STRUCTOR: Wind and Earthquake Load Analysis Calculator Based on NSCP 2015 – A Mobile Application

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Abstract: - A crucial aspect of civil engineering is the behavior of structures under lateral vibrations. In the Philippines, earthquakes and wind loads are two of the most significant causes of lateral vibrations. In response to societal changes, structure designs are becoming taller and more irregular. Unpredictable environmental factors, such as an earthquake or typhoon, can subject the building or structure to lateral excitations, resulting in structural damage or collapse. Therefore, it is critical to understand how these structures behave under multiple hazards of loads and excitations. Thus, the researchers have developed a mobile application called STRUCTOR. This application calculates earthquake and wind loads based on NSCP 2015. The researchers used the Simplified Static Lateral Force and Static Lateral Force procedure to compute earthquake loads and Main Wind-Force Resisting System (Directional Procedure) for wind loads. Through the STRUCTOR mobile application, users can analyze and design structures more conveniently and user-friendly.

Key Words— ***Mobile Application, Earthquake Load, Wind Load, Civil Engineering, NSCP 2015.***

I. Introduction

Being situated in a region prone to typhoons and is located within the Pacific Ring of Fire, the Philippines is considered one of the most vulnerable nations to natural disasters globally. According to the World Risk Index Data (2022), the Philippines tops the list of 193 countries on their risk of experiencing extreme natural events such as earthquakes, typhoons, tsunamis, floods, and drought. Moreover, based on the Global Climate Risk Index (2021), the Philippines is among the top 10 most affected countries (i.e., 2000-2019) and ranked 4th among the continuously affected countries by natural disasters. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) records 100 to 150 earthquakes annually, averaging around 20 earthquakes per day. On the other hand, typhoons occur very often as they happen, on average, about 20-25 times a year (PAGASA, 2022). Hence, these two environmental factors, aside from the gravity loads, are extensively considered in the Philippines.

Wind and Seismic loadings are among the most prevalent forms of lateral dynamic vibrations experienced by structures (Ukey et al., 2019). Both types of loadings are designed to be applied horizontally to the structural system, but there are differences between the two forces. Wind load is considered more of a constant external force, with the wind's magnitude depending on the building's height and surface area subjected to the force. In contrast, earthquake load is almost instantaneous, with the magnitude depending on the structural system's mass and

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stiffness, as well as the acceleration to the earth's surface (Prem et al., n.d.).

In the present-day scenario, designs of structures are becoming tall and more irregular in response to the changes in society. Unpredictable environmental factors, such as an earthquake or typhoon, can subject a building or structure to lateral excitations and induce slight or considerable damage. Extreme wind pressures and earthquakes have been destroying buildings, threatening lives, and obstructing economic activity (Jha et al., 2018). In light of the rising frequency of multi-hazard disasters, resilient and sustainable structures should be constructed. In order to use this information to design, it is crucial to comprehend how such structures behave under multiple hazards of loads and excitations. It is to be considered, especially when the structure has a great possibility of failing.

With the help of technology, numerous kinds of research, analyses, and designs have been proposed to reduce the damages caused by these environmental factors. Technology has created numerous avenues and opportunities within society, and there is now an abundance of tools and resources available for everyone. The advent of modern technology has led to the creation of multifunctional devices like computers and mobile phones with abundant software for different uses, becoming more powerful, more portable, and convenient as time passes (Varkala, 2022).

Over the past few years, the usage of software tools in the field of civil engineering for analyzing and designing various structures has witnessed a notable rise. STAAD.Pro, ETABS, MIDAS, and other software have been greatly used today. Each software application possesses its unique set of analysis and design features, providing distinct advantages that contribute to minimizing errors that may arise from manual calculations (Lallotra, 2017). Although these software tools offer some benefits, there are also a few disadvantages and limitations that are needed to be considered. Some of them are only applicable to one type of structure, while others are versatile; however, engineers should have the proper knowledge and skills to operate them. Most of these software tools cannot be operated without structural knowledge and without the appropriate device, which makes it inconvenient for everyone.

In response to the issues mentioned, the researchers aimed to develop a mobile application that can be used to calculate and analyze wind pressure and the distribution of lateral seismic loads of 2D frame structures. Wind and seismic load calculation applications can provide accurately designed data on building structures. One of the significant benefits of using a mobile application is the convenience it can provide. With the help of a calculation tool, the manual computation procedure would no longer have to be performed. Also, the application has the potential to recalculate loads after a modification of data and values rapidly. Errors are unlikely to occur due to the system's autonomous operation. Additionally, it is user-friendly and convenient since the user will only need to enter the data required and the information needed. It keeps everything in perspective and makes it simple for the user to make any necessary modifications or enhancements. Overall, this mobile application enables users to process and analyze lateral loads efficiently, with convenience, accuracy, and ease of use.

1.1 Research Gap

In civil engineering, structural analysis has been used extensively. Structural analysis is commonly done to determine the structure's reliability and failure probability. Several instances of building failure are brought on by unpredictable environmental factors and human actions, such as adopting an incorrect load during the external design process (Sitompul & Pariatmono, 2022).

These days, skyscrapers are a common sight in large cities practically everywhere in the world. The fact that so many large cities are so close to the shore and that almost all of them are in the active seismic zone presents a significant challenge for tall, multistorey buildings. Such a complicated structure would be too stressful to analyze manually. It is imperative that a quick fix can be found for this problem. Therefore, advanced structural analysis software programs are utilized to examine the wind and seismic effects on structures (Caroll, 2022). Since they are advanced and reliant on the internet, these software programs can only function on computers and web-based platforms.

The researchers introduced a mobile application that focused on wind pressure and distribution of lateral seismic loads of 2D frame structures calculation and analysis based on NSCP 2015. Compared to computers, mobile phones are more lightweight and can fit in a purse or pocket. They are the epitome of portability because they are made to be carried everywhere. Also, mobile phones are powered by batteries, which necessitates efficient power usage (Computer Hope, 2021). Additionally, due to their high cost, not everyone can afford a laptop or a computer. In contrast, mobile phones have become more widely available, and everyone in the modern world carries one or more phones at all times. Using mobile phones reduces the need to learn about complex technicalities just to understand how to navigate the existing software programs properly. Therefore, the researchers proposed a mobile application that will be of great help and an excellent structural analysis software alternative for structural engineers and civil engineering students for wind and seismic load analysis of buildings.

II. METHODOLOGY

This chapter describes the procedures utilized in the study, STRUCTOR: A Wind and Earthquake Load Analysis Calculator based on NSCP 2015 Mobile Application for material takeoff.

2.1 Phase 1: Research Data and Assessment

2.1.1 Criteria for Choosing Respondents and Data Gathering

Using the Purposive sampling method, fourth-year Civil Engineering students and Civil Engineers were evaluated. The researchers ensured that the gathered data was precise and distinct without any form of biased opinion. The researchers aimed to gather data not only from the preferences of professionals but also from students, recognizing its potential benefits for their structural subjects.

2.1.2 Research Strategy

Quantitative approach was utilized in this study. The researchers composed a set of questionnaires to acquire information about the demand for having a mobile application in Wind and Earthquake Load Analysis Calculation based on NSCP 2015.

2.1.3 Research Setting

Evaluation was conducted at Don Honorio Ventura State University-Main Campus regarding Wind and Earthquake Load Analysis Calculation based on NSCP 2015. The survey questionnaires were administered among the Civil Engineering students and Civil Engineers at Don Honorio Ventura State University-Main Campus.

2.1.4 Research Tools and Questionnaires

The instruments created by the researchers to achieve their stated objectives during the research study were the research tools. Descriptive survey analysis was employed in this research.

2.1.4.1 Questionnaires

The researchers composed close-ended questionnaires. These questionnaires included two rating scales, one measuring frequency and the other one for agreement.

2.1.4.2 Construction and Validation of Questionnaire

A questionnaire was created based on the data collected from selected respondents and from the literature review and previous research. The questionnaires were validated by the thesis adviser and by a registered psychometrician.

2.1.4.3 Administration of Questionnaires

A permit to conduct the survey was sought from the Department of Civil Engineering in DHVSU Main Campus. Once the signed permit was obtained, the questionnaires were promptly distributed to the respondents.

2.1.5 Population and Sample Size

2.1.5.1 Population

With an increasing population of Civil Engineering students and faculty on the main campus, the researchers' primary focus are the Civil Engineering professors and students. Respondents were selected from fourth-year students who are enrolled in structural engineering programs.

2.1.5.2 Sample Size

Applying Slovin's formula, with a margin of error of 15%, the researchers conducted a survey among a total of 50 civil engineering students and 20 civil engineering faculty members from Don Honorio Ventura State University.

$$Sample\ Size\ (n) = \frac{N}{(1 + Ne^2)}$$

Where:
N = Population
e = Margin of Error

2.1.6 Data Integration

The data collected through the questionnaires were compiled and counted by the researchers.

2.1.7 Data Interpretation

An analysis of the data was conducted using statistical methods. After integrating the information gathered from the evaluations, the researchers utilized the statistical method of arithmetic mean and Likert's scale. The results were presented using descriptive statistics.

