Wind Loading Code Provisions in the Philippines and Identified Future Improvements

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ABSTRACT: Philippine engineers are recently starting to focus on "typhoon engineering" in general and wind engineering in particular, as strong winds due to typhoons have been shown to have serious damaging effects. A brief discussion about the wind loading provisions in the NSCP 2001 (National Structural Code of the Philippines) is presented. A recent review of the the development of wind speed maps in the Philippines, from which much was learned, is summarized. Ideas for future activities and research related to wind engineering, including possible improvements in the NSCP wind loading provisions, are then suggested.

KEYWORDS: Philippines, NSCP, wind engineering

1 INTRODUCTION: TYPHOON DISASTER MITIGATION EFFORTS BY ENGINEERS

The Philippines is considered to be in the "Typhoon Alley" or "Typhoon Gateway" of the Pacific northwest. [Rellin, et al, ~2002] An average of 9 landfalling typhoons visit the Philippines each year. [Pacheco & Aquino, 2005; after PAGASA]

In 2004, the Philippine Institute of Civil Engineers (PICE) launched a national program named Disaster Mitigation and Preparedness Strategies (DMAPS), to complement the earlier Disaster Quick Response Program (DQRP). See [Pacheco, 2004a and 2004b]. In addition to the response phase and recovery/rehabilitation phase, which historically were the first focus of DQRP, the mitigation phase and preparedness phase of disaster management were now being given due attention. In addition to earthquake which was historically the focus of DQRP, typhoons and other natural hazards were now being discussed.

This report summarizes portions of an earlier paper entitled "DMAPS Looking Forward: Calling for 'Typhoon Engineers'," presented at the PICE National Convention last November 17-19, 2005. The objectives of the paper were:

a. to create an appreciation of the damaging effects of typhoons
b. to introduce "typhoon engineering" and why it is necessary
c. to present sources of useful and available information for typhoon engineers
d. to present recent research and possible future research in typhoon engineering in general
e. to inspire research in wind engineering in particular by presenting possible areas for improvement in the wind loading code

The earlier paper was largely based on a report entitled "Philippine Wind Information for Engineering, Research, and Mitigation," submitted last June 2005 to the Center of Excellence (COE) Program for Wind Effects on Buildings and Urban Environment, at the Tokyo Polytechnic University in Atsugi, Kanagawa, Japan.

2 AVAILABLE TYPHOON DAMAGE INFORMATION AND THEIR USE

2.1 Damages due to Strong Winds from Typhoons

The earlier paper also noted that "typhoon engineering" is a multi-disciplinary field wherein wind engineering is a major component. True enough, typhoon winds cause damages to structures that, although not generally catastrophic, due to the frequency of typhoons, add up more significantly than those by other types of disasters.

Example photos of damages due to strong winds from one typhoon (Typhoon 'Unding,' International Name: Muifa, November 2004) are shown. More damage photos from the same typhoon could be obtained from http://www.typhoon2000.com. The photos show that strong winds could damage electrical transmission lines and their supporting poles or lattice towers, roof structures, windows, internal or external walls, advertisement boards or sign structures, and trees. Additionally, fallen trees, walls, and other structures were shown to damage adjacent houses, transmission lines, and even parked cars.

