Nepal*

[b] *Department of Urban Development and Building Construction, Ministry of Physical Planning and Works, Government of Nepal*

ABSTRACT

Nepal is a mountainous country with a high potential for wind energy. The data base is poor and wind data are not sufficient to make a realistic assessment of the wind energy. The extreme wind speed is as high as 46.76 m/s. For calculating wind load on individual structural elements NBC 104:1994 (wind load) and the Indian standard IS: 875 (part 3)1987 are followed. Every year wind storms kill many people and destroy or damage properties worth hundreds thousands of dollars. On the other hand environmental degradation is another big problem in Nepal which is causing human health hazard particularly due to the air, sound and industrial wastes and pollutions.

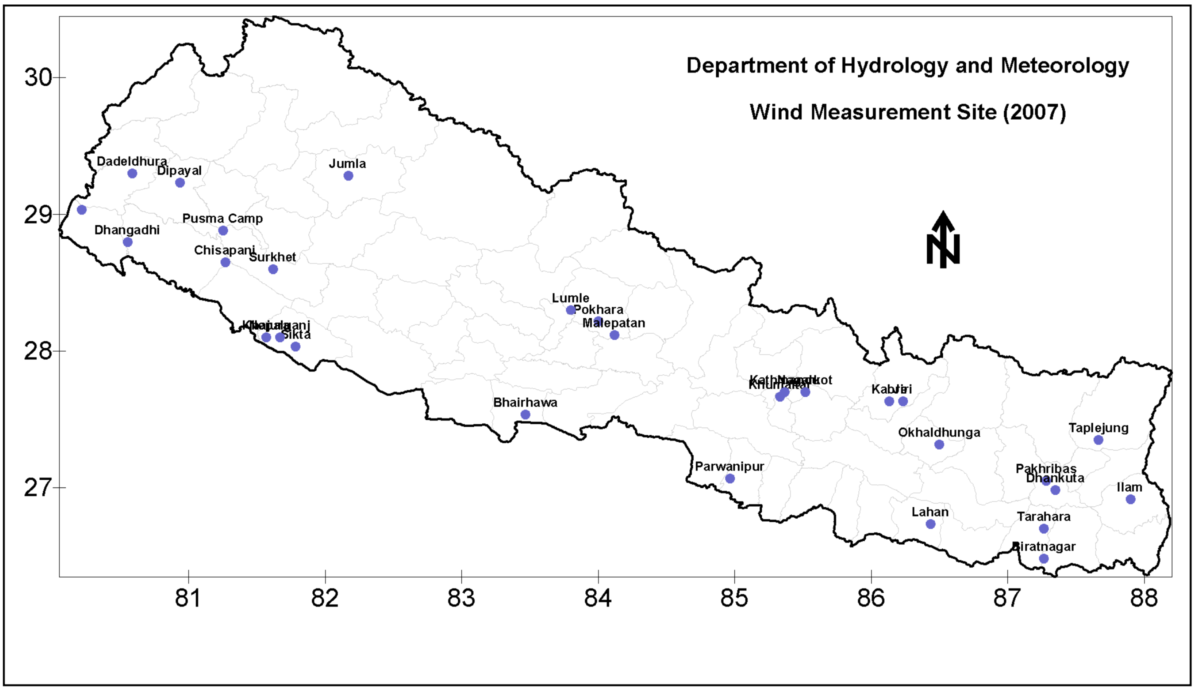
KEY WORDS: Wind load, wind hazard, potential, environment, pollution.

1. INTRODUCTION

Nepal is a mountainous country lying along the middle part of the 2500 km long Himalayan range. It covers an area of about 147,181 sq km and is bounded by the northern latitudes $26^0 22'$ and $30^0 27'$ and the eastern longitudes $80^0 04'$ and $88^0 12'$. Its length is about 885 km along the east-west direction and the width varies from 130 to 255 km. The country is under the influence of the strong SE monsoon climate. Winter is influenced also by a weak SW monsoon. Topography varies from nearly 100 m from msl at the northern edge of the Indo-Gangetic plains to high Himalayan ranges in the north with over 8848 m altitude.