2.1.7.1 Frequency Distribution

The survey results were summarized using a frequency distribution, which is a statistical technique that depicts the pattern of frequencies of a variable. The frequency of a value is determined by the number of times it appears in the dataset in this technique. A frequency distribution, in particular, shows how many times each possible value of a variable occurs in the dataset. To exhibit the data, the researchers used a frequency distribution table, which presents data that makes it more understandable.

2.1.7.2 Likert Scale

For the interpretation of data, the Likert scale was used to measure the respondents' opinions and attitudes to a common statement. The researchers used a 4-point interval Likert scale to collect the extreme response possible.

2.1.7.3 Descriptive Statistics (Mean and Standard Deviation)

Statistical treatment descriptive statistics (mean and standard deviation) were used to determine how much variance there is in the data from the average. The mean depicts the data's center point, while the standard deviation reflects how wide the range of responses is. A smaller standard deviation suggests that the data is closely grouped around the mean, indicating that the values are relatively consistent and less spread out. On the other hand, a larger standard deviation signifies that the data points are more dispersed or spread out from the mean.

2.2 Phase 2: Data Gathering and Analysis for Research Development

The researchers collected all the required data for seismic and wind loads analysis, following the provisions outlined in Section 208 and Section 207 of NSCP 2015, respectively. The researchers then validated and reviewed the data with their research adviser to ensure accuracy and completeness.

2.2.1 Seismic and Wind Loads Analysis Data Gathering

The researchers collected all the necessary data for analyzing seismic and wind loads in compliance with NSCP 2015. For the calculation of seismic loads, the researchers gathered provisions outlined in Section 208 of the NSCP 2015, while for the wind loads, the researchers gathered provisions specified in Section 207 of NSCP 2015.

2.2.1.1 Earthquake Loads in Accordance with NSCP 2015

The calculation of the earthquake loads was based on Section 208 of the National Structural Code of the Philippines or NSCP 2015. The purpose of the succeeding earthquake provisions was primarily to design seismic-resistant structures to safeguard against major structural damage that could have led to the loss of life and property. These provisions were not intended to assure zero damage to structures nor maintain their functionality after a severe earthquake. The structures and portions thereof were required to be designed and constructed, as a minimum, to resist the effects of seismic ground motions as provided in Section 208 of NSCP 2015.

Additionally, when the code-prescribed wind design produces greater effects, the wind design shall govern, but detailing requirements and limitations prescribed in this section and referenced sections shall be made to govern.

Moreover, the procedures and the limitations for the design of structures shall be determined considering seismic zoning, site characteristics, occupancy, configuration, structural system, and height in accordance with Section 208 of NSCP 2015. Structures shall be designed with adequate strength to withstand the lateral displacements induced by the Design Basis Ground Motion, considering the inelastic response of the structure and the inherent redundancy, over-strength, and ductility of the lateral force-resisting system.

The basis for the design of the earthquake loads is listed in the following steps, which will serve as a guide in the analysis of seismic loads:

Step 1: Determine the occupancy category of the Structure.

There are five (5) occupancy categories in the NSCP 2015, based on Table 2.1 these are the following categories:

Table 2.1 Occupancy Category based on Table 103-1 of NSCP 2015

OCCUPANCY CATEGORY	OCCUPANCY OR FUNCTION OF STRUCTURE
I **Essential Facilities**	Occupancies having surgery and emergency treatment areas, Fire and police stations, Garages and shelters for emergency vehicles and emergency aircraft, Structures and shelters in emergency preparedness centers, Aviation control towers, Structures and equipment in communication centers and other facilities required for emergency response. Facilities for standby power-generating equipment for Category I structures. Tanks or other structures containing housing or supporting water or other fire-suppression material or equipment required for the protection of Category I, II or III, IV and V structures Public school buildings, Hospitals, Designated evacuation centers and Power and communication transmission lines.
II **Hazardous Facilities**	Occupancies and structures housing or supporting toxic or explosive chemicals or substances, Non- building structures storing, supporting or containing quantities of toxic or explosive substances.
III **Special Occupancy Structures**	Buildings with an assembly room with an occupant capacity of 1,000 or more, Educational buildings such as museums, libraries, auditorium with a capacity of 300 or more occupants, Buildings used for college or adult education with a capacity of 500 or more occupants, Institutional buildings with 50 or more incapacitated patients, but not included in Category I. Mental hospitals, sanitariums, jails, prisons, and other buildings where personal liberties of inmates are restrained, Churches, Mosques, and other Religion Facilities. All structures with an occupancy of 5,000 or more persons, Structures and equipment in power-generating situations, and other public utility facilities not included in Category I or Category II, and required for continued operation.
IV **Standard Occupancy Structures**	All structures housing occupancies or having functions not listed Category I, II or III, and Category V.
V **Miscellaneous Structures**	Private garages, carports, sheds and fences over 1.5m high.

For purposes of earthquake-resistant design, each structure shall be placed in one of the occupancy categories listed in Table 2.1 above.

Step 2: Determine the Importance Factor of the Structure based on its Occupancy Category

The assigned importance factors, I and Ip, and structural observation requirements for each category are listed below, in table 208-1 of section 208 in NSCP 2015:

Table 2.2 Seismic Importance Factor based on Table 208-1 of NSCP 2015

Occupancy Category	Seismic Importance Factor, I	Seismic Importance Factor, I_p
I. Essential Facilities	1.50	1.50
II. Hazardous Facilities	1.25	1.50
III. Special Occupancy Structures	1.00	1.00
IV. Standard Occupancy Structures	1.00	1.00
V. Miscellaneous Structures	1.00	1.00

The limitation of Ip for panel connections of Structural Framing Systems shall be 1.0 for the entire connector.

Structural observation shall be provided in Seismic Zone 4 when one of the following conditions exists: the structure is defined as occupancy category I, II, III, and IV; the structure is in Seismic Zone 4, Na as set forth in Table 208-4 of NSCP 2015 is greater than 1.0, and lateral design is required for the entire structure; when so designated by the structural engineer, or when such observation is specifically required by the Building Official.

For anchorage of machinery and equipment required for life-safety systems, the value of Ip shall be taken as 1.5.

Step 3: Determine the Site Geology and Soil Characteristics of the Structure

Each site shall be assigned a soil profile type based on properly substantiated geotechnical data using the site categorization procedure. Section 208.4.3.1.1.1 describes the procedure for determining the Soil Profile Types Sa, Sb, Sc, Sd, and Se, which are defined in Table 208-2 of NSCP 2015 below.

Soil Profile type Sf is defined as soils requiring site-specific evaluation as follows: soils vulnerable to potential failure or collapse under seismic loading, such as liquefiable soils, quick and highly sensitive clays, and collapsible weakly cemented soils.; peats and/or highly organic clay exceeds 3.0 m.; very high plasticity clays with a plasticity index, PI > 75, where the depth of clay exceeds 7.5 m.; very thick soft/medium stiff clays, where the depth of clay exceeds 35 m.; the criteria set forth in the definition for soil profile type Sf requiring site-specific evaluation shall be considered.

Table 2.3 Site Geology and Soil Characteristics of the Structure based on Table 208-2 of NSCP 2015

Soil Profile Type	Soil Profile Name / Generic Description	Average Soil Properties for Top 30 m of Soil Profile		
		Shear Wave Velocity, V_s (m/s)	SPT, N (blows/ 300 mm)	Undrained Shear Strength, S_u (kPa)
S_A	Hard Rock	> 1500		
S_B	Rock	760 to 1500		
S_C	Very Dense Soil and Soft Rock	360 to 760	> 50	> 100
S_D	Stiff Soil Profile	180 to 360	15 to 50	50 to 100
S_E	Soft Soil Profile	< 180	< 15	< 50
S_F	Soil Requiring Site-specific Evaluation. See Section 208.4.3.1			

If the site corresponds to these criteria, the site shall be classified as Soil profile Type Sf and a site-specific evaluation shall be conducted. Also, Soil Profile Type Se includes any soil profile with more than 3.0 m of soft clay, defined as a soil with plasticity index PI > wmc ≥ 40% and Su < 24 kPa. The Plasticity Index, PI, and the moisture content, wmc, shall be determined in accordance with approved national standards.

Furthermore, when the soil properties are not known in sufficient detail to determine the soil profile type, Type Sd shall be used. Soil Profile Type Se or Sf need not be assumed unless the building official determines that type Se or Sf may be present at the site or in the event that type Se or Sf is established by geotechnical date.

Step 4: Determine the Seismic Zone of the Structure

The Philippines is divided into two seismic zones only. Zone 2 covers the provinces of Palawan (except Busuanga), Sulu, and Tawi-Tawi, while the rest of the country is under Zone 4. Each structure shall be assigned a seismic zone factor Z, in accordance with Table 208-3 of NSCP 2015 below.

Table 2.4 Seismic Zone Factor based on Table 208-3 of NSCP 2015

ZONE	2	4
Z	0.20	0.40

Step 5: Determine the Seismic Source Type of the Structure

The location and type of seismic sources to be used for design shall be established based on approved geological data. The types of seismic sources are defined in Table 208-4 of NSCP 2015 below.

