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Inspection of Leveling and Verticality of Silo Foundations Due to Settlement Based on SNI 8460: 2017

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ABSTRACT

The foundation is the most essential structural element of a building structure. A solid and stable foundation is a critical factor in ensuring the sustainability and safety of a building. Proper planning and calculations are essential in designing the foundation to withstand the structural loads from the building above it and ensure that the foundation does not experience dangerous settlement or collapse. In this research, the author conducted a study or examination of the condition of Silo Foundation PT XYZ is located in the Tangerang. The number of silo foundations built was 7 units (silo 17, silo 18, silo 19, silo 20, silo 21, silo 22 and silo 23). This silo is a vertical storage structure that functions as a place to store raw materials for animal feed. The condition of the silo foundation structure is known to have decreased after being filled to a maximum capacity of 5000T. To determine the condition of the foundation structure, it is necessary to carry out a measurement survey by checking levelling and verticality using reference standards or rules used by SNI 8640:2017. The results of foundation levelling tests for silo 17, silo 18, silo 19, silo 20, silo 21, silo 22 and silo 23 in Balaraja District, Tangerang Regency, there is the most significant elevation difference occurring at silo 19, namely 127 mm, which is based on SNI Geotechnical 8460-2017 Maximum building settlement is included in High Risk because the settlement is > 75 mm. The elevation differences in the other silos fall into the Small Risk to Medium Risk categories. Meanwhile, based on the results of checking verticality, it was found that the slope value of the structure in Silos 18, 19 and 21 experienced a slope that exceeded the maximum required permit limit of 20mm. Therefore, it is necessary to carry out regular inspections to monitor the movement or decline of the silo foundation so as not to cause risks or conditions of structural failure.

Keywords: *Levelling; Verticallity; Silo Foundation; SNI 8460:2017.*

INTRODUCTION

Concepts in planning building structures must meet the following criteria [1], [2], including:

1. Strong to with stand the planned load
2. Meet serviceability requirements
3. Has high durability
4. Suitability to the surrounding environment
5. Economical

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6. Easy to maintain

Apart from that, there are several principles for planning earthquake-resistant buildings that must be considered [3], [4]:

1. The structural system used must be appropriate to the level of vulnerability (seismic risk) where the building is being built
2. Details of reinforcement, connections and building elements must be bonded effectively into one unit
3. Concrete and steel materials must meet the requirements for earthquake-resistant buildings

The planned building structure must be able to withstand the loads acting on the building structure. These loads include dead loads, live loads and earthquake loads [5]. According to SNI 1727:2020 concerning loads, the definition of these loads is as follows:

1. Dead load is the weight of all installed building construction materials, including walls, roof floors, ceilings, stairs, fixed partition walls, finishing, building cladding and other architectural and structural components, and other installed service equipment, including the weight of taps.
2. Live loads are loads caused by users and occupants of buildings or other structures, and they do not include construction and environmental loads, such as wind, rain, earthquake, flood, or dead loads.
3. Earthquake loads are all equivalent static loads acting on a building or part of a building that imitate the effects of ground movements caused by the earthquake. If the impact of an earthquake on a building structure is determined based on a dynamic analysis, what is meant by earthquake load here is the forces within the structure that occur due to ground movements due to the earthquake.

The design of building structures must use regulations set by the government, including [6] [7]:

1. Minimum load for the design of buildings and other structures (SNI 1727:2020)
2. Structural Concrete Requirements for Buildings (SNI 2847:2019)
3. Procedures for Earthquake Resistance Planning for Building and Non-Building Structures (SNI 1726:2019)

Meanwhile, for foundation structures based on SNI 1726: 2019, parts must be designed to withstand the resulting forces and accommodate movements transmitted to the structure and foundation by designing seismic ground motion. The dynamic nature of the troops, the expected ground motion, the design basis for the strength and energy dissipation capacity of the structure, and the dynamic properties of the soil must be included in determining the foundation design criteria.

