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Assessment of the Structure of the Bappeda Building in Kutai Kartanegara Regency

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***Abstract*— *Since 2019, The Bappeda Building has suffered severe damage, including some cracked walls and cracked tile floors. The damage to this building is thought to be triggered by several factors, such as unstable soil structure and vehicle access that passes beside the Bappeda Building, causing vibrations to the building. The evaluation of the workshop building begins with collecting data in the form of as built drawings, results of inspections for damage to buildings, results of inspections of non-destructive tests and results of soil tests. Furthermore, structural analysis was carried out using the SAP 2000 program to determine the strength of the building and plan the required reinforcement. The results of the analysis show that the structure in the north of the Bappeda Kukar building is unable to withstand the load and the foundation settlement happened, so it is necessary to strengthen the foundation. Structural reinforcement in the form of the addition of 2 drill piles with a diameter of 60 cm and a depth of 32 m, and on top of it is installed using WF 800 mm x 300 mm x 14 mm x 26 mm beams wrapped in concrete which serves as the pedestal of the existing foundation.*

***Keywords*— *Building Assessment, Foundation Reinforcement, Structural Damage.*

I. INTRODUCTION

The Regional Development Planning Agency or Bappeda Kutai Kartanegara building is located in the Kutai Kartanegara Regent's Office Complex, St. Wolter Monginsidi, Timbau, Tenggarong, Kutai Kartanegara Regency, East Kalimantan, Indonesia. The building with a building area of 2,041 m^2 consists of 4 floors and has been in use since 2010.

Fig. 1. Building location

In 2019 this building began to experience damage in several parts, including part of the walls cracked, broken glass doors and windows, cracked tile floors and part of the ceiling collapsed. The damage to the building is estimated to have been triggered by several factors, such as the unstable soil structure and vehicle access next to the Bappeda Building which has direct access to and from the Kukar Bridge, causing vibrations that affect the structure of the Tenggarong Bappeda Building.

Fig. 2. The front view of the building

Fig. 3. Damage to the Bappeda Kukar building

This condition makes all employees/staff working in the building worried if the building they live in collapses. For this reason, it is necessary to conduct research to assess the Bappeda building of Kutai Kartanegara Regency, namely by analyzing the structure of the Bappeda Kutai Kartanegara building in its existing condition and to determine the necessary structural strengthening so that the building can be re-functioned.

II. LITERATURE REVIEW

The concept of building planning needs to pay attention to planning criteria so that it is safe and comfortable to live in and beautiful to look at. In every building construction, technical requirements must be fulfilled that the building must be strong to accept design loads such as dead loads, live loads, wind loads, and earthquake loads. Thus, in the planning stage

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it must be guided by the applicable regulations and must meet the existing technical requirements.

Failure of a building structure in addition to damaging the building also causes accidents that can cause injuries and even fatalities due to falling material. In addition, property damage from the former building collapse requires time to clean, repair and costs money to return to normal.

With the demand that buildings that are damaged must be able to function again as soon as possible, it is necessary to deal with the damage that occurs, either by carrying out repairs or strengthening. Often, with limited time, the repairs or reinforcements carried out do not pay attention to several principles related to the capacity of the structure and implementation procedures as well as quality control.

Therefore, in order to obtain effective repair and strengthening results and achieve the set goals, it is necessary to carry out an investigation to obtain damage data either through visual observation or with the help of non-destructive and semi-destructive testing and review documents of existing structures. From the results of the investigation, an analysis and evaluation is then carried out on the structure to determine whether the damage that occurs only needs repair or needs strengthening or in the worst condition the damaged structure must be demolished and a new structure built.

A. *Types and Causes of Building Structure Failure*

Construction Services Law No.18/1999 Article 1 explains that building failure is the state of the building, which after being handed over by the service provider to the service user, becomes non-functioning either partially or as a whole not in accordance with the provisions contained in the construction work contract or its utilization is deviated as a result of the fault of the service provider and/or service user

B. *Causes of Building Structure Failure*

Some of the common causes of building failure tend to be due to improper planning and implementation of work that is not in accordance with existing references. The use of materials that do not conform to the reference and design failures that occur during the pre-construction stage and operational errors that occur during the construction phase are among the many factors. Errors that arise pre-construction and during the construction phase have the greatest potential effect on the final project outcome.

Building damage can occur due to three parties involved, namely the Consultant, Contractor, and Developer/Owner. In practice, the consultants and contractors may have provided control and supervision of field operations and insufficient quality control, as well as a lack of supervision of the implementation of work from the supervisor owner resulting in deviations in the quality of materials or others.

Below are some of the causes of structural failure:

1) Lifespan/serviceability of the building
2) Disaster
3) Maintenance
4) Planning error
5) Operational error
6) Errors in the feasibility study process
7) Errors in implementation
8) Interior work value
9) Foundation failure

Many building foundations are not properly designed and constructed for the soil conditions at the site, for example the soil has poor bearing capacity or is inadequate to support the weight of the structure.