Table 2.5 Seismic Source Type of the Structure based on Table 208-4 of NSCP 2015

Seismic Source Type	Seismic Source Description	Seismic Source Definition
		Maximum Moment Magnitude, M
A	Faults that are capable of producing large magnitude events and that have a high rate of seismic activity.	$7.0 \leq M \leq 8.4$
B	All faults other than Type A and C.	$6.5 \leq M \leq 7.0$
C	Faults that are not capable of producing large magnitude earthquakes and that have a relatively low rate of seismic activity.	$M < 6.5$

Subduction sources shall be evaluated on a site-specific basis.

Step 6: Determine the Seismic Zone 4 Near-Source Factor

In Seismic Zone 4, each site shall be assigned near-source factors based on the Seismic Source Type of the Structure. For high-rise structures and essential facilities within 2.0 km of a major fault, a site-specific seismic elastic design response spectrum is recommended to be obtained for the specific area. The assigned near-source factors are given in Tables 208-5 and 208-6 of NSCP 2015 below.

Table 2.6.1 Near Source Factor, Na based on Table 208-5 of NSCP 2015

Seismic Source Type	Closest Distance To Known Seismic Source		
	≤ 2 km	5 km	≥ 10 km
A	1.5	1.2	1.0
B	1.3	1.0	1.0
C	1.0	1.0	1.0

Table 2.6.2 Near Source Factor, Nv based on Table 208-6 of NSCP 2015

Seismic Source Type	Closest Distance To Known Seismic Source			
	≤ 2 km	5 km	10 km	≥ 15 km
A	2.0	1.6	1.2	1.0
B	1.6	1.2	1.0	1.0
C	1.0	1.0	1.0	1.0

The Near-Source Factor may be based on the linear interpolation of values for distances other than those shown in the table. The closest distance to seismic source shall be taken as the minimum distance between the site and the area described by the vertical projection of the source on the surface (i.e., surface projection of fault plane). The surface projection need not include portions of the source at depths of 10 km or greater. The largest value of the Near-Source Factor considering all sources shall be used for design.

The Value of Na used to determine Ca need not exceed 1.1 for structures complying with all the following conditions: the soil profile type is Sa, Sb, Sc or Sd.; p = 1.0.; except in single-story structures, residential building accommodating 10 or fewer persons, private garages, carports, sheds, and agricultural buildings, moment frame systems designated as part of the lateral-force-resisting system shall be special moment-resisting frames.; the exceptions to section 515.6.5 of NSCP 2015 shall not apply, except for columns in one-story buildings or columns at the top story of multistorey buildings.; none of the following structural irregularities is present: Type 1, 4, or 5 of Table 208-9 of NSCP 2015, and Type 1 or 4 of Table 2018-10 of NSCP 2015.

Step 7: Determine the Seismic Response Coefficients of the Structure

Each structure shall be assigned a seismic coefficient, Ca, and a seismic coefficient, Cv. These coefficients are in accordance with the tables 208-7 and 208-8, respectively, of NSCP 2015 below:

Table 2.7.1 Seismic Response Coefficient, Ca based on Table 208-7 of NSCP 2015

Soil Profile Type	Seismic Zone Z	
	Z = 0.2	Z = 0.4
S_A	0.16	$0.32N_a$
S_B	0.20	$0.40N_a$
S_C	0.24	$0.40N_a$
S_D	0.28	$0.44N_a$
S_E	0.34	$0.44N_a$
S_F	*See Footnote 1 of Table 208-8*	

Table 2.7.2 Seismic Response Coefficient, Cv based on Table 208-8 of NSCP 2015

Soil Profile Type	Seismic Zone Z	
	Z = 0.2	Z = 0.4
S_A	0.16	$0.32N_v$
S_B	0.20	$0.40N_v$
S_C	0.32	$0.56N_v$
S_D	0.40	$0.64N_v$
S_E	0.64	$0.96N_v$
S_F	*See Footnote 1 of Table 208-8*	

Site-specific geotechnical investigation and dynamic site response analysis shall be performed to determine seismic coefficients.

Step 8: Determine the Configuration of the Structure

Each structure shall be designated as being structurally regular or irregular. Regular structures have no significant physical discontinuities in the plan or vertical configuration or in their lateral-force-resisting systems, such as the irregular features. Irregular structures have significant physical discontinuities in configuration or in their lateral-force resisting systems. Irregular features include but are not limited to, those described in Tables 208-9 and 208-10 of NSCP 2015 below.

Table 2.8.1 Vertical Structural Irregularities based on Table 208-9 of NSCP 2015

Irregularity Type and Definition	Reference Section
1. Stiffness Irregularity - Soft Storey A soft storey is one in which the lateral stiffness is less than 70% of that in the storey above or less than 80 percent of the average stiffness of the three stories above.	208.4.8.3 Item 2
2. Weight (Mass) Irregularity Mass irregularity shall be considered to exist where the effective mass of any storey is more than 150% of the effective mass of an adjacent storey. A roof that is lighter than the floor below need not be considered.	208.4.8.3 Items 2
3. Vertical Geometric Irregularity Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral-force-resisting system in any storey is more than 130% of that in an adjacent storey. One-storey penthouse need not be considered.	208.4.8.3 Item 2
4. In-Plane Discontinuity in Vertical Lateral-Force Resisting Element Irregularity An in-plane offset of the lateral-load-resisting elements greater than the length of those elements.	208.5.8.1.5 1
5. Discontinuity in Capacity - Weak Storey Irregularity A weak storey is one in which the storey strength is less than 80% of that in storey above. The storey strength is the total strength of all seismic-resisting elements sharing the storey for the direction under consideration.	208.4.9.1

Table 2.8.2 Horizontal Structural Irregularities based on Table 208-10 of NSCP 2015

Irregularity Type and Definition	Reference Section
1. Torsional Irregularities –To Be Considered When Diaphragm Are Not Flexible Torsional irregularity shall be considered to exist when the maximum storey drift, computed including accidental torsion, at one end of the structure transverse to an axis more than 1.2 times the average of the storey drifts of the two ends of the structure.	208.7.2.7 Item 6
2. Re-Entrant Corner Irregularity Plan configurations of a structure and its lateral- force-resisting system contain re-entrant corners, where both projections of the structure beyond a re-entrant corner are greater than 15% of the plan dimension of the structure in any given direction.	208.7.2.7 Items 6 and 7
3. Diaphragm Discontinuity Irregularity Diaphragms with abrupt discontinuities or variations in stiffness, including those having cutout or open areas greater than 50% of the gross enclosed area of the diaphragm, or changes in effective diaphragm stiffness of more than 50% from one storey to the next	208.7.2.7 Item 6
4. Out Of-Plane Offsets Irregularity Discontinuities in a lateral force path, such as out-of-plane offsets of the vertical.	208.5.8.1.5 1 208.7.2.7 Item 6
5. Non-parallel Systems Irregularity The vertical lateral–load–resisting elements are not parallel to or symmetric about the major orthogonal axes of the lateral force-resisting system.	208.7.1

All structures in occupancy Categories 4 and 5 in Seismic Zone 2 need to be evaluated only for vertical irregularities of Type 5 and horizontal irregularities of Type 1. Structures having any features listed in Table 208-9 above shall be designated as having a vertical irregularity. This is with the exception where no story drift ratio under design lateral forces is greater than 1.3 times the story drift ratio of the story above, the structure may be deemed to not have the structural irregularities of Type 1 or 2 in Table 208-9 above. The story drifts for this determination may be calculated neglecting torsional effects. Structures having any of the features listed in Tables 208-10 shall be designated as having a plan irregularity.

Step 9: Determine the Structural System of the Structure

Structural Systems shall be classified as one of the types listed in Table 208-11 of NSCP 2015 and defined as the followings:

- Bearing Wall System – a structural system without a complete vertical load-carrying space frame. Bearing walls or bracing systems provide support for all or most gravity loads. Resistance to lateral load is provided by shear walls or braced frames.
- Building Frame System – a structural system with an essentially complete space frame providing support for gravity loads. Resistance to lateral load is provided by shear walls or braced frames.

- Moment-Resisting Frame System – a structural system with an essentially complete space frame providing support for gravity loads. Moment-resisting frames provide resistance to lateral load primarily by flexural action of members.
- Dual System – a structural system with the following features: An essentially complete space frame that provides support for gravity loads.; Resistance to lateral load is provided by shear walls or braced frames and moment-resisting frames (SMRF, IMRF, MMRWF, or steel OMRF). The moment-resisting frames shall be designed to independently resist at least 25 percent of the design base shear.; The two systems shall be designed to resist the total design base shear in proportion to their relative rigidities considering the interaction of the dual system at all levels.

