COMPARISON OF STRUCTURAL DESIGNS OF A LOW-RISE BUILDING USING NSCP 2010 VERSUS USING NSCP 2015

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ABSTRACT

The study compared the structural designs of a standard three-storey building in Apayao using the NSCP 2010 versus using the NSCP 2015. The existing plans of the building were used for the design of the building model. Dead loads, live loads, wind loads, and earthquake loads were the loads needed to be compared in the study. The data from these loads were simulated using STAAD and ETABS. Design adjustments were made during and after obtaining the output. The final analysis and evaluation were made using different parameters such as stresses, moment diagrams, shear reinforcements, and areas of steel reinforcements.

Keywords: *structural design; NSCP; ETABS; STAAD; loads*

INTRODUCTION

From the perfection of the pyramids of Egypt to the erection of the Burj Khalifa, it is proven that civil engineering has tremendously evolved throughout the years. It is with civil engineering that people from the ancient times continued to strive towards constructing facilities and infrastructures to satisfy their needs and provide safety for them. The ancient technology has been modified to modern advancement through innovation by utilizing the knowledge of science and mathematics with incorporation of engineering. [1]

The very concept of structural analysis has led into the construction of various structures. The fundamental methods and theories behind this structural analysis paved the way to formulating standard specifications of the design of a particular structure.

Building codes are one of the means of access formulated to be a guide in following standards for building structures. These building codes are further improved and developed as some of the factors being considered change from time to time. As such, the public welfare and safety, in the end, will always be the priority when it comes to construction of structures.

In the Philippines, the Association of Structural Engineers of the Philippines (ASEP) exists to provide necessary guidelines to standards and specifications in designing structural system which contributes to the welfare of the community as well as to give importance to the environmental sustainability. From this, the first edition of the National Structural Code for Buildings (NSCB) was introduced, and various editions were released—second edition in 1982, third edition in 1987, fourth edition in 1992, and fifth edition in 2001—until the release of the sixth edition which is the National Structural Code of the Philippines (NSCP) in 2010.[2]

The ASEP continues to improve and update the NSCP, for there is a need to meet the needs of new materials and new designs of structural systems. Currently, the seventh edition, the NSCP 2015, is being used.[2]

This study aimed to compare the structural designs of a low-rise building using NSCP 2010 versus using NSCP 2015. Specifically, it aimed to determine the effect of the changes in the combination of loads to the design of the structural members; to determine the effect of the additional live loads incorporated in NSCP 2015; to determine the effect of the geographical location-based wind contour maps incorporated in NSCP 2015 for the computation of the wind loads of the structure; and to determine the effect of the revised near-source factors for 2-km distance in the seismic design of the structure.

This project gave a comparison between the building codes used in construction. This would be of great help to the designers on whether what specifications should be considered and what code is better to use. The NSCP 2015gives new information about the codes and standards that can be passed by professors to their students. The project would help professors teach students how the old and the new code differ from one another, providing better understanding to them. It would be beneficial to students who intend to have a further study with regards to the topic. Moreover, they would already have a prior knowledge regarding the usage of the National Structural Code of the Philippines. This project could be a possible basis for the improvement of the structures to be built in the future, thus providing better service for the people in the community.

This research project covered the comparison of the design of the dead loads, live loads, wind loads, and earthquake loads of NSCP 2010 and NSCP 2015. It only covered changes and developments in the Chapter 2 – Minimum Design Loads, Sections 203, 205, 207, and 208. The foundation of the structure was not designed.

Theoretical Background

Literature Review

The National Structural Code of the Philippines provides civil and structural engineers the design and evaluation of buildings, towers, and other vertical structures around the Philippines since its first edition was published in 1972. It incorporates procurements to steel, concrete, timber, and masonry design and in addition for evaluating joined impacts of dead loads, live loads, wind loads, seismic loads, and other loads. [2][3]The building codes are used to protect life, well-being, and the environment as well. The purpose of these codes is to provide the necessary standards and specifications that should be used in the construction.