Nepal started collecting data on wind speed only from 1967. There are 40 wind measurement stations installed all over the country run under the Department of Hydrology and Meteorology; however, presently only 29 stations are properly running (Fig 1). They measure average monthly wind speed data at particular time of the day, maximum hourly gust and maximum gust. Even among these stations many provide only discontinuous data. Out of the 29 stations, 7 are in the higher Himalayan region, 11 in middle mountain region and 11 in the Terai plains in the south. The average monthly wind speed data from 29 stations are presented in table 1 (DHM, 2008). However, the available database is inadequate both in terms of spatial distribution and duration for wind design structures. Modern wind design codes are based on the peak gust velocity averaged over a short interval of about 3 seconds with a 50 years return period. The database is also insufficient to prepare the wind zone map.

Environmental degradation is another big problem in Nepal which is causing human health and other hazards particularly due to the air, sound, heat and industrial wastes and pollutions. The major causes of environmental degradation are: collection of firewood, grazing, deforestation, crop raiding by wild animals, animal poaching, environmental pressure from tourism, pollution from factories, fishing using explosives and poison, hydropower plant construction, high tension electrical transmission, irrigation canals, flooding, siltation, garbage, collection of medicinal plants, unscientific waste disposal, tree felling, excessive



human encroachment, collection of medicinal plants etc. Similarly, low level of public awareness, weak institutional, administrative, planning and management capacity; lack of integrated land and water use planning; inadequate data and information management; and inadequate policies and strategies for environmental protection are the other causes of environmental degradation in Nepal.

Fig. 1: Location of the 29 wind monitoring stations in Nepal in 2009

Table 1: Wind speed data for last three years (2005-2008). Wind Speed in Km/hr

Sr. No.	Index No.	Station	Elevation	Latitude	Longitude	Maximum monthly value 2005	Maximum monthly value 2006	Maximum monthly value 2007	Maximum monthly value 2008
1	104	Dadeldhura	1848 m.	29 °18 ' N	80 °35 ' E	4.4	4.8	3.7	3.9
2	105	Mahendra Nagar	176 m.	29°02 ' N	80°13 ' E	4.2	3.4	2.8	NA
3	209	Dhangadhi	170 m.	28 °41' N	80° 36' E	1.9	2.4	NA	2.5
4	218	Dipayal	617 m.	29 ° 15' N	80 °57 ' E	3.2	3.2	3.1	2.6
5	303	Jumla	2300 m.	29 °17 ' N	82 °10 ' E	8.5	7.0	6.8	6.4
6	401	Pusmacamp	950 m.	28° 53' N	81° 15' E	2.7	3.5	2.5	2.9
7	405	Chisapani	225 m.	28° 39' N	81°16' E	14	12	13	NA
8	406	Birendra Nagar	720 m.	28 ° 36' N	81° 37' E	2.4	1.9	1.7	2.5
9	409	Khajura	190 m.	28° 06' N	81° 34' E	3.5	2.8	3.0	3.0
10	419	Sikta	195 m.	28 ° 02' N	81° 47' E	3.75	3.00	1.40	2.1
11	420	Nepalgunj	165 m.	28° 06' N	81° 40' E	4.9	3.2	3.2	3.0
12	707	Bhairahawa Agri.	120 m.	27° 32' N	83° 28' E	5.4	4.9	6.1	NA
13	715	Kanchikot	1760 m.	27° 56' N	83° 09' E	9.8	0.0	0.0	NA
14	804	Pokhara	827 m.	28° 13' N	84° 00' E	3.1	3.1	2.9	2.8