Table 2.9.1 Earthquake-Force-Resisting Structural Systems of Concrete based on Table 208-11A of NSCP 2015

Basic Seismic-Force Resisting System	R	Ω_O	System Limitation and Building Height Limitation by Seismic Zone, m	
			Zone 2	Zone 4
A. Bearing Wall Systems				
• Special reinforced concrete shear walls	4.5	2.8	NL	50
• Ordinary reinforced concrete shear walls	4.5	2.8	NL	NP
B. Building Frame Systems				
• Special reinforced concrete shear walls or braced frames (shear walls)	5.0	2.8	NL	75
• Ordinary reinforced concrete shear walls or braced frames	5.6	2.2	NL	NP
• Intermediate precast shear walls or braced frames	5.0	2.5	NL	10
C. Moment-Resisting Frame System				
• Special reinforced concrete moment frames	8.5	2.8	NL	NL
• Intermediate reinforced concrete moment frames	5.5	2.8	NL	NP
• Ordinary reinforced concrete moment frames	3.5	2.8	NL	NP
D. Dual Systems				
• Special reinforced concrete shear walls	8.5	2.8	NL	NL
• Ordinary reinforced concrete shear walls	6.5	2.8	NL	NP
E. Dual System with Intermediate Moment Frames				
• Special reinforced concrete shear walls	6.5	2.8	NL	50
• Ordinary reinforced concrete shear walls	5.5	2.8	NL	NP
• Shear wall frame interactive system with ordinary reinforced concrete moments frames and ordinary reinforced concrete shear walls	4.2	2.8	NP	NP
F. Cantilevered Column Building Systems				
• Cantilevered column elements	2.2	2.0	NL	10
G. Shear Wall-Frame Interaction Systems	5.5	2.8	NL	50

- Cantilevered Column System – a structural system relying on cantilevered column elements for lateral resistance.
- Undefined Structural System – a structural system not listed in Table 208-11 of NSCP 2015.
- Non-building Structural System – a structural system conforming to Section 208.8 of NSCP 2015.

Table 2.9.2 Earthquake-Force-Resisting Structural Systems of Steel based on Table 208-11B of NSCP 2015

Basic Seismic-Force Resisting System	R	Ω_O	System Limitation and Building Height Limitation by Seismic Zone, m	
			Zone 2	Zone 4
A. Bearing Wall Systems				
• Light steel-framed bearing walls with tension-only bracing	2.8	2.2	NL	20
• Braced frames where bracing carries gravity load	4.4	2.2	NL	50
• Light framed walls sheathed with steel sheets structural panels rated for shear resistance or steel sheets	5.5	2.8	NL	20
• Light-framed walls with shear panels of all other light materials	4.5	2.8	NL	20
• Light-framed wall system using flat strap bracing	2.8	2.2	NL	NP
B. Building Frame Systems				
• Steel eccentrically braced frames (EBF), moment- resisting connections at columns away from links	8.0	2.8	NL	30
• Steel eccentrically braced frames (EBF), non-moment- resisting connections at columns away from links	6.0	2.2	NL	30
• Special concentrically braced frames (SCBF)	6.0	2.2	NL	30
• Ordinary concentrically braced frames (OCBF)	3.2	2.2	NL	NP
• Light-framed walls sheathed with steel sheet structural panels / sheet steel panels	6.5	2.8	NL	20
• Light frame walls with shear panel of all other materials	2.5	2.8	NL	NP
• Buckling-restrained braced frames (BRBF), non- moment -resisting beam-column connection	7.0	2.8	NL	30
• Buckling-restrained braced frames (BRBF), moment- resisting beam-column connections	8.0	2.8	NL	30
• Special steel plate shear walls (SPSW)	7.0	2.8	NL	30
C. Moment-Resisting Frame Systems				
• Special moment-resisting frame (SMRF)	8.0	3.0	NL	NL
• Intermediate steel moment frames (IMF)	4.5	3.0	NL	NP
• Ordinary moment frames (OMF)	3.5	3.0	NL	NP
• Special truss moment frames (STMF)	6.5	3.0	NL	NP
• Special composite steel and concrete moment frames	8.0	3.0	NL	NL
• Intermediate composite moment frames	5.0	3.0	NL	NP
• Composite partially restrained moment frames	6.0	3.0	50	NP
• Ordinary composite moment frames	3.0	3.0	NP	NP
D. Dual Systems with Special Moment Frames				
• Steel eccentrically braced frames	8.0	2.8	NL	NL
• Special steel concentrically braced frames	7.0	2.8	NL	NL
• Composite steel and concrete eccentrically braced frame	8.0	2.8	NL	NL
• Composite steel and concrete concentrically braced frame	6.0	2.8	NL	NL
• Composite steel plate shear walls	7.5	2.8	NL	NL
• Buckling-restrained braced frame	8.0	2.8	NL	NL
• Special steel plate shear walls	8.0	2.8	NL	NL
• Masonry shear wall with steel OMRF	4.2	2.8	NL	50
• Steel EBF with steel SMRF	8.5	2.8	NL	NL
• Steel EBF with steel OMRF	4.2	2.8	NL	50
• Special concentrically braced frames with steel SMRF	7.5	2.8	NL	NL
• Special concentrically braced frames with steel OMRF	4.2	2.8	NL	50
E. Dual System with Intermediate Moment Frames				
• Special streel concentrically braced frame	6.0	2.8	NL	NP
• Composite steel and concrete concentrically braced frame	5.5	2.8	NL	NP
• Ordinary composite braced frame	3.5	2.8	NL	NP
• Ordinary composite reinforced concrete shear walls with steel elements	5.0	3.0	NL	NP
F. Cantilevered Column Building Systems				
• Special steel moment frames	2.2	2.0	10	10
• Intermediate steel moment frames	1.2	2.0	10	NP
• Ordinary steel moment frames	1.0	2.0	10	NP
• Cantilevered column elements	2.2	2.0	NL	10
G. Steel Systems not Specifically Detailed for Seismic Resistance, Excluding Cantilever Systems	3.0	3.0	NL	NP

Table 2.9.3 Earthquake-Force-Resisting Structural Systems of Masonry based on Table 208-11C of NSCP 2015

Basic Seismic-Force Resisting System	*R*	*Ω₀*	System Limitation and Building Height Limitation by Seismic Zone, m	
			Zone 2	Zone 4
A. Bearing Wall Systems				
• Masonry shear walls	4.5	2.8	NL	50
B. Building Frame Systems				
• Masonry shear walls	5.5	2.8	NL	50
C. Moment-Resisting Frame Systems				
• Masonry moment-resisting wall frames (MMRWF)	6.5	2.8	NL	50
D. Dual Systems				
• Masonry shear walls with SMRF	5.5	2.8	NL	50
• Masonry shear walls with steel OMRF	4.2	2.8	NL	50
• Masonry shear walls with concrete IMRF	4.2	2.8	NL	NP
• Masonry shear walls with masonry MMRWF	6.0	2.8	NL	50

Table 2.9.4 Earthquake-Force-Resisting Structural Systems of Wood based on Table 208-11D of NSCP 2015

Basic Seismic-Force Resisting System	*R*	*Ω₀*	System Limitation and Building Height Limitation by Seismic Zone, m	
			Zone 2	Zone 4
A. Bearing Wall Systems				
• Light-framed walls with shear panels: wood structural panel walls for structures three stories or less	5.5	2.8	NL	20
• Heavy timber braced frames where bracing carries gravity load	2.8	2.2	NL	20
• All other light framed walls	NA	NA		
B. Building Frame Systems				
• Ordinary heavy timber- braced frames	5.6	2.2	NL	20

Step 10: Selection of Lateral Force Procedure

For the simplification of the seismic load calculation, the researchers have only used the Simplified Static Lateral Force and Static Lateral Force procedure. The simplified static lateral force procedure set forth in section 208.5.1.1 of the NSCP 2015 may be used for the Structures with occupancy category 4 (Standard Occupancy Structures) or 5 (Miscellaneous Structures) that are not more than two stories excluding basements and light-frame construction not more than 3 stories. Moreover, the static lateral force procedure of section 208.5 may be used for the following: "All structures in Occupancy Categories 4 and 5 in Seismic Zone 2"; "Regular structures under 75 m in height with lateral force resistance provided by systems listed in Table 208-11, except where Section 208.4.8.3, Item 4, applies"; "Irregular structures not more than five stories or 20 m in height"; "Structures having a flexible upper portion supported on a rigid lower portion where both portions of the structure considered separately can be classified as being regular, the average story stiffness of the lower portion is at least 10 times the average story stiffness of the upper portion and the period of the entire structure is not greater than 1.1 times the period of the upper portion considered as a separate structure fixed at the base."

Step 11: Determination of Seismic Factors (x) and R

For specific elements of the structure, as specifically identified in NSCP 2015, the minimum design strength shall be the product of the seismic force over-strength factor (X) and the design seismic forces set forth in Section 208.5 of NSCP 2015. For both Allowable Stress Design and Strength Design, the Seismic Force Over-strength Factor, (x) shall be taken from Table 208-11. The value of R shall be taken from Table 208-11 of NSCP 2015 above.

