“Typhoon Engineering” Efforts in the Philippines

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ABSTRACT: In the Philippines where there is an average of 9 landfalling tropical cyclones annually, “typhoons” collectively account for a significant number of damages and injuries, much more than other natural disasters. In recognition of this, the Philippine Institute of Civil Engineers has extended its Disaster Quick Response Program which had a focus on earthquakes, to the more comprehensive Disaster Mitigation, Adaptation and Preparedness Strategies (DMAPS) program. The original 5 strategies under the DMAPS program are discussed, as well as corresponding recent efforts in “typhoon engineering,” which is equivalent to “wind-related disaster risk reduction.”

KEYWORDS: Philippines, wind-related disaster risk reduction, typhoon engineering.

1 INTRODUCTION

“Typhoon engineering” is a term introduced in the Philippines in 2005 (Pacheco & Aquino, 2005a) that is considered synonymous with “wind-related disaster risk reduction,” or WRDRR. The current paper being presented at the APEC-WW and IG-WRDRR Joint Workshop on “Wind-Related Disaster Risk Reduction Activities in Asia-Pacific Region and Cooperative Actions” in Incheon, Korea on 24 October 2010, discusses typhoon engineering efforts in the Philippines. Note that for purposes of this paper, the term “typhoon” is used interchangeably with “storm,” “wind storm,” or “tropical cyclone,” all of which has one equivalent in the Filipino language: “bagyo.”

1.1 *The Philippines and natural disasters*

The Philippines tends to be visited by a lot of natural disasters. A database of natural and technological disasters worldwide shows that the Philippines is one of the most disaster-prone countries in the world, experiencing more than 480 natural disasters from 1900-2010. (Source: "EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels - Belgium"; as cited by Pacheco, 2004b.) The Asian Disaster Reduction Center (Japan), analyzed trends from the same database, and showed that typhoons rank first as the worst natural disaster type, followed by floods and earth-related disasters. (Refer to ADRC, 2002, and Pacheco, 2004b. See Table 1.) Individual typhoon events also comprise most of the historical top 10 worst natural disasters in the Philippines in terms of number of people killed and affected, and total damages. (Table 2)

Table 1. Total Damages by Top 5 Recorded Natural Disaster Types in the Philippines (1901-2009)

Disaster Type	# of Events	Killed	Total Affected	Damage (000 US$)
Typhoon	283	37,182	107,356,117	6,414,643
Flood	103	3,005	14,663,446	1,230,271
Earth mass movement	29	2,698	316,634	33,281
Earthquake-related	23	9,612	2,223,269	519,575

Source: "EM-DAT: The OFDA/CRED International Disaster Databasewww.em-dat.net - Université Catholique de Louvain - Brussels - Belgium"; Data as of 30 August 2010.

Table 2. Top 10 Natural Disasters in the Philippines between 1901 and 2009, in terms of Number of People Killed, Number of People Affected, and Total Cost of Damages

Disaster	Year	Killed	Disaster	Year	Total Affected	Disaster	Year	Damage (US$)
Earthquake	1976	6,000	Typhoon	1990	6,159,569	Flood	1995	700M
Typhoon	1991	5,956	Typhoon	2009	4,901,763	Typhoon	2009	592M
Earthquake	1990	2,412	Typhoon	2008	4,785,460	Typhoon	1990	388M
Typhoon	2004	1,619	Typhoon	2009	4,478,491	Earthquake	1990	370M
Typhoon	1970	1,551	Typhoon	1998	3,902,424	Typhoon	2008	285M
Typhoon	1984	1,399	Typhoon	2006	3,842,406	Typhoon	1995	244M
Typhoon	2006	1,399	Typhoon	1973	3,400,024	Typhoon	1988	240M
Volcano	1911	1,335	Typhoon	1988	3,250,208	Typhoon	2009	237M
Mudslide	2006	1,126	Flood	1972	2,770,647	Flood	1972	220M
Typhoon	1984	1,079	Typhoon	1976	2,700,000	Typhoon	1984	217M

Source: "EM-DAT: The OFDA/CRED International Disaster Databasewww.em-dat.net - Université Catholique de Louvain - Brussels - Belgium"; Data as of 30 August 2010.