The National Structural Code of the Philippines is produced and updated by the Association of Structural Engineers of the Philippines (ASEP) and is affirmed by the Department of Public Works and Highways (DPWH), the national government organization ordered to uphold auxiliary norms in the Philippines. [2][3]Should there be any modifications, the aesthetic value of the structure should be maintained.

NSCP 2010 Wind Loads are based on ASCE 7-05. Wind loads are now updated according to ASCE 7-10 on NSCP 2015. [2]ASCE (American Society of Civil Engineers) 7 gives minimum load prerequisites for the design of structures. Loads and appropriate load combinations, which were produced to be utilized together, are put forward in two design methods: strength design and allowable stress design. [4][5] For different categories of building occupancies, ASCE 7-10 uses three different basic wind speed maps while ASCE 7-05 uses one basic wind speed map. Basic wind speeds that are directly applicable for determining pressures for strength design are provided in these three maps.

Using spectral acceleration, ASCE 7-10 is recognized as an alternative procedure in the determination of the earthquake loads instead of the previously used ASCE 7-05. [2] ASCE 7-10 requires liquefaction potential assessment utilizing mapped peak ground acceleration adjusted for site effects, as opposed to utilizing the ASCE 7-05 approximation for peak ground acceleration equal to the brief time frame spectral acceleration multiplied by a factor of 0.4. [5] The new maps give considerably more precise values for peak ground acceleration because they depend on peak ground acceleration attenuation relationships.

Dead Loads comprise of the weights of different structural members and the weights of any items that are permanently appended to the structure. Consequently, for a building, the dead loads incorporate the weights of the girder, beam, column, walls, floors, roofs, ceilings, stairways and other fixed equipment. Live Loads can be of different magnitude and location. They are caused by the weights of items briefly set on a structure.[6] In National Structural Code of the Philippines 2015, the table for minimum uniform and concentrated loads have additional live loads particularly the parking garage and ramp live load. Dead loads and live loads will be obtained from NSCP 2010 and NSCP 2015. ETABS will be used to analyse the data.

METHOD

Research Design

This study employed the engineering design method comparative type of research. The structure of a three-storey building was designed in accordance with NSCP 2010 and NSCP 2015. Comparisons of design analysis in each case were used to answer the research questions.

Research Instrument

Structural plans of a low-rise building designed using the NSCP 2010 building code were used as the basis of preliminary design of its structural elements. The provisions of the old code were used as the basis for the requirements needed for the design of the low-rise building. The provisions of the new code were used as the basis for the requirements needed for the design of the low -rise building. STAAD was used for the design of the steel truss, and ETABS to analyse and design the structure in both the old and new provisions.

Design Procedure

The building models were designed based from the structural plans of an existing three-storey building. Dead loads, live loads, wind loads, and earthquake loads were then obtained through the use of NSCP 2010 and NSCP 2015. These data and the design requirements, specifically the STAAD design of the steel roof truss, were transferred to ETABS and were analyzed to obtain the output. Design adjustments were made during the designing and after obtaining the output. The parameters for the comparison were defined, and the final comparison was made from the data gathered and results obtained.

RESULTS AND DISCUSSIONS

Failures of Structural Members

After the analysis, the following members failed:

Table 1. Failures of Structural Members

Second Floor	G-13, G-24, B-1, and B-12
Third Floor	B-1 and B-12

Percentage increase in the areas of shear reinforcements

The percentage increase in the areas of shear reinforcements of all the members (beams and girders) were tabulated using Microsoft Excel.

For the left bars, an average of 75.19% increase was obtained.

For the middle bars, an average of 71.19% increase was obtained.

For the right bars, an average of 51.27% increase was obtained.

Percentage increase in the Max and Shear max of failed members

For comparison, the percentage increase in the maximum moment and maximum shear of failed members were tabulated using Microsoft Excel.