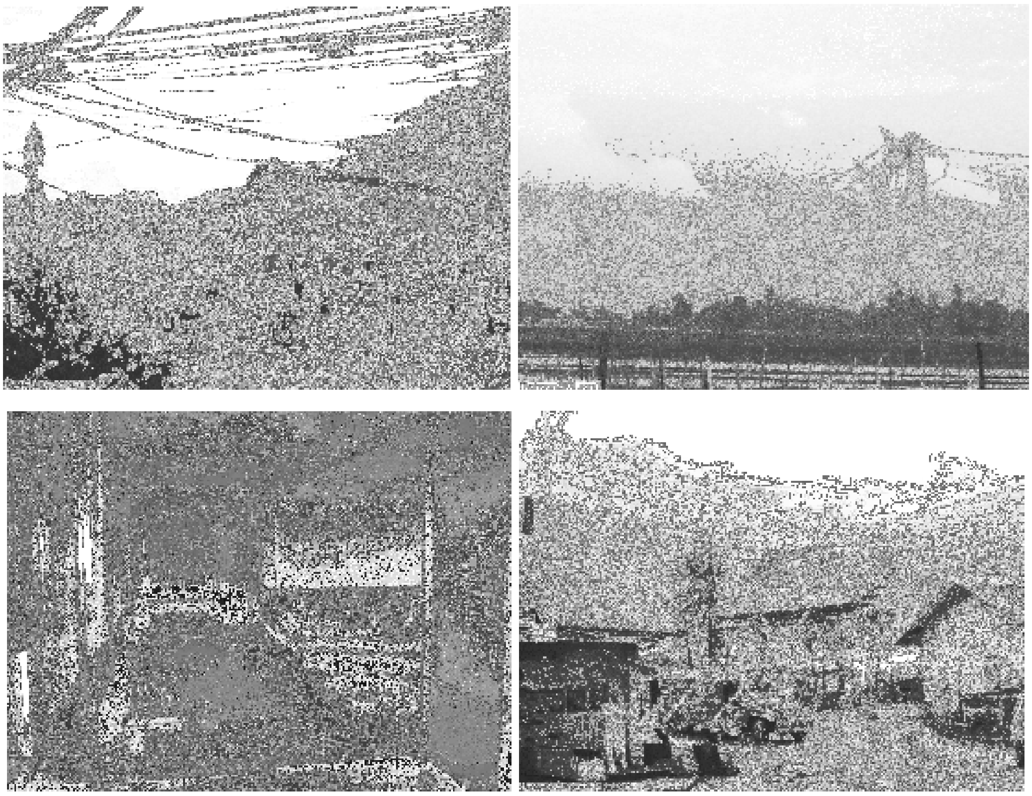

Figure 1. Sample photos of damages due to typhoons

2.2 Sources of General Typhoon Damage Information

Various sources of typhoon damage information were cited, including the OCD-NDCC (Office of Civil Defense – National Disaster Coordinating Council), PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration), and even Philippine media (newspapers, TV and radio, and other Internet websites).

PAGASA's public storm warning signals correspond to forecasted or recorded maximum sustained winds, and expected damages. It was noted however that these "expected damages," with the appropriate mitigation and preparedness, could be reduced.

2.3 Developing "Typhoon Disaster Maps" and "Typhoon Vulnerability Maps"

Currently available typhoon damage information were found to be useful for initial attempts in preparing historical "typhoon disaster maps". The tropical cyclone tracks and corresponding wind speeds provided by PAGASA are also particularly useful information.

Likewise, the effects of disasters also shown in the available damage information could provide a starting point in preparing current "typhoon vulnerability maps." Engineers were asked to at least document damages due to typhoons within their locality, ideally with accompanying photographs, notes, and sketches, as these could provide information as to typhoon vulnerabilities of our structure types and other properties.

3 BRIEF DISCUSSION ON PRESENT NSCP WIND LOAD PROVISIONS

Wind hazard mitigation begins with the National Structural Code of the Philippines (NSCP), wherein wind loads are specified in Section 207.

The NSCP 2001, Volume 1 – Buildings, Towers, and Other Vertical Structures, has significant improvements over its predecessor (NSCP 1992) in general, and in their wind loading provisions in particular: (a) use of 3-second gust speeds instead of fastest-kilometer wind speeds; (b) consideration of dynamic effects as well as torsional effects; and (c) consideration of topographic effects. Additional details can be found in [Tanzo & Pacheco, 2004].

However, it should be noted that Volume 2 of the NSCP (for Bridges) has not been updated. Also, the NSCP 1992 wind loading provisions are still being used by a small fraction of the engineering community. This is acceptable as long as design wind loads computed using the NSCP 1992 are well above the minimum required by the newer NSCP 2001. Some possible issues in using the previous version are raised though.

