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Assessment of the Crack Level in Silo Foundations Due to Settlement

Yosie Malinda[1*], Desiana Vidayanti[2], Zel Citra[3]
[1,2,3] Civil Engineering, Faculty of Engineering, Universitas Mercu Buana, Indonesia
*Corresponding author, email: yosie_malinda@mercubuana.ac.id

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ABSTRACT

A silo is a structure used to store bulk materials (bulk materials). Silos are generally used in agriculture as storage for grains and animal feed. The foundation silo must be designed to withstand the forces generated and accommodate the movements transmitted to the structure and foundation by the seismic ground motion design. The dynamic properties of the soil, the anticipated ground motion, the design basis for the strength and energy dissipation capacity of the structure, and the dynamic characteristics of the soil should be included in determining the foundation design criteria. In PT X, SILO structure serves as a place for livestock feed production, with the hope that it can last for a relatively long time. The condition of the existing SILO structure is currently some cracks in several parts of the piles and the bottom slab. The results of the visual inspection in the field regarding the condition and level of cracking in the silo foundation were compiled into a matrix inspection table using four categories: category 1 indicates no repairs needed, category 2 marked in green, represents an acceptable cracking condition with minor repairs, category 3 marked in yellow indicates moderate cracking that requires attention, and category 4 marked in red signifies major cracking or unacceptable conditions that require structural repairs. The results of the field inspection indicate that approximately 57% of the concrete slab foundation of the silo requires needs attention or repair. The condition of the plate/slab structure has some cracks measuring 0.3mm - 0.5mm, but injection and patching have been carried out. As for the condition of the silo foundation, about 30% requires needs attention and repair as well.

Keywords: *Foundation, Pile, Slab, Crack, Silo*

INTRODUCTION

In building construction, the foundation plays a very important role. This is because the foundation serves as an underground structure that transfers the load from the weight of the foundation itself and the weight of the building above it to the underground layers below [1] [2]. Tthe foundation is the lowest structural component of a building that transfers the building's load to the soil or rock beneath it. In general, foundations are divided into two classifications: shallow foundations and deep foundations. A shallow foundation is defined as a foundation that can only support relatively small loads and directly bears the weight of the structure. A deep foundation is defined as a foundation that can support large building loads and transfer the weight of the structure to hard soil or rock that is very deep [3] [4].

The foundation must be designed to withstand the forces generated and accommodate the movements transmitted to the structure and foundation by the seismic ground motion design. The dynamic properties of the soil, the anticipated ground motion, the design basis for the

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strength and energy dissipation capacity of the structure, and the dynamic characteristics of the soil should be included in determining the foundation design criteria [5]. The foundation system must succeed before the upper structure. If this goal is to be achieved, then the combination of internal loads must also be reviewed in the foundation design, including more appropriate strength factors [6] [7] [8]. The materials used for the design and construction of foundations must meet the requirements and additional criteria for foundations on soil that has the potential for liquefaction [9].

A silo is a structure used to store bulk materials (bulk materials). Silos are generally used in agriculture as storage for grains and animal feed. Outside of agriculture, silos are used to store coal, cement, wood chips, and sawdust. Three types of silos are widely used to this day, namely tower type, bunker type, and bag type. In loading bulk materials into a silo, a grain elevator mechanism such as conveyors (belt conveyors, air conveyors, bucket conveyors), augers, and hoppers is required, depending on the type of bulk material being loaded. The filling is done from the top level, so those that enter first will be at the bottom. Meanwhile, the bulk material is taken from the bottom. Depending on the materials loaded, the environmental control inside can vary. Controlling the humidity in the air is necessary and should be adjusted to the equilibrium moisture content of the material if a long storage time is desired.

One of the largest feed companies in Indonesia is PT X, which produces the largest feed and processed food in the country. The case study for this research is from the Expand SILO Structure of PT. X located on Jalan Raya Serang, Tangerang Regency. The Expand SILO structure serves as a place for livestock feed production, with the hope that it can last for a relatively long time. The condition of the existing SILO structure is currently some cracks in several parts of the piles and the bottom slab. Therefore, it is very important to conduct an analysis of the current condition and feasibility of the existing SILO structure in withstanding the working loads. This aims to assess its utility based on safety factors and maintenance. To assess the feasibility of the existing SILO structure, a visual inspection for check of the crack level due to settlement. It is expected to obtain the results of the feasibility information of the existing SILO structure through structural analysis so that it can provide recommendations for repairs/strengthening if necessary.