Movement of the foundation can occur if soil coating and drainage are not uniform, as inadequate drainage, pipe leaks, and evaporation, can cause soil variations. The topsoil provides the bearing capacity to hold up the structure and ensures the stability of the foundation. If the bearing soil is not sufficiently compacted prior to construction, the chances of structural failure are enormous.

C. *Structural Repair Methods and Materialse*

In choosing a reinforcement method, several things must be considered, namely the capacity of the structure, the environment in which the structure is located, the equipment available, the ability of the implementing staff and the limitations of the owner such as limited work space, ease of implementation, implementation time and cost of reinforcement. The most common reinforcement methods are:

1) Shorten the span of the structure with concrete construction or with steel construction.
   The aim is to minimize the internal forces that occur, but it must be re-analyzed as a result of this shortening of the span which causes changes in these internal forces. Generally done by adding beams or columns of either concrete or steel.
2) Enlarge dimensions than concrete construction.
   Generally used concrete as a material to enlarge the dimensions of the structure; with the introduction of a new generation of concrete admixtures, it is possible to produce self-compacting concrete, explained in section 4 – Self Compacting Concrete. As a result of the addition of these dimensions, it must be considered that the overall load of the building increases, so a thorough analysis must be carried out from the superstructure to the foundation.
3) Add steel plate.
   The purpose of this addition is to increase the tensile strength of the building structure. In adding the steel plate, it must be guaranteed that the steel plate becomes one unit with the existing structure, generally to ensure the bond between the steel plate and the concrete structure, epoxy adhesive is used.
4) Perform external prestressing.
   With this method, the capacity of the structure is increased by prestressing the outside of the structure, not inside as in a new structure. What needs to be considered is the placement of the anchor head, so it does not cause a weakening of the existing structure. The material generally used is prestressed steel, but at this time the material from FRP (Fibre Reinforced Polymer) has begun to be used.
5) Using FRP (Fibre Reinforced Polymer)
   The principle of adding FRP is the same as adding steel plates, namely increasing the strength in the tensile part of the structure. The type of FRP that is often used in

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strengthening structures is made of carbon, aramid, and glass. The forms of FRP that are often used in structural reinforcement are plate / composite and fabric / wrap. Plate shape is more effective and efficient for flexural reinforcement both on beams and plates as well as on walls; while the wrap form is more effective and efficient for shear reinforcement in beams and for increasing the axial and shear load capacity of columns.

6) Self Compacting Concrete
Commonly abbreviated as SCC is fresh concrete that is very plastic and easy to flow because its own weight fills the entire mold because the concrete has the properties to compact itself, without the help of a vibrator. Good SCC concrete must remain homogeneous, cohesive, non-segregating, no blocking, and no bleeding. The use of SCC concrete as a repair material can improve the quality of repair concrete because it can avoid some of the potential for human error due to manual compaction. Improper compaction during the casting process can result in reduced concrete durability. On the other hand, with SCC concrete, the repair concrete structure becomes denser, especially in dense iron areas, and the casting time is also faster.

D. *Foundation Improvement Method*

To prevent further settlement, the foundation design is designed on the side of the foundation which has decreased as shown in Figure (4). From the calculation results, the foundation design is obtained as follows.

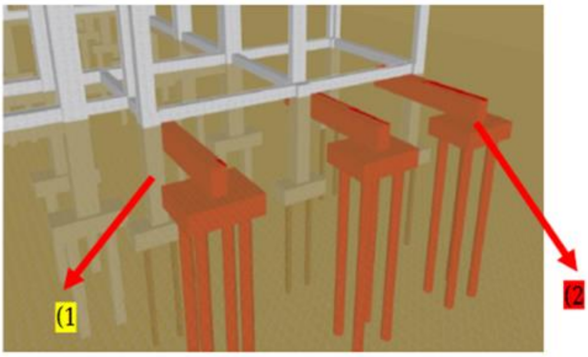

Fig. 4. Foundation repair sketch

At point (yellow 1) the foundation has decreased because it cannot withstand the weight of the building. At point (red 2) a new foundation is made to withstand the load on the foundation (yellow 1) so that the foundation does not experience a settlement later.

III. Research Methodology

In general, the research method used is described in the following steps:

A. *Data Collection*

1) Collect as-built drawing data,
2) Collecting data on plate, beam, column, and foundation dimension,
3) Collect data on the results of non-destructive testing,
4) Collect data on the results of soil testing.

B. *Image Verification and Test Result Data*

1) Verify the distance between the axles of the building columns taken by sampling by comparing them to the drawings,
2) Verify the dimensions of the columns, beams, and building slabs taken by sampling by comparing the drawings,
3) Recapitulation of test results data.