Step 12: Determination of Structure Period

The value of T for all buildings may be approximated from the equation:

$$T = C_t\,(h_n)^{3/4}$$

Where:
Ct = 0.0853 for steel moment-resisting frames
Ct = 0.0731 for reinforced concrete moment-resisting frames and eccentrically braced frames
Ct = 0.0488 for all other buildings
hn = height of the building

Step 13: Design of Base Shear

➢ *Simplified Static Force Procedure*

The total design of base shear in a given direction shall be determined from the following equation:

$$V = \frac{3\,C_a}{R}W$$

Where the value of Ca shall be based on Table 208-7 for the soil profile type. When the soil properties are not known in sufficient detail to determine soil profile type, Type Sd shall be used in Seismic Zone 4, and Type Se shall be used in Seismic Zone 2. In Seismic Zone 4, the Near Source Factor, Na, need not be greater than 1.2 if none of the following structural irregularities are present: Type 1, 4, or 5 of Table 208-9, or Type 1 or 4 of Table 208-10 of NSCP 2015.

➢ *Static Lateral Force Procedure*

The total design base shear in a given direction shall be determined from the following equation:

$$V = \frac{C_v I}{RT} W$$

The total design base shear need not exceed the following:

$$V = \frac{2.5\, C_a I}{R} W$$

The total design base shear shall not be less than the following:

$$V = 0.11\, C_a IW$$

In addition, for Seismic Zone 4, the total base shear shall also not be less than the following:

$$V = \frac{0.8\, ZN_v I}{R} W$$

Step 14: Determination of Vertical Distribution of Force

➢ *Simplified Static Lateral Force Procedure*

The forces at each level shall be calculated using the following equation:

$$F_x = \frac{3\, C_a}{R} W_i$$

Where the value of Ca shall be determined as in Section 208.5.1.1 of NSCP 2015.

➢ *Static Lateral Force Procedure*

When a more detailed procedure is not available, the total force shall be distributed over the height of the structure based on the following equations:

$$V = F_t + \sum_{i=1}^{n} F_i$$

The concentrated force Ft at the top, which is in addition to Fn, shall be determined from the equation:

$$F_t = 0.07TV$$

The value of T used for the purpose of calculating Ft shall be the period that corresponds with the design base shear as computed using the previous given equation in solving the structure period. Ft need not exceed 0.25V and may be considered as zero where T is 0.7 s or less. The remaining portion of the base shear shall be distributed over the height of the structure, including Level n, according to the following equation:

$$F_x = \frac{(V - F_t) W_x h_x}{\sum_{i=1}^{n} W_i h_i}$$

At each level designated as x, the force Fx shall be applied over the area of the building in accordance with the mass distribution at that level. Structural displacements and design seismic forces shall be calculated as the effect of forces Fx and Ft applied at the appropriate levels above the base.

2.2.1.2 Wind Loads in Accordance with NSCP 2015

Wind Loads result from the flow of wind around a structure. The amount of Wind Loads a structure may experience is influenced by several factors, including the structure's location, surrounding terrain, obstacles like neighboring buildings, and the structure's own shape and vibration properties.

2.2.1.2.1 Main Wind-Force Resisting System (MWFRS)

To determine wind loads for Main Wind-Force Resisting System (MWFRS), one of the following procedures must be used:

1. Directional Procedure, which applies to buildings of all heights as stated in Section 207B for buildings that meet the specified requirements.
2. Envelope Procedure, which applies to low-rise buildings as stated in Section 207C for buildings that meet the specified requirements.
3. Directional Procedure for Building Appurtenances and Other Structures, which applies to rooftop structures and equipment, solid freestanding walls and signs, chimneys, tanks, open signs, lattice frameworks, and trussed towers as specified in Section 207D.
4. Wind Tunnel Procedure, which applies to all buildings and structures as specified in Section.

2.2.1.2.2 Wind Loads on Buildings—MWFRS (Directional Procedure)

The Directional Procedure, which is a provision in Method 2 of NSCP 2010 (ASCE 7-05) for MWFRS, is used to apply to buildings of all heights. However, a simplified version based on this procedure is now used for buildings that are 49 meters tall or less. This traditional approach considers pressure coefficients that account for the actual wind loading on each surface of the building based on the wind direction, whether it is parallel or perpendicular to the ridge line.

2.2.1.2.3 Steps to Determine MWFRS Wind Loads for Enclosed, Partially Enclosed and Open Buildings of All Heights

Step 1: Determine risk category of building or other structure, see Table 2.1

Step 2: Determine the basic wind speed, V, for the applicable risk category, see Figure 207A.5-1A, B or C

Fig. 2.1-A Basic Wind Speeds for Occupancy Category III, IV and V Buildings and Other Structures from Figure 207A.5-1A of NSCP 2015

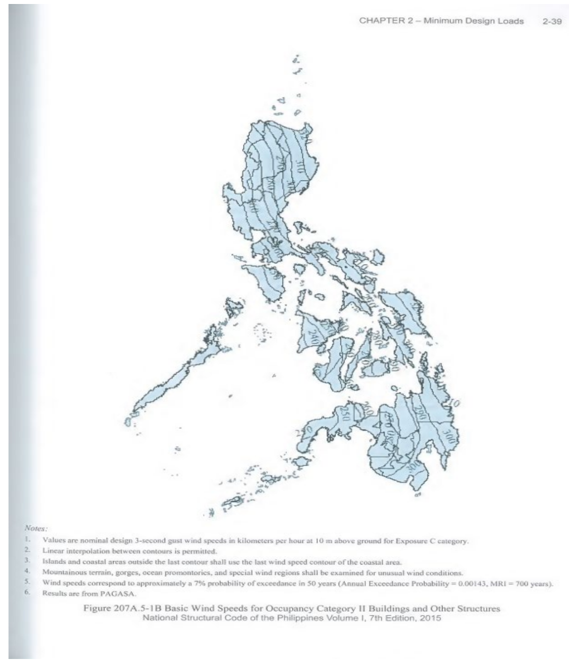

Fig. 2.1-B Basic Wind Speeds for Occupancy Category III, IV and V Buildings and Other Structures from Figure 207A.5-1B of NSCP 2015

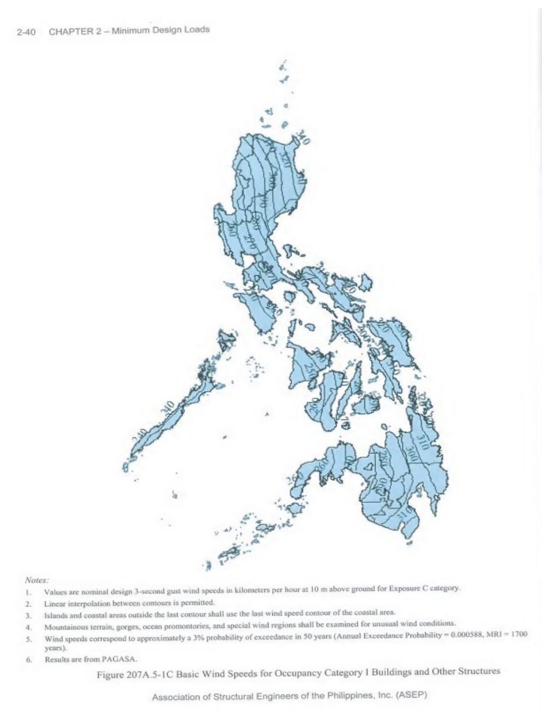

Fig. 2.1-C Basic Wind Speeds for Occupancy Category III, IV, and V Buildings and Other Structures from Figure 207A.5-1C of NSCP 2015

Step 3: Determine wind load parameters

➢ *Wind directionality factor, Kd, see Section 207A.6 and Table 207A.6-1*

Given that the design of the Main Wind-Force Resisting System (MWFRS) is the focus of this study, the directionality factor (Kd) will be set to 0.85. This value is determined based on the relevant design codes and standards that govern wind load calculations for MWFRS.

Table 2.10 Wind Directionality Factor, Kd based on Table 207A.6-1 of NSCP 2015

Structure Type	Directionality Factor Kd
Building	
Main Wind Force Resisting System	0.85
Components and Cladding	0.85
Arched Roofs	0.85
Chimneys, Tanks, and Similar Structures	
Square,	0.90
Hexagonal	0.95
Round	0.95
Solid Freestanding Walls and Solid Freestanding and Attached Signs	0.85
Open Signs and Lattice Framework	0.85
Trussed Towers	
Triangular, square, rectangular	0.85
All other cross sections	0.95

*Directionality Factor Kd has been calibrated with combinations of loads specified in Section 203. This factor shall only be applied when used in conjunction with the load combination specifies in Sections 203.3 and 203.4.

➢ *Exposure category, see Section 207A.7*

For the purpose of this study, the investigation of surface roughness will be limited to exposure category C. This decision is based on time constraints and the scope of the study, which focuses solely on buildings situated on flat or open terrains.

➢ *Topographic factor, Kzt, see Section 207A.S and Table 207A.8-1*

Considering the scope of this study, which exclusively examines buildings located on flat or open terrains, a topographic factor value of Kzt = 1.0 will be used. This decision is made based on the understanding that the topography of the terrain has a negligible effect on the wind load calculations in such situations.

➢ *Gust Effect Factor, G, see Section 207A.9 (page 109)*

As low-rise buildings possess a natural high-frequency response, they can be categorized as rigid structures for the purpose of wind load calculations. Consequently, a gust effect factor of 0.85 will be applied in accordance with relevant design codes and standards. For enclosure classification, see Section 207A.10.