METHOD

The research method employed includes coordination with relevant parties, such as the owner and the engineering team of the company, to determine the direction of activities and the process of synchronizing plans related to the coordination of inspections on the structure, reviewing documents, and existing data from the owner. The technical documents of the structure owned by the owner are very important to review before conducting the inspection. Data sourced from the document must be verified through field inspections if deemed necessary. Meanwhile, important data that is not available should be obtained through field inspections. Technical, structural documents include:

1. Planning documents and drawings
2. Execution documents and drawings (As-built drawings)
3. Documents certifying materials and test results of materials

The technical specification data for the silo foundation is as follows:
Structure Name : Silo Foundation PT. X (Code: 17,18,19,20,21,22,23)

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Number of Floors : 1 Floor
Structure Type : Reinforced Concrete Silo Foundation
Pile Foundation : Spunpile D45cm
Concrete Compressive Strenght : K550

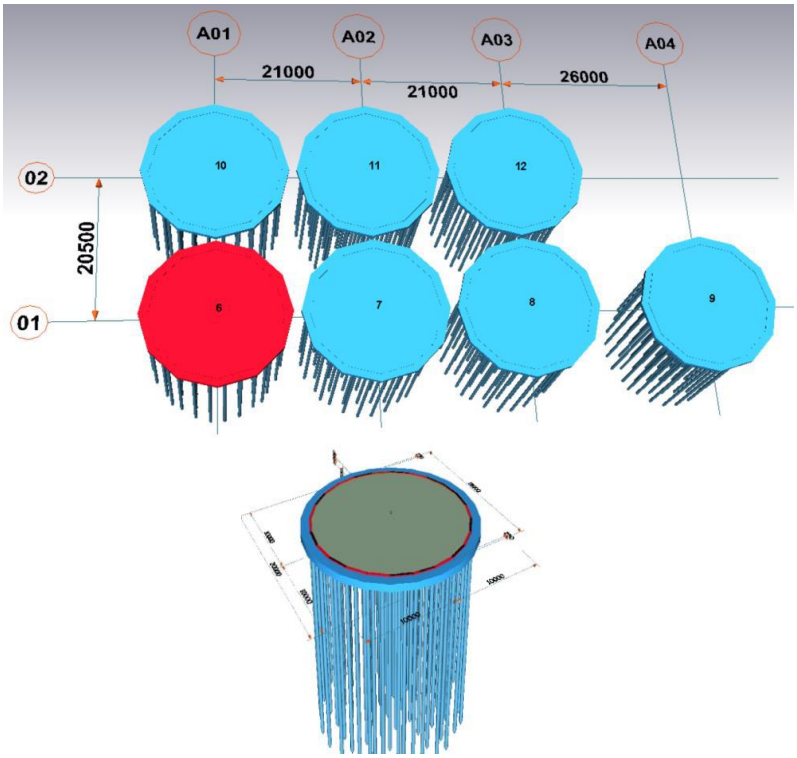

Figure 1. Silo foundation modeling

RESULTS AND DISCUSSION

Foundation conditions in the field are a type of general visual inspection conducted on structural elements and their environmental conditions aimed at obtaining data and information regarding the structure. The visual inspection is carried out using the sense of sight and standard measuring tools to examine each structural element, which will then be documented along with the type of structural element and its location.

Table 1. Matrix of Result Inspection Silo Foundation

Schedule Sign Off		
No	Colour	Description
1	N / A	For items that are not part of building's system
2	Acceptable	When the item fully functional, properly maintained, and capable of withstanding inclement weather that may occur
3	Needs Attention	When the item requires general maintenance or replacement before it reaches the point of failure
4	Not Acceptable	When the item requires repair, maintenance or replacement in the near future (could be subject to failure)

From the Tabel 1. The results of the visual inspection in the field regarding the condition and level of cracking in the silo foundation were compiled into a matrix inspection table using

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four categories: category 1 indicates no repairs needed, category 2 marked in green, represents an acceptable cracking condition with minor repairs, category 3 marked in yellow indicates moderate cracking that requires attention, and category 4 marked in red signifies major cracking or unacceptable conditions that require structural repairs.