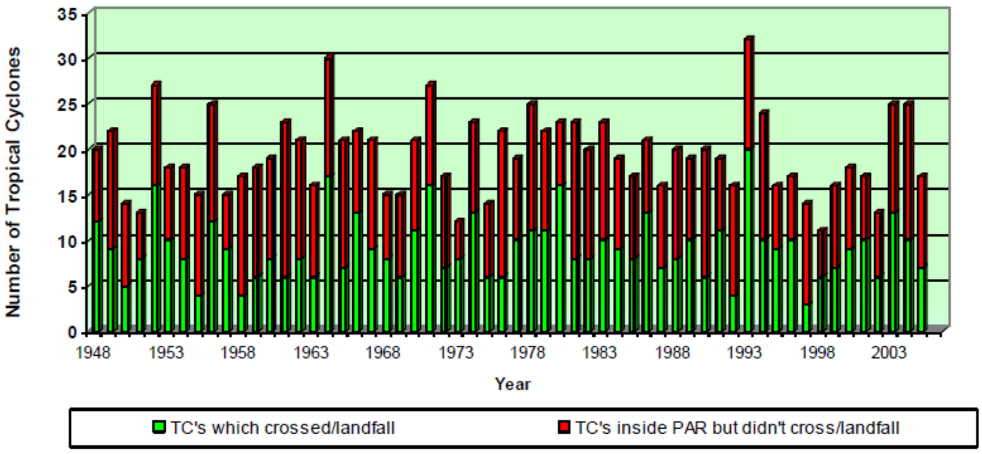

Figure 1. Annual number of tropical cyclones inside the PAR from 1948-2005, after Cinco et al, 2010.

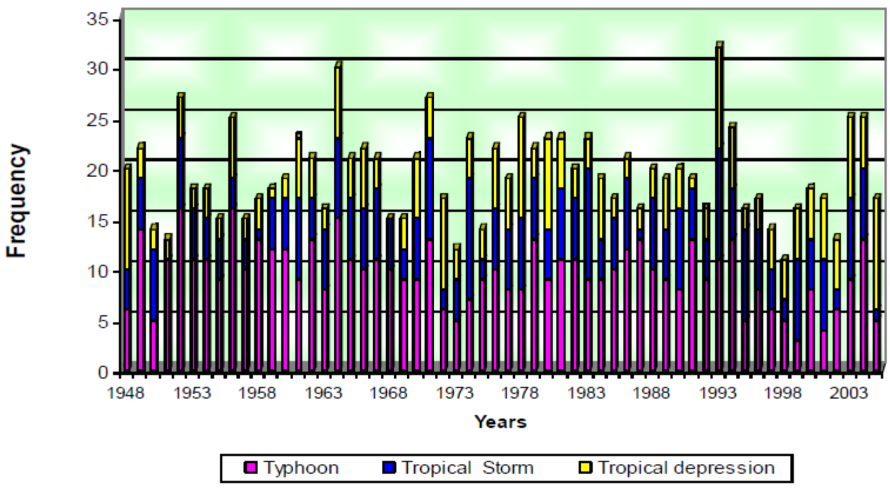

Figure 2. Annual number of tropical cyclones inside the PAR from 1948-2005, by intensity, after Cinco et al, 2010.

As mentioned, “Typhoon” in the above tables could mean tropical cyclone, local storms, tornado, and the like, as defined for meteorological “storms” in the EM-DAT database. Typhoon impact could be more intense than that suggested by average annual numbers from the said database, because these disasters would hit in relatively short durations, and that the numbers from the first half of the century were almost surely understated because relatively few major disasters had been adequately recorded prior to 1975 (Pacheco, 2004b).

1.2 *Typhoons in the Philippines*

The Philippines is considered to be in the "Typhoon Alley" or "Typhoon Gateway" of the Pacific northwest. An average of 20 tropical cyclones, mostly coming from the Pacific, pass through the Philippine Area of Responsibility (PAR) each year. Around half of these are typhoon-level strength. About 9 of these 20 are landfalling, or actually crossing the archipelago. Five of these 9 are usually typhoon-level strength. Five of these 9, not necessarily typhoon-level strength, are also considered "destructive," i.e. causing a significant number of property damages, or human injuries, fatal or otherwise. In contrast, annual averages for landfalling tropical cyclones in some neighbouring countries are around 3 to 5 only.

For some years, there were as few as 11 (e.g. 1998) and as much as 32 (e.g. 1993) tropical cyclones that entered the PAR, and as few as 4 (e.g. 1997) and as much as 19 (e.g. 1993) landfalling. (See Figures 1 & 2.) However, numbers do not indicate the effects on people and property. In 1998, a "dry" year with only 11 cyclones passing through the PAR, damages brought about by Typhoon Iliang (International Name: Zeb) which affected more than 2 million people, and Typhoon Loleng (International Name: Babs) which caused around US$ 140 thousand in damages, are comparable to other destructive typhoons.