In building construction, the foundation is the most essential structural element. A solid and stable foundation is a critical factor in ensuring the sustainability and safety of a building. Proper planning and calculations in designing the foundation are essential to withstand the structural loads from the building above it and ensure that the foundation does not experience dangerous settlement or collapse. Meanwhile, the foundation requirements are based on SNI 8460: 2017 [8]; the foundation structure must meet the following criteria [9]:

1. Structural strength requirements: the foundation must be strong enough to accept the loads acting on it. In principle, Foundations burdened by their structural capacity will experience disaster.

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2. Serviceability requirements: besides having to be strong enough to carry the load on it, the foundation must also be able to function well due to the service loads acting on it. Requirements that must be met include, among others, settlement, lateral movement, vibration, durability and so on.

In this case study research, the author conducted a study analysis of the condition Silo Foundation in PT. XYZ is located in the Tangerang. The number of silo foundations built was 7 units. This silo is a vertical storage structure that functions as a place to store raw materials for animal feed. The condition of the silo foundation structure is known to have decreased after being filled to a maximum capacity of 5000T. After several weeks of observation, the foundation structure experienced cracks in several parts of the pile and bottom plate. To determine the condition and suitability of the foundation structure to withstand the working load, it is necessary to carry out a measurement survey regarding the levelling and verticality of the foundation condition [10], [11].

METHOD

The implementation method that was decided to resolve the above problems was first by studying and reopening the technical documents of the design structure for scrutiny before carrying out the inspection. The data sourced from these documents must be verified by field inspection. Meanwhile, essential data that is unavailable must be obtained through field inspection. The structural technical documents include the following:

1. Planning documents and drawings
2. Documents and implementation drawings (As-built-drawing)
3. Material certificate documents and material test results

The levelling test aims to determine differences in elevation in the building so that areas that experience subsidence can be identified. Verticality testing seeks to determine the slope of the building when viewed from the sides of the building vertically. So you can know the slope of the building vertically. Levelling and verticality equipment consists of:

1. Tripods
2. Measuring Signs
3. Water level
4. Theodolite (Figure 1)
5. Meter

Figure 1. Theodolite

The planning data to support checking the condition of the silo foundation and Pile piles will be checked using the following data:

1. Structure Name : Silo Foundation PT. XYZ
2. Foundation Unit Names : Silo 17, Silo 18, Silo 19, Silo 20, Silo 21, Silo 22, Silo 23
3. Location : Balaraja - Tangerang Regency
4. Main Structure : Concrete Structure

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5. Foundation : Spun Pile dia 45cm

The stages of research and testing or inspection in the field for collecting data using a theodolite are carried out in the following stages as show in Figure 2:

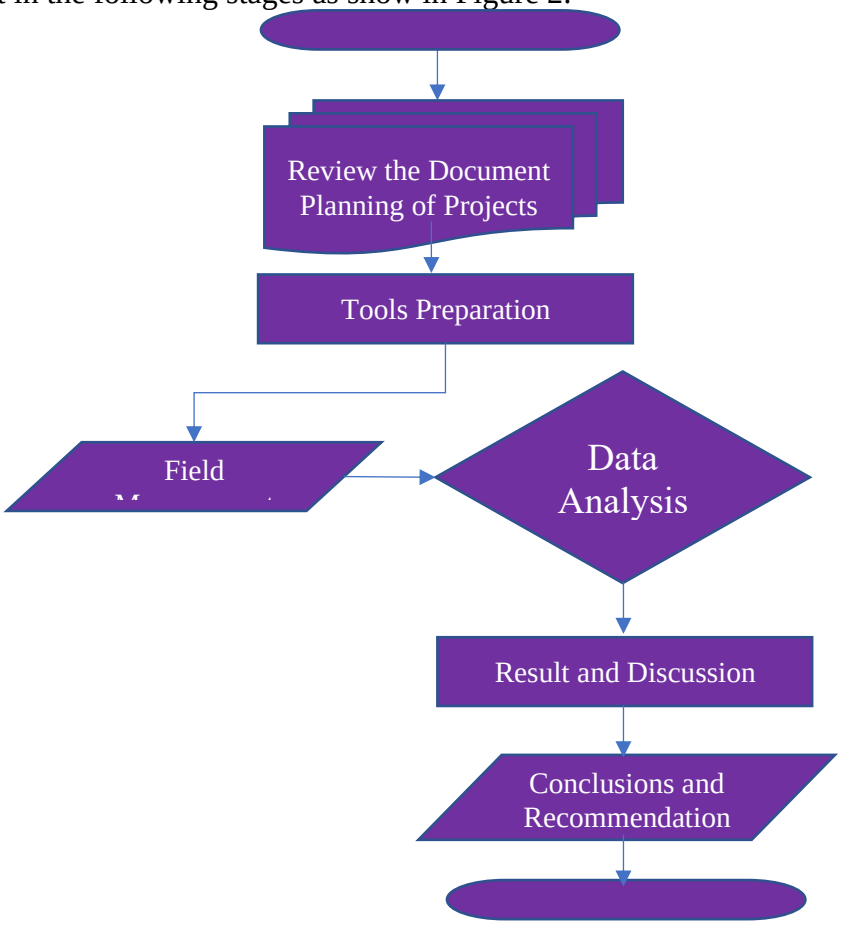

Figure 2. Levelling dan Verticality Testing Flowchart

The results of building levelling and verticality measurements aim to determine whether the levelling or foundation slope reduction value still meets the slope tolerances permitted by applicable regulatory standards. Thus, based on the results of these measurements, the following appropriate action can be determined so that the foundation can still meet the needs according to its function.

RESULTS AND DISCUSSION

Results of checking the condition of the silo foundation structure by checking levelling and verticality at PT. XYZ is located in Balaraja District - Tangerang Regency, which has 7 units (silo 17, silo 18, silo 19, silo 20, silo 21, silo 22 and silo 23) which experienced a decrease after filling with a maximum capacity of 5000 tons. It can be seen in the layout as shown in Figure 3 and Figure 4.

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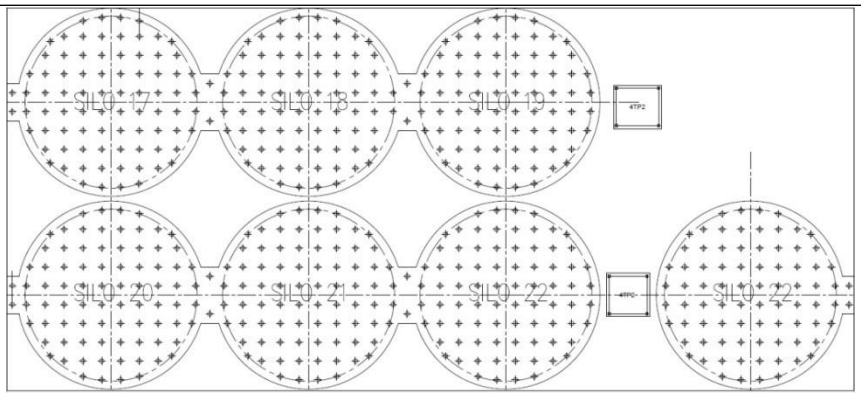