➢ *Internal pressure coefficient, (GCpi), see Section 207A. 1 1 and Table 207A. 11-1*

As this study exclusively focuses on low-rise buildings and residential houses, the enclosure classification and associated internal pressure coefficient will be determined accordingly. Specifically, a value of ±0.18 will be used for the internal pressure coefficient in accordance with relevant design codes and standards.

Table 2.11 Internal Pressure Coefficient, (GCpi) based on Table 207A.11-1 of NSCP 2015

Main Wind Force Resisting System and Components and Cladding	**All Heights**
Enclosed, Partially Enclosed, and Open Buildings	**Walls and Roofs**
Enclosure Classification	**(GCpi)**
Open Buildings	0.00
Partially Enclosed Buildings	+0.55 -0.55
Enclosed Buildings	+0.18 -0.18

Step 4: Determine velocity pressure exposure coefficient, Kz or Kh see Table 207B.3-1

To determine the velocity pressure exposure coefficients, the researchers will refer to Table 207B.3-1 as per the relevant design codes and standards. If the height value is not listed in the table, the researchers will employ the formulas kz = 2.01(z/zg)^(2/a) or kh = 2.01(h/zg)^(2/a), as appropriate. These formulas are recommended by the design codes for the calculation of the wind velocity pressure coefficients for heights beyond the range provided in Table 207B.3-1.

Table 2.12. Velocity Pressure Exposure Coefficient, Kh and Kz Main Wind Force Resisting System based on Table 207C.3-1 of NSCP 2015

Height above ground level, z	Exposure		
m	B	C	D
0-4.6	0.57	0.85	1.03
6.0	0.62	0.90	1.08
7.5	0.66	0.94	1.12
9.0	0.70	0.98	1.16
12.0	0.76	1.04	1.22
15.0	0.81	10.9	1.27
18.0	0.85	1.13	1.31
21.0	0.89	1.17	1.34
24.0	0.93	1.21	1.38
27.0	0.96	1.24	1.40
30.0	0.99	1.26	1.43
36.0	1.04	1.31	1.48
42.0	1.09	1.36	1.52
48.0	1.13	1.39	1.55
54.0	1.17	1.43	1.58
60.0	1.20	1.46	1.61
75.0	1.28	1.53	1.68
90.0	1.35	1.59	1.73
105.0	1.41	1.64	1.78
120.0	1.47	1.69	1.82
135.0	1.52	1.73	1.86
150.0	1.56	1.77	1.89

Step 5: Determine velocity Equation 207B.3-1 pressure qz or qh

In view of the fact that Exposure Category C is the sole consideration for this study, the values of alpha (α) and zg will remain constant at 9.5 and 274.32, respectively. These values are determined by the relevant design codes and standards and are applicable for Exposure Category C in wind load calculations.

Table 2.13 Terrain Exposure Constants based on Table 207A.9-1 of NSCP 2015.

Exposure	α	z_g	$\hat{a}$	$\hat{b}$	$\bar{\alpha}$	$\bar{b}$	c	ℓ (m)	$\bar{\epsilon}$	z_{min} (m)
B	7.0	365.76	1/7	0.84	1/4.0	0.45	0.30	97.54	1/3.0	9.14
C	9.5	274.32	1/9.5	1.00	1/6.5	0.65	0.20	152.4	1/5.0	4.57
D	11.5	213.26	1/11.5	1.07	1/9.0	0.80	0.15	198.12	1/8.0	2.13

*zmin = minimum height used to ensure that the equivalent height $\bar{z}$ is greater or 0.6h or zmin . For buildings with h ≤ zmin , $\bar{z}$ shall be taken as zmin .

Velocity pressure, qz, evaluated at height z shall be calculated by the following equation:

$$q_z = 0.613 K_z\, K_{zt}\, K_d\, V^2 (N/m^2); V \; in \; m/s$$

Step 6: Determine external pressure coefficient, Cp or Ch

The windward and sidewall coefficients (cp) will be assumed constant at 0.8 and -0.7, respectively, in accordance with the relevant design codes and standards. However, the leeward coefficient value will be based on the formula L/B, where L and B represent the horizontal dimensions of the building measured parallel and normal to the wind direction, respectively. If the value of L/B falls within the range of 0 to 1, the leeward coefficient value will be taken as -0.5. For L/B = 2, the coefficient value will be -0.3, and for L/B values greater than or equal to 4, the value of cp will be -0.2. These coefficient values are recommended by the design codes for wind load calculations on buildings.

Table 2.14 Wall Pressure Coefficients

Wall Pressure Coefficients, C_p			
Surface	L/B	C_p	Use Width
Windward Wall	All values	0.8	q_z
Leeward Wall	0 - 1 2 >4	-0.5 -0.3 -0.2	q_h
Side Wall	All values	-0.7	q_h

Step 7: Calculate wind pressure, p, on each building surface.

Given that only rigid and enclosed buildings are being considered in this study, the relevant wind load calculation equation will be Equation 207B.4-1, as per the relevant design codes and standards. This equation is recommended for computing the design wind loads on rigid buildings subjected to wind forces.

$$p = qGC_p - q_i\,(GC_{pi})(N/m^2)$$

where:

q = qz for windward walls evaluated at height z above the ground

q = qh for leeward walls, side walls, and roofs, evaluated at height h

qi = qh for windward walls, side walls, leeward walls, and roofs of enclosed building and for negative internal pressure evaluation in partially enclosed buildings
qi = qz for positive internal pressure evaluation in partially enclosed buildings where height z is defined as the level of the highest opening in the building that could affect the positive internal pressure. For buildings sited in windborne debris regions, glazing that is not impact resistant or protected with an impact resistant covering shall be treated as an opening in accordance with Section 207A.10.3.

For positive internal pressure evaluation. qi may conservatively be evaluated at height h(qi = qh)
G = gust-effect factor, see Section 207A.9 of NSCP 2015
Cp = external pressure coefficient from Figures 207B.4-1, 207B.4-2 and 207B.4-3 in NSCP 2015.
(GCpi) = internal pressure coefficient from Table 207A.11-1 of NSCP 2015

When determining the external wind pressure acting on a building, two conditions must be considered: burst condition and suction. The gcpi coefficient value for burst condition is positive, while it is negative for suction condition. These coefficients are determined based on the relevant design codes and standards for wind load calculations on buildings.

2.2.2 Data Validation

The researchers consulted with their research adviser to validate and include all the necessary data for formulating the provisions required for developing the mobile application.

2.2.3 Data Integration

The researchers integrated and quantified all the validated information gathered from the National Structural Code of the Philippines 2015. They used this information to develop a mobile earthquake and wind load calculator application.

2.2.4 Application Development

After combining and quantifying the essential data from the National Structural Code of the Philippines 2015, the researchers used a structured process to construct the mobile application for the earthquake and wind load calculator. First, an early layout for the STRUCTOR design application was produced using Adobe XD as the base.

The researchers engaged the app developer to identify what was needed for the application, and the app developer offered suggestions to increase the effectiveness of the mobile application's development. Since the target users of the app are already professionals and students studying civil engineering who may already have some technical understanding in the topic, the app developer advised deleting any extraneous tutorials. To improve the user experience, the app developer also proposed combining the input prompts onto a single screen. The design was subsequently made simpler by the researchers so that development would be simpler.

The researchers developed a flowchart that detailed the crucial phases for the computation of earthquake and wind loads in order to ensure an accurate and effective development process. A visual representation of the algorithm that would be used by the program to carry out calculations was provided by the flowchart. The researchers created pseudocode from the flowchart, together with a high-level description of the program and a tool to aid the app developer in comprehending the reasoning behind the algorithm and serving as a manual for generating the actual code.

The inputs, calculations, and outputs that were essential for the application to carry out the calculations for the seismic and wind loads were given in the pseudocode. Since everything was organized logically and was simple to understand, the app developer was able to divide difficult issues into simpler, more manageable parts. The team was able to evaluate the program's logic using the pseudocode prior to actually developing it, which ultimately saved time and effort.

In order to write the application's actual code, the app developer used this pseudocode as a guide. The required features and formulas were specified during the development phase, and the pseudocode and flowchart were used to direct the programming procedure.

2.3 Phase 3: Research Output and Final Testing

2.3.1 Alpha and Beta Testing of the Application

Once the development of the STRUCTOR was completed, the researchers carried out alpha testing. The researchers conducted a comparative analysis of the results obtained through manual calculation and from the STRUCTOR application. This was to validate if the application worked properly and see if the wind and earthquake loads were calculated accurately. When the alpha testing of the application was successful, validation or beta testing was then executed.

III. RESULTS AND DISCUSSION

3.1 Research Data

The researchers conducted an initial survey to assess the possible interest and readiness of users to employ a mobile application that computes wind pressure and lateral seismic load distribution. The survey questionnaire was designed with two distinct parts. The first part focused on gathering information about the frequency with which respondents performed wind and earthquake load calculations of structures, either manually or using load analysis software. In the second part of the survey, various statements were used to measure respondents' level of agreement regarding wind and earthquake load calculations, as well as the proposed STRUCTOR application.