First, considering that the NSCP 2001 wind zone map has been based on extreme value statistical analysis of a more consistent and more extensive set of data, the equivalent fastest-kilometer wind speeds for each of the three zones could be calculated after some conversion. Results (*Table 1*) show that NSCP 1992 basic wind speeds may be underestimated in Zone I, and overestimated in Zone III, similar to conclusions by Rosaria & Pacheco [2002a, 2002b]. Engineers were thus warned when using the NSCP 1992 wind zone map together with the NSCP 2001 wind loading provisions.

Table 1. Conversion of NSCP 2001 3-sec Gust Speeds to Fastest-Kilometer Wind Speeds

Zone	NSCP 2001 3-sec gust (kph)	NSCP 2001 equiv. fastest-km (kph)	NSCP 1992 fastest-km (kph)	% diff
I	250	230	200	-13%
II	200	180	175	-3%
III	125	110	150	36%

Secondly, the NSCP 2001 specifies the use of an independent gust effect factor (GEF) that is meant to primarily account for dynamic amplification due to resonance with wind gusts. Resonant response is ignored in NSCP 1992. An example was cited, showing that for one flexible structure, there is possibly an under-design of about 15% if dynamic effects were not considered. [Pacheco & Aquino, 2005]

And lastly, possibly the most significant new feature of NSCP 2001 is the consideration of topographic effects, particularly for structures that are on top of hills, ridges, or escarpments. As Rosaria & Pacheco [2002b] have noted, in some cases, the design wind loads computed using the NSCP 1992 and NSCP 2001 are just about equal before the calculation of any topographic multiplier. However, for the said structures on one of the mentioned topographic features, the topographic multiplier could increase the design wind loads by as much as 200%.

4 A REVIEW OF WIND SPEED MAPS: TOWARDS IMPROVING THE NSCP WIND SPEED MAP

4.1 Data from PAGASA

The development of wind speed maps in the Philippines starts with the gathering of meteorological data from PAGASA, which presently has around 56 synoptic stations. However, as Rosaria & Pacheco [2002a] have noted, the actual terrain exposure, elevation, and calibration of instruments, as well as topographic features at the stations have not been surveyed.

Two types of raw data files have been used in developing extreme wind speed maps for the Philippines: the "Monthly Maximum Wind Speed and Direction" (MMWS) data file, and the "Daily and Monthly Climatic Data" (DMCD) data file. These files include what could be considered as monthly or daily maximum 10-minute average and 3-second gust wind speeds, as well as corresponding wind directions. It was also shown that the data could be used in generating wind directionality factors.

There were other documents cited that are available from PAGASA which could be useful for engineers.

4.2 Studies on Extreme Wind Speeds and Wind Speed Mapping in the Philippines

Various extreme wind speed maps or extreme wind speed estimation for the Philippines were cited, such as those by Simiu [1974], ASEP [1972-2001], Rosaria [2001], Rellin et al [2002], Holmes & Weller [2002], and Garciano et al [2005a].

4.3 Wind Speed Data from Other Sources

It was noted that wind power companies also conduct wind speed measurements at heights higher than 10 meters, and usually at 30 meters, for one to two straight years, usually at an ideal location for a wind farm. A similar work presented was by Elliott et al [2001].

Also cited was the recording of wind speeds in Naga City during the passing of Typhoon Unding in November 2004, also freely available from the Typhoon2000.com website. Weather and other wind- and typhoon-related information in the Philippines were shown to be available from various other websites.

4.4 Towards Improving the NSCP Wind Speed Maps

Data from PAGASA and other sources are available, and in fact have already been used in a number of studies by different groups in estimating extreme wind speeds in the Philippines. It was shown that existing "wind hazard maps" such as the wind zone map in the NSCP could still use some improvement. Some of these possible improvements were also discussed (see next chapter). The idea that one single group could coordinate activities of all groups involved in developing these hazard maps was also suggested.

5 LEARNING FROM RECENT WIND ENGINEERING RESEARCH

While in recent years, there have been a number of research studies related to typhoon and wind engineering in the Philippines, it was shown that there are still more possible activities and research studies that may be conducted in the Philippines, given the amount of available information. Collaboration, and harmonization of documents and data between engineers and researchers from other fields were also promoted.