C. *Field Data Processing*

1) Recap the visual inspection results based on the findings at each observation location,
2) Analyze all processed data and compare them with applicable standard values.

D. *Structural Analyze*

1) Structural modeling and input loading on buildings according to the results of document review and processing of test results using SAP 2000 software to determine the reliability of the structure (operability feasibility) according to the existing conditions.

E. *Structural Stengthening Method*

1) Determine the reinforcement method requires for the structure of the Kutai Kartanegara Bappeda Building.

F. *Conclusions and Suggestions*

1) Formulate conclusions
2) Make suggestions.

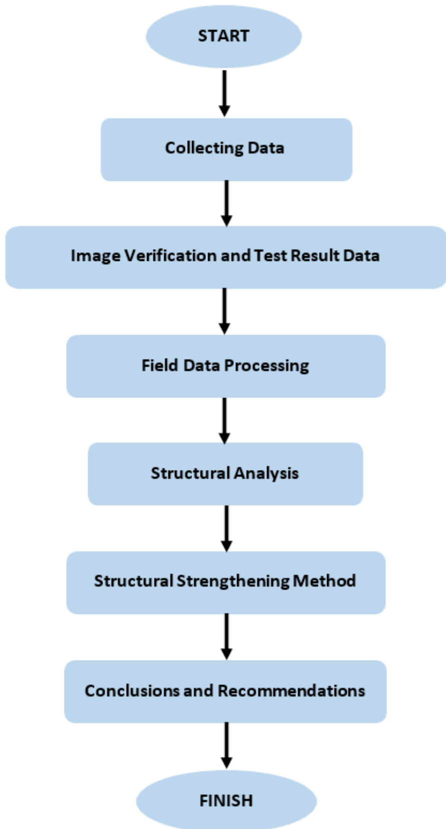

Fig. 5. Assessment flowchart

IV. RESEARCH RESULTS AND EXPLANATION

A. *Concept of Structural Analysis*

From the evaluation of the field inspection data, it was found that the north/back side of the Bappeda Kutai Kartanegara building experienced a settlement due to the subsidence of the land around it. This resulted in the building being damaged, including some of the walls were cracked, broken glass doors and windows, cracked tile floors, and part of the ceiling collapsed.

Furthermore, checking the analysis of beams, columns, and plates based on the results of field inspection with the applicable regulatory reference standards in order to obtain the maximum load received by the foundation. The structure is modeled as a dual system with a reinforced concrete frame bearing special moments which is clamped on the ground floor and consists of columns, beams, and slabs modeled using the SAP2000 computer program version 14. From this analysis, axial forces will be obtained acting on each column.

B. *Structural Modeling*

1) Structural analysis method
   Assumptions and limitations used in the analysis:
   - 3D portal structure modeling using the SAP2000 version 14 program.
   - The main elements are columns, beams, and sloofs as frame elements.
   - The dead load comes from its own weight and additional dead loads as well as other supporting elements which are attached to Portal Loading Calculation 1-1.
   - The review was carried out on the attached portal (Portal 1-1).
2) Structural analysis
   - The structural analysis model is as shown in the following figure. 2D modeling with frame elements to model sloofs, columns, and beams.

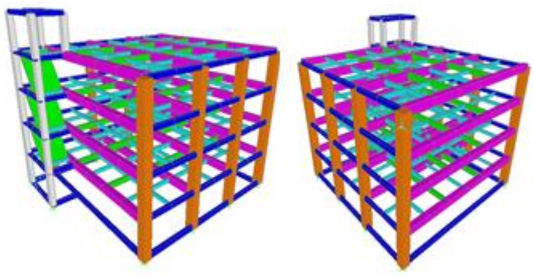

Fig. 6. Perspective view

C. *Calculation of Bored Pile Foundation Bearing Capacity*

An analysis of the bearing capacity of the foundation is carried out based on the dimensions of the foundation that have been determined and the soil characteristics that have been obtained from the results of soil investigation.

In calculating the bearing capacity of this pile, it is planned to use a drilled pile foundation with a diameter of 60 cm. The characteristics of the soil used are based on the N-SPT test data obtained from a soil investigation with a foundation depth of 32 m.

BH. 01	
Kedalaman (meter)	Nilai N (N.2 + N.3)
2	6
4	7
6	5
8	6
10	7
12	5
14	5
16	9
18	10
20	12
22	14
24	15
26	17
28	18
30	21
32	60+

BH. 02	
Kedalaman (meter)	Nilai N (N.2 + N.3)
2	2
4	2
6	8
8	7
10	4
12	4
14	5
16	5
18	6
20	6
22	7
24	7
26	12
28	20
30	37
32	60+
34	60+
36	60+
38	60+
40	60+

BH. 03	
Kedalaman (meter)	Nilai N (N.2 + N.3)
2	2
4	3
6	4
8	6
10	10
12	12
14	21
16	23
18	25
20	40
22	60+
24	60+
26	60+
28	60+
30	60+

Fig. 7. Soil investigation results

The ultimate bearing capacity is obtained by adding the skin friction capacity to the pile end bearing capacity.