Table 2. Silo Foundation Condition

Silo 17	
 	- The condition of the plate/slab structure has some cracks 0,45mm, but injection and patching have been carried out.
	- The condition of the spun pile structure has cracks in several areas.

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Silo 18	
 	- The condition of the plate/slab structure has some cracking, but it has already been coated with carbon fiber FRP.
	- The spun pile condition has some cracks, but it has already been coated with FRP carbon fiber.

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Silo 19	
 	- The condition of the plate/slab structure has some cracks 0,4mm – 0,5mm.

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- The condition of the spun pile structure has cracks in several areas.

Silo 20

- The condition of the spun pile structure is still quite good.

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- The condition of the plate/slab structure has some cracks 0,3mm – 0,4mm.

Silo 21

- The condition of the plate/slab structure has some cracks 0,4mm – 0,5mm.

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- The spun pile condition has some cracks, but it has already been coated with FRP carbon fiber.

Silo 22

- The condition of the plate/slab structure has some cracks 0,35mm – 0,5mm.

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- The spun pile condition has some cracks, but it has already been coated with FRP carbon fiber.

Silo 23

- The condition of the plate/slab structure has some cracks 0,35mm, but injection and patching have been carried out.

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 	 - The spun pile condition has some cracks, but it has already been coated with FRP carbon fiber.

The results of silo foundation condition after inspection and visual check the field based on images the matrix table above revealed several cracks in the spun pile foundation columns, with cracks in the foundation slab ranging from 0.3mm to 0.5mm. However, some of the cracks in both the foundation structure and the foundation slab have already been repaired through injection and coating with carbon fibre FRP. Subsequently, a recapitulation of the silo foundation structure conditions has been presented in the graph below:

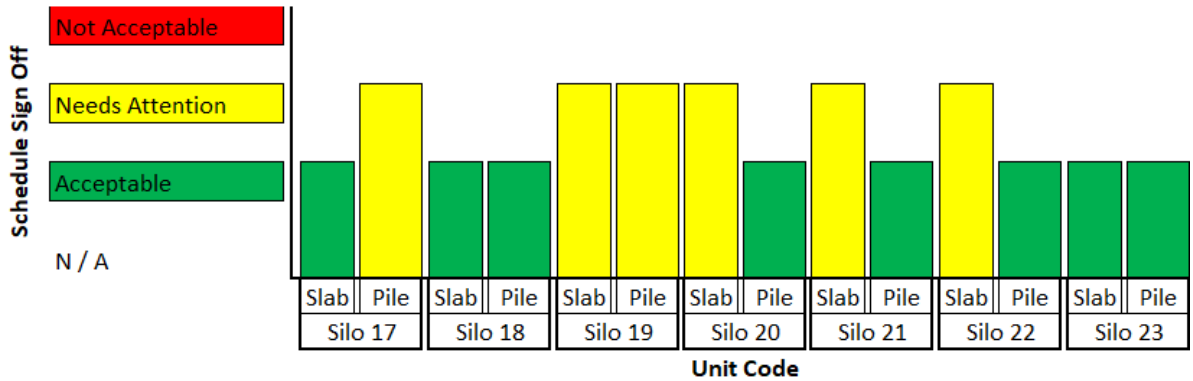

Figure 3. Graph of slab and pile silo's condition

CONCLUSION

Foundation conditions in the field are a type of general visual inspection conducted on structural elements and their environmental conditions aimed at obtaining data and information regarding the structure. The condition of the existing SILO structure is currently

some cracks in several parts of the piles and the bottom slab. The results of the visual inspection in the field regarding the condition and level of cracking in the silo foundation were compiled into a matrix inspection table using four categories: category 1 indicates no repairs needed, category 2 marked in green, represents an acceptable cracking condition with minor repairs, category 3 marked in yellow indicates moderate cracking that requires attention, and category 4 marked in red signifies major cracking or unacceptable conditions that require structural repairs. The results of the field inspection indicate that approximately 57% of the concrete slab foundation of the silo requires needs attention or repair. The condition of the plate/slab structure has some cracks measuring 0.3mm - 0.5mm, but injection and patching have been carried out. As for the condition of the silo foundation, about 30% requires needs attention and repair as well.

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