The researchers conducted the survey among civil engineering faculty and civil engineering students in their fourth year at DHVSU Main Campus. Using Slovin's formula with a margin of error of 15%, the sample size was determined.

$$Sample\ Size\ (n)\ = \frac{N}{(1 + Ne^2)}$$

Where:
N = Population
e = Margin of Error

$$Sample\ Size\ (n)\ = \frac{713}{1 + 713(0.15)^2}$$

$$Sample\ Size\ (n)\ =\ 41.84\ say\ 50\ CE\ students$$

$$Sample\ Size\ (n)\ = \frac{35}{1 + 35(0.15)^2}$$

$$Sample\ Size\ (n) =\ 19.58$$
$$say\ 20\ Civil\ Engineering\ Faculty\ Members$$

3.1.1 Summary of Responses from the Initial Survey

The researchers gathered a combined total of 70 responses among the two groups. The results from the survey are shown in Tables 3.1 and 3.2.

Table 3.1 Summary of Survey Responses: Frequency of Wind and Earthquake Load Analysis and Software Engagement

Questions	1 - Never	2 - Rarely	3 - Sometimes	4 - Always
How often do you calculate the wind and earthquake loads of structures?	4	17	43	6
How often do you perform manual computations when analyzing wind and earthquake loads?	8	17	27	18
Compared to manual analysis, how often do you prefer using load analysis software?	7	12	24	27
How often do you use computer programs (STAAD.PRO, ETABS, MIDAS, SAP-2000, etc.) to analyze wind and earthquake loads?	10	19	32	9

Presented in Table 3.1 are the responses from the first part of the survey. The purpose of this part of the survey was to determine how frequently respondents engage with the calculation of earthquake and wind loads, either manually or by utilizing load analysis software programs. There are four questions in it, and respondents can select "always," "sometimes," "rarely," or "never" as their response.

The first question pertained to the frequency at which the respondents perform earthquake and wind load calculations. 43 respondents answered that they perform these computations "sometimes," 17 answered "rarely," six answered "always," and four answered "never."

The second question sought how often the respondents perform manual calculations for earthquake and wind loads. Twenty-seven respondents answered that they perform manual computations "sometimes," 18 answered "always," 17 answered "rarely," and eight answered "never."

The third question asked how often respondents prefer utilizing load analysis software compared to the manual analysis of earthquake and wind loads. Twenty-seven respondents answered they prefer using load analysis software "always," 24 answered "sometimes," 12 answered "rarely," and seven answered "never."

Lastly, the fourth question determined how often the respondents use computer programs, like STAAD.PRO, ETABS, MIDAS, SAP-2000, to analyze earthquake and wind loads. Thirty-two answered using these computer programs "sometimes," 19 answered "rarely," 10 answered "never," and nine answered "always."

Table 3.2 Summary of Survey Responses: Assessment of User Perspectives and Preferences Regarding Mobile Applications for Wind and Earthquake Load Calculations

Statements	1 - Strongly Disagree	2 - Disagree	3 - Agree	4 - Strongly Agree
It is difficult to manually calculate wind and earthquake loads.	0	11	47	12
Rather than manual calculations, it is more efficient to carry out wind and earthquake load calculations using a software program.	0	2	24	44
Using these software programs (STAAD.PRO, ETABS, MIDAS, SAP-2000, etc.) can be overwhelming and complex.	3	12	40	15
It is preferable to have a mobile application to measure wind and earthquake loads	3	2	28	37
It would be extremely helpful if there were a mobile application that calculates wind and earthquake loads according to the NSCP 2015.	1	2	19	48
I am interested to try an application in the future as an alternative solver software for wind and earthquake load calculations.	0	3	19	48
I would consider using the STRUCTOR Application in the future in my profession.	1	0	24	45

Table 3.2 presents the results of the second part of the survey, which was conducted to evaluate the level of agreement among the respondents concerning statements related to earthquake and wind loads computations and the STRUCTOR application. This section of the survey comprises seven statements that were presented to the respondents to assess their level of agreement on a scale that spans from "strongly disagree" to "strongly agree."

The first statement indicates that it is difficult to calculate earthquake and wind loads manually. 47 respondents agreed with the statement, 12 strongly agreed, 11 disagreed, and none strongly disagreed.

The second statement suggests that the use of software programs for computing wind and earthquake loads is more efficient than manual calculations. 44 respondents strongly agreed with the statement, 24 agreed, two disagreed, and none strongly disagreed.

The third statement implies that software programs such as STAAD.PRO, ETABS, MIDAS, SAP-2000, etc., can be overwhelming and complex. 40 respondents agreed with the statement, 15 strongly agreed, 12 disagreed, and three strongly disagreed.

The fourth statement explores the preference for mobile applications for measuring wind and earthquake loads. 37 respondents strongly agreed with the statement, 28 agreed, two disagreed, and three strongly disagreed.

The fifth statement examines whether there is a need for a mobile application that can compute wind and earthquake loads, according to NSCP 2015. 48 respondents strongly agreed with the statement, 19 agreed, two disagreed, and one strongly disagreed.

The sixth statement inquiries about the students' interest in trying an application as an alternative solver software for wind and earthquake load calculations. 48 respondents strongly agreed with the statement, 19 agreed, three disagreed, and none strongly disagreed.

The seventh statement assesses whether the students will utilize the STRUCTOR application in their future profession. 45 respondents strongly agreed with the statement, 24 agreed, one strongly disagreed, and none disagreed.

3.1.2 Interpretation of Responses

The survey data was analyzed using Statistical treatment Descriptive Statistics (Mean and Standard Deviation). Tables 3.4 and 3.6 display each question and statement's mean and standard deviation. The constructed interval and its equivalent interpretation, utilizing a four-point Likert scale, were presented in Tables 3.3 and 3.5 to interpret the mean. The Standard Deviation indicates how wide the range of responses was. A low standard deviation indicates that data are concentrated around the mean. On the other hand, a high standard deviation suggests that data are more dispersed, indicating that the data points are more widely spread out. A standard deviation close to zero suggests that data points are proximate to the mean, while a significant standard deviation implies that data points are far from the mean.

Table 3.3 4-Point Interval Likert Scale

Likert Scale	Mean Range	Interpretation
1	1.00 - 1.50	Never
2	1.51 - 2.50	Rarely
3	2.51 - 3.50	Sometimes
4	3.51 - 4.00	Always

Table 3.4 Interpretation of Survey Responses: Frequency of Wind and Earthquake Load Analysis and Software Engagement

Question	Mean	Standard Deviation	Interpretation
How often do you calculate the wind and earthquake loads of structures?	2.73	0.70	Sometimes
How often do you perform manual computations when analyzing wind and earthquake loads?	2.79	0.96	Sometimes
Compared to manual analysis, how often do you prefer using load analysis software?	3.01	0.99	Sometimes
How often do you use computer programs (STAAD.PRO, ETABS, MIDAS, SAP-2000, etc.) to analyze wind and earthquake loads?	2.57	0.89	Sometimes

Table 3.4 displays the survey outcomes conducted to inquire about participants' frequency of performing wind and earthquake load calculations and analyses. The mean and standard deviation were computed for each question; the results are presented in the table. The mean is interpreted using a 4-point Likert scale in Table 3.3 with the constructed interval and its equivalent interpretation.

In the first question, "How often do you calculate the wind and earthquake loads of structures?" most respondents calculate wind and earthquake loads of structures occasionally, as evidenced by a mean score of 2.73 and a standard deviation of 0.70.

The second question, "How often do you perform manual computations when analyzing wind and earthquake loads?" received a mean score of 2.79 and a standard deviation of 0.96, indicating that most respondents sometimes perform manual computations when analyzing wind and earthquake loads.

On the third question, when asked, "Compared to manual analysis, how often do you prefer using load analysis software?" the mean score of the responses was 3.01, and the standard deviation was 0.99, suggesting that the majority of respondents sometimes prefer using load analysis software compared to manual analysis.

As for the fourth and final question, "How often do you use computer programs (STAAD.PRO, ETABS, MIDAS, SAP-2000, etc.) to analyze wind and earthquake loads?" it received a mean score of 2.57 and a standard deviation of 0.89, indicating that the majority of respondents sometimes use computer programs such as STAAD.PRO, ETABS, MIDAS, SAP-2000, etc., to analyze wind and earthquake loads.

Overall, the interpretation of the responses from this table suggests that the respondents have a moderate level of experience with wind and earthquake load calculations using both manual computations and computer programs. Most respondents occasionally prefer the use of wind and earthquake load analysis compared to manual calculations.