		Airport							
15	811	Malepatan	856 m.	28° 07' N	84° 07' E	0.6	0.8	0.9	0.7
16	814	Lumle	1740 m.	28° 18' N	83° 48' E	1.8	1.6	2.2	1.6
17	911	Parwanipur	115 m	27° 04' N	84° 58' E	4.8	3.9	1.9	3.6
18	1029	Khumaltar	1350 m.	27° 40' N	85° 20' E	3.8	3.8	3.9	3.9
19	1030	Kathmandu Airport	1337 m.	27° 42' N	85° 22' E	1.3	1.2	1.2	1.6
20	1043	Nagarkot	2163 m.	27° 42' N	85° 31' E	5.9	5.3	4.3	5.4
21	1103	Jiri	2003 m.	27° 38' N	86° 14' E	4.2	4.2	3.9	4.2
22	1206	Okhaldhunga	1720 m.	27° 19' N	86° 30' E	5.3	7.0	7.9	8.4
23	1215	Lahan	138 m.	26° 44' N	86° 26' E	6.2	0.0	2.5	4.8
24	1304	Pakhribas	1680 m.	27° 03' N	87° 17' E	1.9	2.1	2.0	3.7
25	1307	Dhankuta	1210 m.	26° 59' N	87° 21' E	5.0	5.2	4.4	4.2
26	1319	Biratnagar Airport	72 m.	26° 29' N	87° 16' E	3.5	4.0	9.7	11.2
27	1320	Tarahara	200 m.	26° 42' N	87° 16' E	7.8	10.7	10.8	9.9
28	1405	Taplejung	1732 m.	27° 21' N	87° 40' E	3.7	2.5	2.9	3.5
29	1407	Ilam Tea Estate	1300 m.	26° 55' N	87° 54' E	1.7	2.3	1.6	NA

In Nepal, the wind velocities in low altitude valleys are lower in magnitude than those in the high altitude valleys and mountain ridges. This is evident from data observed in Kathmandu (low values) and Kaligandaki valleys (high values). Nepal national building code NBC 104:1994 on windload has divided the whole country into two regions:

- **a.** The lower plains and hills generally include the southern plains (Terai), Kathmandu Valley and areas generally below 3000 m altitude. Here the **basic wind velocity of 47 m/s is adopted.**
- **b.** The second zone lies above 3000 m. Here the **basic wind velocity of 55 m/s has been adopted.**

Based on the available data, a wind zoning map of Nepal has been prepared (Fig. 2).

2. NEPAL STANDARD ON WIND LOAD

Though the database on wind velocity within Nepal is not adequate, based on the locally available data as well as the data from similar topographic zones of India; and also taking consideration of the Indian standard IS: 875 (part 3)1987, code of practice for design loads (other than earthquake) for building and structures with amendments as set out on basic wind speed as (a) and (b), a Nepal standard on wind load has been prepared.

According to IS: 875 (part 3) -1987:

The design wind pressure at any height above mean sea level shall be obtained by the following relationship between wind pressure and wind velocity:

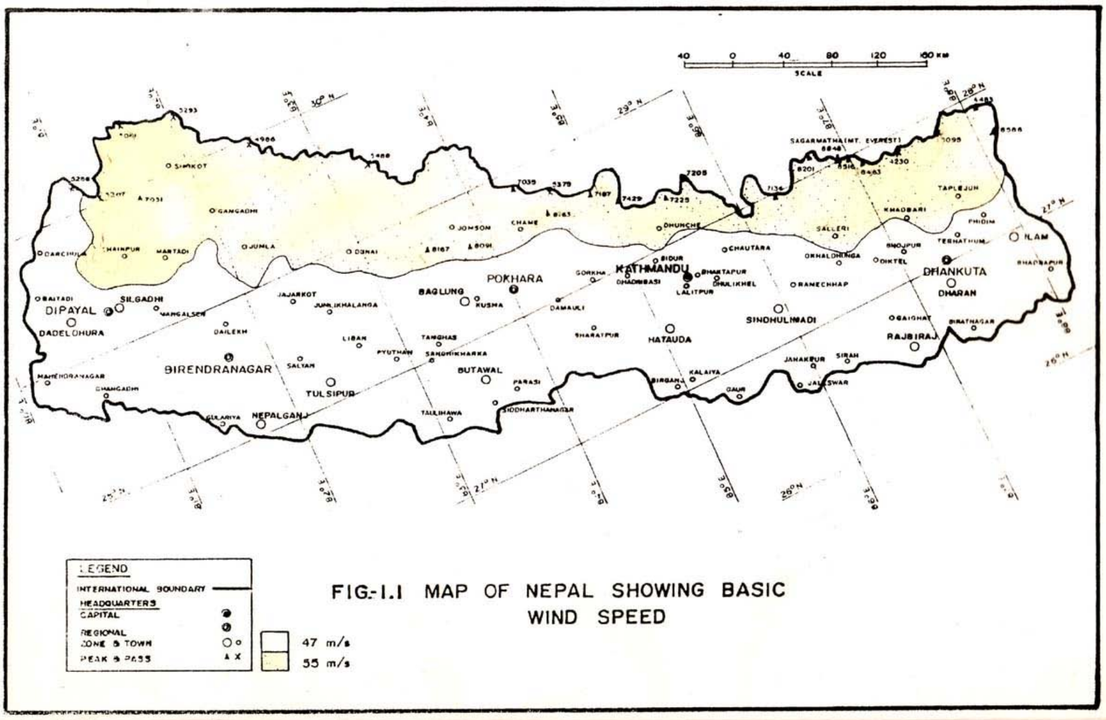
$$Pz = 0.6 (Vz)^2$$

Where pz is design wind pressure in N/sq m at height Z and Vz is design wind velocity in m/sec at height Z.

2.1 *Wind pressure and force on building*

The wind load on buildings shall be calculated for: (a) the building as a whole, (b) individual structural elements as roofs and walls (c) Individual cladding units including glazing and their fixings.

The wind load acting normal to a surface is obtained by multiplying the areas of that surfaces or its appropriate portion by the pressure coefficient and the design pressure at



the height of the surface from ground. The average values of these pressure coefficients for some building shape are given in clause no 6.2.2 and 6.2.3.

Fig. 2. Wind zoning map of Nepal.

Average values of the pressure coefficients are given for critical wind directions in one or more quadrants. In order to determine the maximum wind load on the building, the total load should be calculated for each of the critical directions shown from all quadrants. In addition, areas of high local suction (negative pressure concentration) frequently occurring near the edge of wall and roofs are separately shown in table 2.

When calculating the wind load on individual structural elements such as roof, walls and individual cladding units and their fittings, the pressure difference between opposite faces of such elements or units are taken into account. The wind load F acting in direction normal to the individual structural elements or cladding unit is:

$F = (C_{pe} - C_{pi})\ A\ p_a$

Where, C_{pe} - external pressure coefficient ,

C_{pi} - Internal pressure coefficient,

A - Surface area of the structural elements or cladding unit

p_a - design wind pressure

The Average external pressure coefficients for the walls of clad buildings of rectangular plan are given in table 3(From IS 875-1985).