1.3 *History of the PICE DMAPS program and typhoon engineering in the Philippines*

There is much attention to the effects of devastating earthquakes in the Philippines, being in the "Pacific Ring of Fire," although this is the same case as in other countries, including Japan and parts of the USA. This could perhaps be explained by looking at numbers for individual events, such as from Table 2. We can see that the worst individual earthquakes ranked 1st and 3rd in number of people killed, as well as within the top 10 in damages in terms of monetary costs, than the worst individual wind storms, or floods.

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) (Pacheco, 2004a). 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 historically was the focus of DQRP, typhoons, floods and other natural hazards were now being discussed.

More recently, adaptation is recognized as a twin strategy with mitigation: adaptation being more associated with slow-onset hazards such as those associated with climate change, while mitigation is more associated with earthquakes and the like. Hence DMAPS is now formally Disaster Mitigation, Adaptation and Preparedness Strategies.

Given the frequency of tropical cyclones, and the total damage by all tropical cyclones combined being greater than those by all other disasters combined, and because typhoons cause not only strong winds but also floods, landslides, mudslides, storm surges, and occasionally tornadoes, while strong winds also cause "wind-borne missiles" or are magnified due to built environment, there is a potentially wide range work in wind-related disaster risk reduction, or collectively referred to here as "typhoon engineering."

The term was probably first used by Sawada (2002), in the context of disaster prevention, and in parallel to "earthquake-proofing" of infrastructures. A similar term, "hurricane engineering," was probably first used by the Louisiana State University (USA) as a new academic program in 2000 (Ward, 2000).

Typhoon engineering covers a broad range of various disciplines in the natural and social sciences, and engineering. Thus, typhoon engineering in the context of this paper is similar to earthquake engineering as a multi-disciplinary field. It is a common ground of at least the following disciplines:

- wind engineering and meteorology
- structural and geotechnical engineering
- hydrology and flood control engineering
- coastal engineering
- disaster management and evacuation planning

- public health and sanitation
- community development
- infrastructure development
- architecture and urban planning
- wind power generation

This paper presents the original strategies of the PICE DMAPS program, and recent activities relevant to typhoon engineering.

2 THE ORIGINAL 5 STRATEGIES OF THE PICE DMAPS PROGRAM

PICE being a huge organization with nationwide reach, through its 95 chapters in all the regions, and being an organization of technology professionals, is able and willing to advance volunteerism at the community level to help mitigate and prepare for disasters. PICE members shall become volunteers not only as responders but also as planners. DMAPS shall be an area-based disaster mitigation, adaptation and preparedness project, with nationwide coordination.

Activities shall include data dissemination (researching and distributing) and capacity building (training and organizing), with the focus being on all natural disasters including drought, earthquake, epidemic, flood, insect infestation, slide, volcano eruption, water wave/surge, wild fire, wind storm, etc. as catalogued by the Asian Disaster Reduction Center or by the OFDA/CRED International Disaster Database. Activities are summarized by the following 5 strategies.

2.1 *Strategy #1: disaster mapping*

Under Strategy #1 of the PICE DMAPS project, catalogued disaster events shall be map-linked as accurately as possible by the PICE chapters nationwide. It shall be the immediate purpose of such Disaster Maps to heighten the public awareness of historical disasters. For example, the PICE Baguio Chapter shall map the past landslides in Baguio and in the Cordillera Autonomous Region. Each area shall draw attention to past events not only in its present geographic territory, but also in territories of all adjoining chapters.

2.2 *Strategy #2: hazard mapping*

Strategy #2 shall include development, gathering, or updating of Hazard Maps covering each area, wherein natural hazards as presently existing in the natural environment shall be indicated. It shall be the immediate purpose of such hazard maps to heighten the public consciousness of existing natural threats. Preferably, the relative level or degree of hazard shall be reflected in the maps as well.

An example is the PICE Manila Chapter mapping the districts of Manila threatened by annual floods. Another example is the PICE East Metro Manila Chapter and other PICE chapter in the National Capital Region gathering maps showing traces of the Valley Fault System. One last example includes PICE Chapters in Region 9, the Autonomous Region of Muslim Mindanao (ARMM), and Region 12 marking the coastal zones in Southern Mindanao that are threatened by tsunami waves.

2.3 *Strategy #3: vulnerability mapping*

Under Strategy #3, elements of the built environment that may be prone to the effects of natural hazards shall be inventoried and indicated on Vulnerability Maps. Vulnerability Maps shall differ from hazard maps, as the former shall highlight those types of built structures or facilities that are deemed technically to be relatively more vulnerable to certain hazards.