Table 3.5 4-Point Interval Likert Scale

Likert Scale	Mean Range	Interpretation
1	1.00 - 1.50	Strongly Disagree
2	1.51 - 2.50	Disagree
3	2.51 - 3.50	Agree
4	3.51 - 4.00	Strongly Agree

Table 3.6 Interpretation of Survey Responses: Assessment on User Perspectives and Preferences Regarding Mobile Applications for Wind and Earthquake Load Calculations

Statement	Mean	Standard Deviation	Interpretation
It is difficult to manually calculate wind and earthquake loads	3.01	0.58	Agree
Rather than manual calculations, it is more efficient to carry out wind and earthquake load calculations using a software program.	3.60	0.55	Strongly Agree
Using these software programs (STAAD.PRO, ETABS, MIDAS, SAP-2000, etc.) can be overwhelming and complex.	2.96	0.75	Agree
It is preferable to have a mobile application to measure wind and earthquake loads.	3.41	0.75	Agree
It would be extremely helpful if there were a mobile application that calculates wind and earthquake loads according to the NSCP 2015.	3.63	0.62	Strongly Agree
I am interested to try an application in the future as an alternative solver software for wind and earthquake load calculations.	3.64	0.57	Strongly Agree
I would consider using the STRUCTOR Application in the future in my profession.	3.61	0.57	Strongly Agree

Table 3.6 presents the results of a survey conducted to determine the level of agreement among participants regarding seven statements related to wind and earthquake load calculations. The table includes six statements and their corresponding mean scores and standard. The mean was interpreted using Table 3.5, which ranges from strongly agree to strongly disagree.

The first statement, "It is difficult to manually calculate wind and earthquake loads," received a mean score of 3.01 and a standard deviation of 0.58, indicating that most participants agreed that manual calculations of wind and earthquake loads are difficult.

The second statement, "Rather than manual calculations, it is more efficient to carry out wind and earthquake load calculations using a software program," received a significantly higher mean score of 3.60 and a lower standard deviation of 0.55, indicating that the majority of participants strongly agreed that using software programs is more efficient than manual calculations for wind and earthquake loads.

The third statement, "Using these software programs (STAAD.PRO, ETABS, MIDAS, SAP-2000, etc.) can be overwhelming and complex," got a mean score of 2.96 and a higher standard deviation of 0.75, indicating that participants agreed that these software programs could be complex and overwhelming.

The fourth statement, "It is preferable to have a mobile application to measure wind and earthquake loads," received a mean score of 3.41 and a standard deviation of 0.75, indicating that participants agreed that having a mobile application to measure wind and earthquake loads is preferable.

The fifth statement, "It would be extremely helpful if there were a mobile application that calculates wind and earthquake loads according to the NSCP 2015," received a mean score of 3.63 and a standard deviation of 0.62, indicating that participants strongly agreed that such an application would be extremely helpful.

The sixth final statement, "I am interested to try an application in the future as an alternative solver software for wind and earthquake load calculations," received a mean score of 3.64 and a standard deviation of 0.57, indicating that participants strongly agreed that they were interested in trying an application in the future as an alternative solver software for wind and earthquake load calculations.

The participants firmly agreed that they would consider using the STRUCTOR application in their future profession, as evidenced by the seventh and final statement, "I would consider using the STRUCTOR Application in the future in my profession," which obtained a mean score of 3.61 and a standard deviation of 0.57.

In general, the survey's findings indicate that participants in the field of civil engineering strongly favor using software applications and mobile applications to calculate wind and earthquake loads and that they think doing so would be advantageous and effective. The findings also point to a sizable interest in and need for mobile applications that are simple to use, precise, and interoperable with already available load analysis software solutions.

The survey results are particularly essential for creating mobile applications for calculating wind and earthquake loads since they indicate the wants and preferences of professionals in the area. Based on these results, scientists went on to create the STRUCTOR mobile app, which attempts to meet these needs and preferences by offering a user-friendly interface, precise computations, and interoperability with well-known load analysis software applications.

3.2 STRUCTOR Application

3.2.1 Application Features

The STRUCTOR application is developed to analyze lateral loads affecting low- to mid-rise structures, particularly wind and earthquake loads. The application offers an easy-to-use interface that requires only a few inputs from users. The user must enter the following information to determine the building's earthquake load: the seismic zone factor, the type of soil profile, the type of seismic source, the closest location to the known seismic source, the total building height, the Ct value, the occupancy category, the number of stories, the numerical coefficient representative of ductility and overstrength, the weight of the structure per level, and the height per level from the building's base. After the parameters were entered, the STRUCTOR will automatically calculate the base shear and lateral force distribution acting on the structure. The height of the structure from the ground to the roofline, the horizontal dimension of the building measured normal to wind deflection, and the horizontal dimension of the building measured parallel to wind deflection is the only four inputs needed for a wind load analysis. The wind pressures under burst and suction circumstances are then calculated by the program.

Features in the STRUCTOR application make it a useful tool for engineers and students. It offers a straightforward, understandable method for precisely and swiftly analyzing structural loads. The user-friendly design of the application's input requirements makes it accessible to many users with prior industry experience.

To assure accuracy and dependability, the application's outputs underwent simulation, testing, and comparison to manual computations. The validation procedure has shown the software to be trustworthy and credible.

3.2.2 Limitations of the Application

- The application doesn't have the capability to solve a structure's total dead weight.
- The STRUCTOR application doesn't provide a detailed solution of the calculations for both wind and earthquake load.
- The STRUCTOR application can only solve the design base shear and distribution of lateral forces for earthquake load analysis.
- Manual input of basic wind speed for wind load analysis.
- For the wind load analysis, the application is exclusively dependent on exposure category C.
- The application is limited by the lack of a feature that enables users to calculate wind load pressures for structures that have roofs.

3.3 Alpha and Beta Testing of the STRUCTOR Mobile Application

Upon the completion of the mobile application, the researchers conducted alpha testing with the assistance of their research adviser. They utilized both the application and manual computations to determine wind and earthquake loads in order to evaluate the application's functionality. Following this, the researchers conducted a comparative analysis of the results obtained from each method of calculation, concluding that the results were consistent.

Upon completion of alpha testing, the researchers-initiated beta testing by administering survey questionnaires to a targeted population consisting of 50 fourth-year civil engineering students and 20 faculty members in the field of civil engineering. The principal purpose was to solicit crucial feedback and recommendations from future users of the STRUCTOR application. The survey used during the beta testing phase of the mobile application featured ten straightforward Yes/No questions in addition to more open-ended prompts that allowed the participants to share their perspectives in greater detail.

In Table 3.7 below, the researchers have compiled all user responses to provide an overview of their feedback and proposals regarding STRUCTOR's functionality.

Table 3.7 Summary of Beta Testing Responses on STRUCTOR Mobile Application

Questions	Yes	No
Does the Application have a well-developed and beginner-friendly user interface?	70	0
Did you find the application easy to navigate?	69	1
Do you think the mobile application needs any improvements in terms of functionality or features?	25	45
Did you encounter any technical issues while using the mobile application?	1	69
Did you find the mobile application to be accurate in its calculations of earthquake and wind load?	70	0
Was the mobile application efficient and quick in its calculations?	70	0
Did the application make it easy for you to calculate wind and earthquake loads?	70	0
Would you continue to use the application in the future?	70	0
Would you recommend the application to structural engineers and civil engineering students?	70	0
Is there anything else you would like to share about your experience with STRUCTOR?	18	52

According to the findings, all 70 respondents expressed that the application had a well-developed and user-friendly user interface. Similarly, they all agreed that the STRUCTOR exhibits precision, efficiency, and quickness in its calculation of the two lateral loads. Furthermore, a total of 69 respondents reported that the application is easy to navigate.

Nevertheless, some respondents provided comments and recommendations to enhance the mobile application, in terms of its features and performance. The following are comments and suggestions provided by respondents regarding the STRUCTOR.

"Very convenient to use."

"It would be very helpful in solving such loads, thus making someone save time."

"Provide units, step-by-step tutorials for beginners."

"Friendly interface, but wind load computation is too limited in scope."

"Add portal method."

"Specify units of values, program the limitations for the needed value inputs (type of data, decimal places, etc.), revise button names/captions for easier understanding."

"As an improvement of the application, if possible, it is better to include an option to generate the detailed calculations (earthquake/wind) to make it more functional for other users."

After carefully considering these suggestions, the researchers upgraded and enhanced the STRUCTOR application. However, due to a lack of time and money, not all of these can be addressed.

The survey's overall findings showed that beta testers generally liked the STRUCTOR program.

IV. Conclusion

Based on the outcomes derived from this research, the researchers conclude that the newly invented software displays considerable potential as an initial structural evaluation tool. In addition, the data collected thus far confirms how reliable STRUCTOR is at analyzing or forecasting details regarding earthquake or any other wind loading situations on diverse structures. To assist in outlining basic design parameters concerning building structures, the researchers have devised a simple yet efficient formula that is utilized by the application, allowing for easier calculations dealing specifically with earthquake or wind loadings. Not only does the STRUCTOR application simplify these key determinations, but it also supports the validation of manual calculations.

However, please do note that due to limitations concerning resource availability and time constraints, the ability of this program to compute accurate earthquake loads is restricted in the sense that it can only estimate base shear and lateral forces. Calculating wind loads requires users to input the basic wind speed, which may challenge some users. Moreover, the application's functionality is constrained by its reliance solely on exposure category C, which may not be universally applicable to all structures and geographical settings. Another area for improvement of the application is the absence of a feature that allows users to calculate wind load pressures for structures with angled roofs.

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