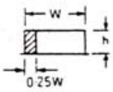
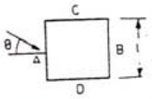
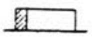
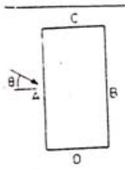
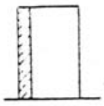
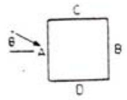
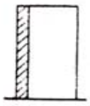
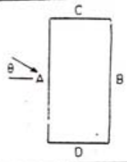
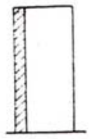
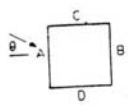
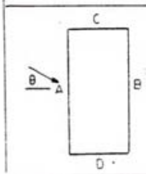
Building Height Ratio	Building Plan Ratio	Elevation	Plan	Wind Angle θ	C_{pe} for Surface A	B	C	D	Local C_{pe}
				degrees					
$\frac{h}{w} < \frac{1}{2}$	$1 < \frac{l}{w} < \frac{3}{2}$			0	+0·7	−0·2	−0·5	−0·5	−0·8
				90	−0·5	−0·5	+0·7	−0·2	
	$\frac{3}{2} < \frac{l}{w} < 4$			0	+0·7	−0·25	−0·6	−0·6	−1·0
				90	−0·5	−0·5	+0·7	−0·1	
$\frac{1}{2} < \frac{h}{w} < \frac{3}{2}$	$1 < \frac{l}{w} < \frac{3}{2}$			0	+0·7	−0·25	−0·6	−0·6	−1·1
				90	−0·6	−0·6	+0·7	−0·25	
	$\frac{3}{2} < \frac{l}{w} < 4$			0	+0·7	−0·3	−0·7	−0·7	−1·1
				90	−0·5	−0·5	+0·7	−0·1	
$\frac{3}{2} < \frac{h}{w} < 6$	$1 < \frac{l}{w} < \frac{3}{2}$			0	+0·8	−0·25	−0·8	−0·8	−1·2
				90	−0·8	−0·8	+0·8	−0·25	
	$\frac{3}{2} < \frac{l}{w} < 4$			0	+0·7	−0·4	−0·7	−0·7	−1·2
				90	−0·5	−0·5	+0·8	−0·1	

Table 2: External pressure coefficients (C_{pe}) for walls of rectangular class buildings

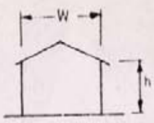
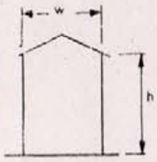
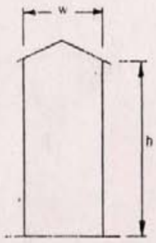
Building Height Ratio	Roof Angle α	Wind Angle θ 0° EF	Wind Angle θ 0° GH	Wind Angle θ 90° EG	Wind Angle θ 90° FH	Local Coefficients			
	degrees								
$\frac{h}{w} \leqslant \frac{1}{2}$ 	0	−0·8	−0·4	−0·8	−0·4	−2·0	−2·0	−2·0	—
	5	−0·9	−0·4	−0·8	−0·4	−1·4	−1·2	−1·2	−1·0
	10	−1·2	−0·4	−0·8	−0·6	−1·4	−1·4		−1·2
	20	−0·4	−0·4	−0·7	−0·6	−1·0			−1·2
	30	0	−0·4	−0·7	−0·6	−0·8			−1·1
	45	+0·3	−0·5	−0·7	−0·6				−1·1
	60	+0·7	−0·6	−0·7	−0·6				−1·1
$\frac{1}{2} < \frac{h}{w} \leqslant \frac{3}{2}$ 	0	−0·8	−0·6	−1·0	−0·6	−2·0	−2·0	−2·0	—
	5	−0·9	−0·6	−0·9	−0·6	−2·0	−2·0	−1·5	−1·0
	10	−1·1	−0·6	−0·8	−0·6	−2·0	−2·0	−1·5	−1·2
	20	−0·7	−0·5	−0·8	−0·6	−1·5	−1·5	−1·5	−1·0
	30	−0·2	−0·5	−0·8	−0·8	−1·0			−1·0
	45	+0·2	−0·5	−0·8	−0·8				
	60	+0·6	−0·5	−0·8	−0·8				
$\frac{3}{2} < \frac{h}{w} < 6$ 	0	−0·7	−0·6	−0·9	−0·7	−2·0	−2·0	−2·0	—
	5	−0·7	−0·6	−0·8	−0·8	−2·0	−2·0	−1·5	−1·0
	10	−0·7	−0·6	−0·8	−0·8	−2·0	−2·0	−1·5	−1·2
	20	−0·8	−0·6	−0·8	−0·8	−1·5	−1·5	−1·5	−1·2
	30	−1·0	−0·5	−0·8	−0·7	−1·5			
	40	−0·2	−0·5	−0·8	−0·7	−1·0			
	50	+0·2	−0·5	−0·8	−0·7				
	60	+0·5	−0·5	−0·8	−0·7				

Table 3: The average external pressure coefficients and pressure concentration coefficients for pitched roofs of rectangular clad buildings from IS code IS 875-1985.