5.1 Learning from International Wind Loading Codes

There have been significant recent developments in international wind loading codes. Many different features in recently updated wind loading codes such as those from the USA (ASCE7-05), Japan (AIJ-RLB-2004), and Australia/New Zealand (AS/NZS1170.2: 2002) may soon be adopted in the next edition of the NSCP. (*Table 2*)

Table 2. Some Recent Developments in International Wind Loading Codes

Wind speed contour map or hybrid zone/contour wind map
Simplified procedure for regular, low-rise buildings
Modified gust effect factor formulation
Across-wind and/or torsional response of buildings and similar structures
Monte-carlo simulation of typhoons/hurricanes
Independent wind directionality factor

5.2 PAGASA Research Studies Related to Wind

PAGASA research in different fields of the natural and social sciences related to mitigating the effects of typhoons and wind were presented as these were almost unknown to the civil engineering community. *Table 3* lists some of these research studies by two branches of PAGASA. It is noted that PAGASA also conducts research on air pollution modeling.

5.3 Possible Improvements in NSCP 2001 Wind Loading Provisions

There are certainly some more studies that could be conducted to further improve the NSCP wind loading provisions. Some additional suggestions presented are listed in *Table 4*.

5.4 Other Possible Research Activities in Typhoon Engineering

There are many more possibilities for research in the many sub-fields of typhoon engineering. Even more suggested research ideas are listed in *Table 5*.

Table 3. Some Research Studies by PAGASA Related to Wind

Year	Title of Research Study by PAGASA-AGSSB http://www.pagasa.dost.gov.ph/researchAGSSB.html
Tropical Cyclone Variations	
2003	A Study Of Tropical Cyclone Activity Over Northwest Pacific Before, During And After The 1997-1998 El Niño Episode
1990	Variations Of Tropical Cyclones In The Western North Pacific
1989	Long Period Variations Of Tropical Cyclones In The Western North Pacific
Air Pollution	
1976	Air Pollution Model For Metropolitan Manila Area Using The Gaussian Distribution
Miscellaneous Research Related to Wind	
2004	Simulation Of Sea And Mountain Breezes Over Metro Manila
1970	An Analysis Of The Relationship Between The Position Of The Major Wind Discontinuity And The Position Of Areas Of Rainfall Over The Philippines

Year	Title of Technical Report by PAGASA-NDRB (Tech. Rep. No.) http://www.pagasa.dost.gov.ph/researchNDRB.html
Extreme Wind Speeds	
~2002	Extreme Wind Hazard Mapping in the Philippines (111)
Tropical Cyclone Variations	
~2002	A Study of Tropical Cyclones Originating from the South China Sea (110)
1997	Southwest Monsoon Surge Associated with Tropical Cyclone (93)
1996	Tropical Cyclone Wind Profiles (87)
Tropical Cyclone Forecasting	
~2000	A Verification of 1994-1998 Tropical Cyclone Movement Forecasts of PAGASA (106)
1999	Analyses Of Vorticity, Omega And 850 HPa Wind of the FLM 12 in Relation to Tropical Cyclones Forecasting (104)
1999	The Revised Analog Method of Forecasting Tropical Cyclone Movement (101)
1998	The Development And Application Of The Direct Model Output Statistics (DMOS) to Improve Forecasting Of Tropical Cyclone Tracks (97)

Table 4. Some Possible Research Studies to Further Improve the NSCP 2001 Wind Load Provisions

Correction of wind speed measurements
Calibration of mass density of air constant
Simplified procedure for simple structures
Applicability for lattice towers and other structures (e.g. gust effect factor formulations)
For which types of structures or components do wind loads govern over earthquake loads
Performance-based design; guidelines for habitability design of buildings

Table 5. Other Possible Activities and Research for Wind Hazard Mitigation in the Philippines

- Wind-response monitoring
- Feasibility of setting up a wind tunnel for extensive wind engineering research
- Low-cost typhoon-resistant construction materials and methods
- ISO-compatible version of NSCP 2001
- Feasibility of special “typhoon shelters”
- Introduction to natural disasters and their effects on property and the population for college students
- Separately published, continuously updated wind zone map, or Dynamic/digital wind hazard map
- Development of Typhoon/Wind Design Manual

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