Table 2. Percentage increase in the Max and Shear max of failed members

Beam / Girder	Maximum Shear Percent Increase (%)	Maximum Moment Percent Increase (%)
G13	790.58	1416.39
G24	101.66	75.16
B1 (2nd Floor)	109.53	35.98
B12 (2nd Floor)	63.41	13.94
B1 (3rd Floor)	81.61	6.81
B12 (3rd Floor)	64.17	14.51

T Test Results

To statistically determine if there is a significant change in the NSCP 2010 and NSCP 2015 design of the three-storey building, the researchers conducted a T test in the areas of steel reinforcements of the 2010 and 2015 design, using Microsoft Excel.

Table 3. T Test Results

	NSCP 2010	*NSCP 2015*
Mean	542.7351892	524.6009993
Variance	473666.9791	465374.8757
Standard Deviation	688.2346832	682.1839017
Observations	1401	1401
Hypothesized Mean Difference	0	
df	1400	
t Stat	4.403285397	
P(T<=t) two-tail	1.15E-05	
t Critical two-tail	1.961659905	

T Test: Paired Two Sample for Means

A paired-samples t-test was conducted to compare NSCP 2010 and NSCP 2015 designs. t Stat is greater than t critical. Therefore, there was a significant difference in the NSCP 2010 (mean = 542.74, SD = 688.23) and NSCP 2015 (mean = 524.60, SD = 682.18); t = 4.40, P = 0.0000115.

CONCLUSION

The main purpose of the study was to compare the structural designs of a three-storey school building using NSCP 2010 versus using NSCP 2015. A comparative approach was used to execute the analysis of the designs of both provisions. With the conducted analyses and results shown, the following conclusions are safe to generalize with regards to the designed standard three-storey building.

The difference in the load combinations used for the analyses shows that the designs in overall aspect changed significantly. As shown in the STAAD design of the steel roof truss, there was a difference in the computed reactions that were transferred to the ETABS design. In the ETABS analyses, it can be inferred that the changes in the combinations of loads had an impact in the failure of the whole system, i.e. some members failed after the analyses.

Additional live loads in the NSCP 2015 did not affect much of the results of the analyses. This is due to the additional live loads that were not applied or were not applicable for the designs of the structure. Moreover, most changes in the NSCP 2015 are for the parking garage and ramp live loads.

The changes in the geographical location-based wind contour maps incorporated in NSCP 2015 affected the designs of both provisions. A lot of differences were presented considering the wind loads applied to the structure. One instance is the difference of basic wind speed which has significantly contributed to the differences in the results of both analyses.

The revised near-source factors for 2-km distance in the seismic design of the structure had a significant change as shown in the results of the analyses.

Overall, the study shows that there is a significant change in the design of the standard three-storey building using NSCP 2010 and NSCP 2015. This is mathematically shown by the large percentage increase of the areas of shear reinforcement and the maximum shear and maximum moment of failed members and statistically proven by the T test. Therefore, NSCP 2015, in this particular structure, is the building code that should have been used by the designers and civil engineers involved in the construction.

RECOMMENDATIONS

The following are the recommendations based on the analyses and results gathered in the study. It is suggested to the researchers to address to the professionals involved in the construction the concern regarding the failed members in the design of the standard three-storey structure using NSCP 2015.

The building or the structure to be used such further studies will be done can be a high-rise building. In this way, a lot of parameters can be put into the analysis and can be used for better comparison. Moreover, an irregularly shaped structure may be used.

In the future studies, it is recommended that the foundation of the substructure be designed, for a lot of factors may be affecting the analysis of the structure.

Other loads can also be taken into consideration such as the flood load, soil pressure, temperature loads, and fluid loads for better comparison.

Comparisons regarding the revised NSCP 2015 code must be further studied, and comparisons of building codes and/or other revised building codes must be further studied as well.

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