An example is PICE chapters in Region 5 mapping those structures more likely to be severely damaged by typhoon winds, in contrast to the less vulnerable structures.

2.4 *Strategy #4: coordination at national level*

Under Strategy #4, the national DMAPS & DQRP committee shall coordinate and oversee the preparation of national guidelines, standards, and manuals in all phases of the project, while individual PICE chapter committees shall plan and implement their unique activities locally at community level.

2.5 *Strategy #5: training*

Under Strategy #5, educational seminars in the development, handling, and communicating the different types of maps shall be conducted in a way proactive to mitigate disasters. Also part of this strategy shall be to prepare engineers with practical skills for emergency response. Among those trained volunteers, teams or clusters shall be formed at various levels, from areas/chapters to regions to national.

2.6 *Specific plans*

During the first year of the DMAPS program, the following specific activities, in line with the 5 strategies, were planned:

1. Gathering of data on historical disasters, natural hazards, and vulnerabilities.
2. Formalization of guidelines, standards, and manuals.
3. Accreditation of Trainors & Volunteers certificates and identification (ID) cards.
4. Issuance of inspection manual, tools/ kit – safety helmet / survival kit.
5. Training of Trainors.
6. Extending formal linkage with the OCD – NDCC.
7. Establishing direct linkage of PICE Chapters with local government units (LGUs)
8. Establishing direct linkage with the Red Cross and other similar institutions
9. Planning out fund raising
10. Schedule Training of DQRP Volunteers as soon as possible

Under "accreditation of trainors & volunteers," the objective is to provide official credentials. The fund raising is to be carried out courtesy of the Ways and Means Committee of the PICE. The training of DQRP volunteers is conducted usually by PICE Trainors who have been accredited since the 2004 PICE Midyear Convention, with supervision from the Association of Structural Engineers of the Philippines (ASEP).

Note that the DMAPS is now really the encompassing program in which the DQRP is one component of. Nonetheless, DQRP being the original program, thus the official name of the committee is "DMAPS & DQRP."

From the above planned specific activities, items #3, #4, #5, #6, and #10 have been completed as of the time of writing of this paper. Regarding #6, the PICE together with ASEP has already signed a Memorandum of Agreement with the Office of Civil Defense – National Disaster Coordinating Council (OCD-NDCC).

3 DMAPS EFFORTS IN TYPHOON ENGINEERING

3.1 *A call for typhoon engineers, 2005*

As mentioned, the concept of typhoon engineering was first introduced in the Philippines in 2005 by the PICE DMAPS program (which itself was started in 2004). This "call for typhoon engineers," by way of a paper and presentation at the 2005 PICE National Convention in Manila, Philippines, was the first activity of the program. (The PICE National Convention is a semi-annual gathering of civil engineers in the Philippines.) This paper emphasized the importance of typhoon engineering, just as earthquake engineering has been given importance in the country. It also presented available disaster, hazard, and vulnerability information. Vulnerability information was presented in the form of wind loading code history, wherein structures designed to older codes are likely to be found more vulnerable than newer structures. This activity was aligned primarily with DMAPS Strategy #5, but is considered as a step covering all 5 strategies. (Pacheco & Aquino, 2005a)

3.2 *Establishing linkages with PAGASA, 2005*

In succession to the call for typhoon engineers at the PICE National Convention the same year, PICE DMAPS members also started establishing linkages with meteorology experts from the government's Department of Science and Technology, namely, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and the Philippine Meteorological Society (PMS), by attendance to the 1st National Meteorological-Hydrological Convention which was co-organized by the PMS and PAGASA. A paper focusing on informational needs for typhoon engineering efforts was presented in front of meteorologists, hydrologists, other scientists, and engineers. This activity was aligned primarily with DMAPS Strategy #2. (Pacheco & Aquino, 2005b)

3.3 *Proposed strategy for updating the national wind hazard map, 2007*

Available wind hazard information has been gathered from relevant literature and other sources, and newer wind hazard information from PAGASA is likewise now readily available. The next step was to review existing wind hazard maps in the form of wind speed maps from the structural code, and other maps from relevant literature, to come up with proposed strategies for future wind hazard maps. This activity was aligned primarily with DMAPS Strategy #2. (Pacheco et al, 2007b)