Figure 3. Silo Layout Foundation

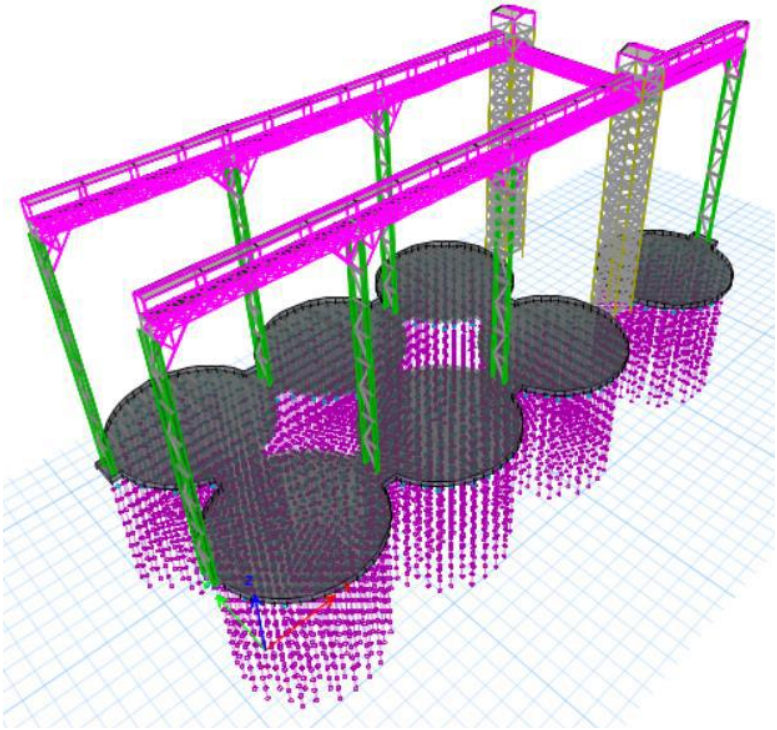

Figure 4. Silo Foundation Modeling

In the analysis of the results of the foundation settlement inspection using levelling and verticality tests that have been carried out, the requirements for foundation settlement according to SNI 8460:2017 are view in Table 1.

Table 1. Building Settlement of Standard by SNI 8460:2017

No	Maksimum Building Settlement (mm)	Risk Description
1	< 10	**Abandoned** because damage was minimal
2	10 to 50	**Minor/Small Risk** because the damage is very shallow and does not constitute significant structural damage

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3	50 to 75	**Moderate/Medium Risk** due to superficial damage with expected structural damage
4	> 75	**High** due to structural damage to the building

Levelling tests using a theodolite to check the foundation settlement of silos 17, silo 18, silo 19, silo 20, silo 21, silo 22 and silo 23 in Balaraja, Tangerang Regency, obtained results as in Table 2.

Table 2. Silo Foundation Levelling Test Result

No	Unit	Elevation Difference (mm)	Allowable Limit (mm)	Description
1	Silo 17	56	50 - 75	Medium Risk
2	Silo 18	54	50 - 75	Medium Risk
3	Silo 19	127	> 75	High Risk
4	Silo 20	48	10 - 50	Small Risk
5	Silo 21	61	50 - 75	Medium Risk
6	Silo 22	25	10 - 50	Small Risk
7	Silo 23	18	10 - 50	Small Risk

The results of the levelling measurements in Table 2 show that the most significant elevation difference occurred at silo 19, namely 127 mm, which is based on SNI Geotechnical 8460-2017. The maximum building subsidence is included in high risk because the subsidence is > 75 mm. while the elevation difference in the other silos falls into the small to medium risk category.

Meanwhile, verticality measurements are intended to determine the level of precision or uprightness of the silo foundation structure. Measurements were carried out on the silo foundation pile columns using a Theodolite with the results obtained can be seen in Table 3.

Table 3. Silo Foundation Verticality Test Result

No	Unit	Slope of Foundation Structure in X Direction (mm)	Slope of Foundation Structure in Y Direction (mm)	Maximum Slope Allowable Limit 1% of Structure Height (mm)	Description
1	Silo 17	16	14	20	OK
2	Silo 18	-22	27	20	NOT OK
3	Silo 19	28	30	20	NOT OK
4	Silo 20	16	18	20	OK
5	Silo 21	17	-27	20	NOT OK
6	Silo 22	-15	18	20	OK
7	Silo 23	15	-16	20	OK

The verticality test results in Table 3 above show that the slope value of the structure in Silos 18, 19 and 21 experienced a slope that exceeded the allowable limit of >20mm, which is required by SNI 8460:2017.

CONCLUSION

The results of foundation levelling tests for silo 17, silo 18, silo 19, silo 20, silo 21, silo 22 and silo 23 in Balaraja District, Tangerang, there is the most significant elevation difference occurring at silo 19, namely 127 mm, which is based on SNI Geotechnical 8460-2017 Maximum building settlement is included in High Risk because the settlement is > 75 mm. The elevation differences in the other silos fall into the Small Risk to Medium Risk categories. Meanwhile, based on the results of checking verticality, it was found that the slope value of the structure in Silos 18, 19 and 21 experienced a slope that exceeded the maximum required permit limit of 20mm. Therefore, it is necessary to carry out regular inspections to monitor the movement or decline of the silo foundation so as not to cause risks or conditions of structural failure.

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