3. WIND HAZARD IN NEPAL

Every year Nepal suffers from disaster due to wind storms which come with gusts. The wind disaster occurs mostly during the months from February to June when the country is constantly under low pressure. Rural areas are more commonly affected than the urban areas. The main reason for disasters is due to the low quality building construction and most buildings do not follow the Nepal's National Building Code on wind load. The wind disaster data of losses of human lives and physical properties from the year 1998 to 2008 available from the Ministry of Home Affairs is presented in table 4 below.

As shown in the table 4, the human life loss is above 40 and the loss of property is more than 4 million US dollars in ten years period. The table clearly shows that in terms of the physical size of the country and the population – the losses of precious human lives and physical properties are quite high. This situation demands government's initiative for the implementation of building code so as to ensure that the constructions of physical infrastructures are wind hazard resistant.

Table 4: Loss of Lives and Properties by Wind Storms (1998 to 2008)

Description	Unit	Years										
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Dead/ Missing	Nos.	6	6	3	1	3	20	0	0	2	2	0
Injured	Nos.	2	7	2	0	0	30	2	0	1	0	0
Affected Families	Nos.	172	293	59	77	227	3302	8	1	601	107	2
Animal Losses	Nos.	3	1	2	0	0	7	0	0	8	7	0
Houses destroyed	Nos.	140	51	57	16	70	2520	8	1	215	79	2
Cattle Sheds destroyed	Nos.	6	3	2	2	45	1344	0	0	1	2	0
Total Est. Losses (In millions)	US$	3.17	0.07	0.02	0.01	0.06	0.26	0.07	0.08	0.17	0.05	0.01

Source: Ministry of Home Affairs

4. CONCLUSIONS

Nepal has a high potential for wind energy. However, it needs concerted efforts to survey the wind potential of the country to harness the energy. Due to its topographic condition, it needs a large number of wind stations distributed according to the altitude and locations and continue the survey for sufficiently long period. High altitude areas are yet to be surveyed.

For development of the National building code on wind load these data are very important. Based on the new data, revised building code for Nepal has to be prepared. Although Nepal has a high potential for wind energy, only an insignificant amount of energy has been harnessed so far. Wind could be a very good alternative source of energy in remote and rural areas of Nepal where national grid of electricity will not reach in foreseeable future. Every year storms kill many people destroy or damage properties worth hundreds of thousands of dollars. If we see the loss of lives and physical properties in the above table 4, it is evident that the losses are enormous. Therefore, low cost wind resistant building designs need to be designed for rural, sub-urban as well as urban areas of least developing countries like Nepal.

REFERENCES

Code of practice for design loads (other than earthquake) for buildings and structures (IS 875, Part 3-1987, Reaffirmed 1997 Second Revision), 1989. Bureau of Indian Standards, New Delhi.58p.

DHM (Department of Hydrology and Meteorology, Ministry of Environment, Science and Technology), 2008. Climatological Records of Nepal 1967-2007., Kathmandu.

GoN-NPC, 2009, Statistical Year of Nepal 2009, Central Bureau of Statistics, National Planning Commission, HMGN, Kathmandu, Nepal.

Nepal National Building Code (NBC 104:1994), 2003. Department of Urban Development and Building Construction, His Majesty's government of Nepal, Kathmandu., 6p.

Nepal Disaster Report: The Hazardscape and Vulnerability, Disaster Preparedness Network-Nepal, 2009.

Poudyal Chhetri, M.B. (2001), "A Practitioner's View of Disaster Management in Nepal: Organization, System, Problems and Prospects," Risk Management: An International Journal, Vol. 3, No.4, Published by Perpetuity Press Ltd., Leicester, UK.

Poudyal Chhetri, M.B. (1999), "Disaster Management in Nepal: Problems and Solutions " An Article Published in the Book on Natural Disaster Management, Edited by Jon Ingleton, Tudor Rose, Holdings Limited, Leicester, England.