3.4 *Research on reducing typhoon vulnerability, 2004-2010*

In 2004 and 2006, typhoons with peak gust speeds much less than the 50-year return period design gust speeds for trussed towers (e.g. antenna and transmission towers) and billboard truss structures caused such structures to collapse. A study that aimed to improve the wind-resistant design of such structures with recommendations for updating the structural code was conducted. (Aquino et al, 2006)

In 2004, 2005, 2006, 2007, 2009, and 2010, in Atsugi, Japan, Hong Kong, China, New Delhi, India, Shanghai, China, Taipei, Taiwan, and in Incheon, South Korea, PICE DMAPS members attended the series of "Workshop(s) on Regional Harmonization of Wind Loading and Wind Environmental Specifications in Asia-Pacific Economies," or APEC-WW. It was primarily organized initially by the Japanese Government's Ministry of Education's Center of Excellence (COE) Program at Tokyo Polytechnic University, headed by Prof. Yukio Tamura, and starting in 2009 by its continuation, the Global Center of Excellence (GCOE) program. Aside from aligning with the aims of the APEC-WW, the Philippine delegation also aimed to gain knowledge on wind loading standards from neighboring nations in order to improve the quality of its own wind loading standards, which somewhat is considered to dictate typhoon vulnerability. (Tanzo & Pacheco, 2004; Pacheco et al, 2005c, 2006, 2007a, 2009, 2010)

Further to this, members of the PICE DMAPS committee became active members in the Codes and Standards Committee of ASEP. ASEP has since released the 6th and latest edition of the National Structural Code of the Philippines, with heavily updated wind loading provisions. (Pacheco et al, 2010.)

This group of activities is considered to be aligned primarily with DMAPS Strategy #3. It should be mentioned here that codes are considered as the first line of defense in disaster risk reduction.

3.5 *Preparation of pre- and post-event survey forms, 2009-*

In 2009, the PICE DMAPS program started discussions about standardization of pre- and post-event survey forms for "rapid visual assessment," to identify vulnerabilities and disasters, respectively, for natural hazards other than earthquakes. The idea was taken from earthquake engineering efforts wherein a standardized form from FEMA 154, "Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, Second Edition" (FEMA, 2002) has been used under the DQRP program. Preliminary proposals for survey forms for billboard structures which are primarily vulnerable under typhoon winds and landslides have been prepared. (Pacheco et al, 2009) This activity has been aligned with DMAPS Strategy #4, with the aim of jumpstarting activities under Strategy #1 and #3.

3.6 *Workshop on Earthquake and Severe Wind Exposure and Vulnerability, 2010*

In 2010, Geosciences Australia (GA), together with the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and PAGASA organized the Earthquake and Severe Wind Exposure and Vulnerability Workshop. This was the 2nd workshop after one that focused on earthquake exposure and vulnerability in 2009 wherein it was realized that vulnerability to severe wind (i.e. typhoons) was likewise an important matter. Attendees from the academe and other research institutions, such as from the Institute of Civil Engineering at the University of the Philippines in Diliman, Quezon City, and from professional organizations such as PICE, PICE's DMAPS committee members, and ASEP also made presentations. The program consisted of the following typhoon engineering related presentations:

1. Updating tropical cyclone climatology in the Philippines, by T.A. Cinco et al
2. Highest wind pattern in the Philippines, by V. Manalo
3. Conceptual typhoon damage model, by L. Amadore
4. Exposure database using NSO data, by I. Narag
5. Exposure database: a capability to underpin risk assessment, by K. Nadimpalli
6. Assessing the risk from tropical cyclones, by C. Arthur
7. Typhoon damage scale model, by L. Amadore
8. Design wind loads on lattice towers in the Philippines, by R.E.R. Aquino
9. Wind damage to tower structures, by A. Abinales
10. Benchmark wind vulnerability curves, by B.M. Pacheco and M. Edwards
11. Disaster risk management, by B.M. Pacheco

This activity is aligned primarily with DMAPS Strategy #3, but is considered as one covering all 5 strategies.

4 CONCLUDING REMARKS

Given the frequency of typhoon occurrence in the Philippines and its effect of causing the most property damages and human injuries, fatal or otherwise, it was deemed that efforts previously focusing on earthquake engineering were also to consider "typhoon engineering," which is equivalent to "wind-related disaster risk reduction." Typhoon engineering requires a multidisciplinary effort to be realized. In line with this, the PICE has created the DMAPS program which since its creation in 2005 has conducted activities in line with its 5 strategies of disaster mapping, hazard mapping, vulnerability mapping, national coordination, and training. In the future, the program hopes to secure funding and to conduct even more activities in typhoon engineering.

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