Control of Allowable Pile Group Bearing Capacity

Qg = 0,875 x 298,43
= 261,126 ton

Q all = n x Qg > 330 ton
= 2 x 261,126 > 467,65 ton
= 522,252 > 330 ton … (OK)

D. *Reinforcement of the necessary structures*

From the results of the analysis and evaluation of the structure of the Bappeda Kutai Kartanegara Building, it was found that reinforcement would be given to the foundation on the north side/back of the building which was experiencing a decline. The reinforcement is in the form of adding 2 drilled piles to the right and left of the existing foundation. The drilled pile is planned to have a diameter of 60 cm with a depth of 32 m and on top of that a WF 800 x 300 x 14 x 26 beam wrapped in concrete which functions as a pedestal for the existing foundation is installed. Strengthening Portal 1-1 and Portal 2-2 with the following illustration:

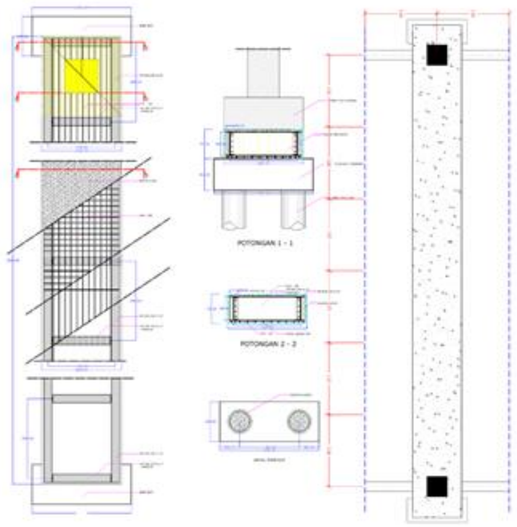

Fig. 8. Portal reinforcement illustration 1-1

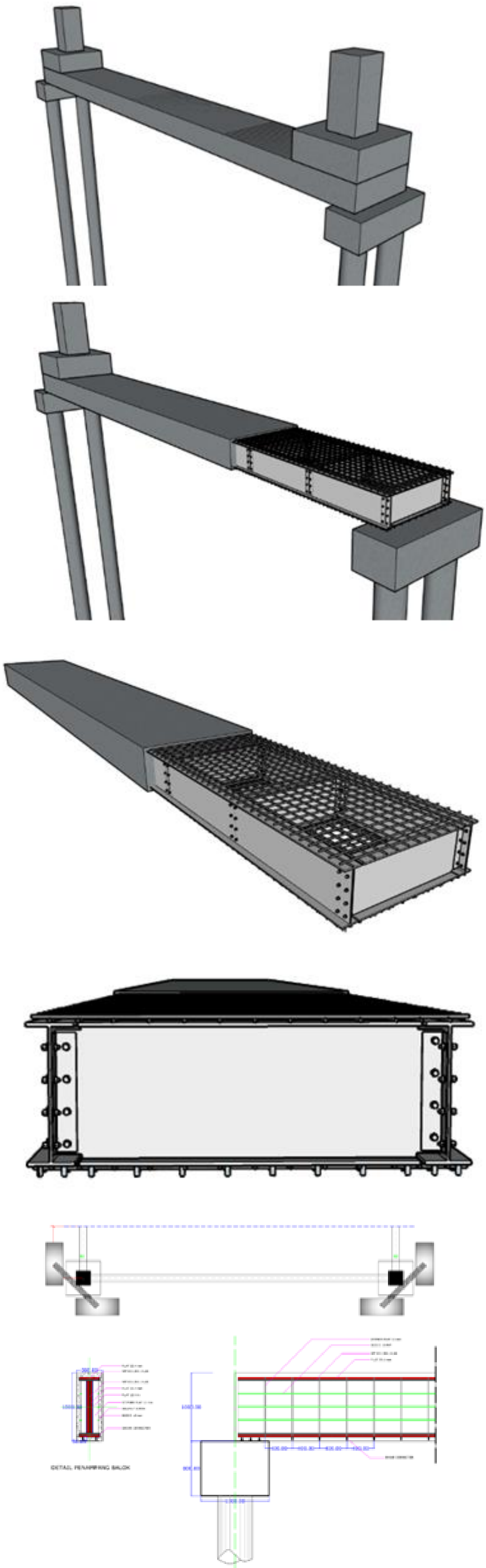

Fig. 9. Foundation reinforcement details

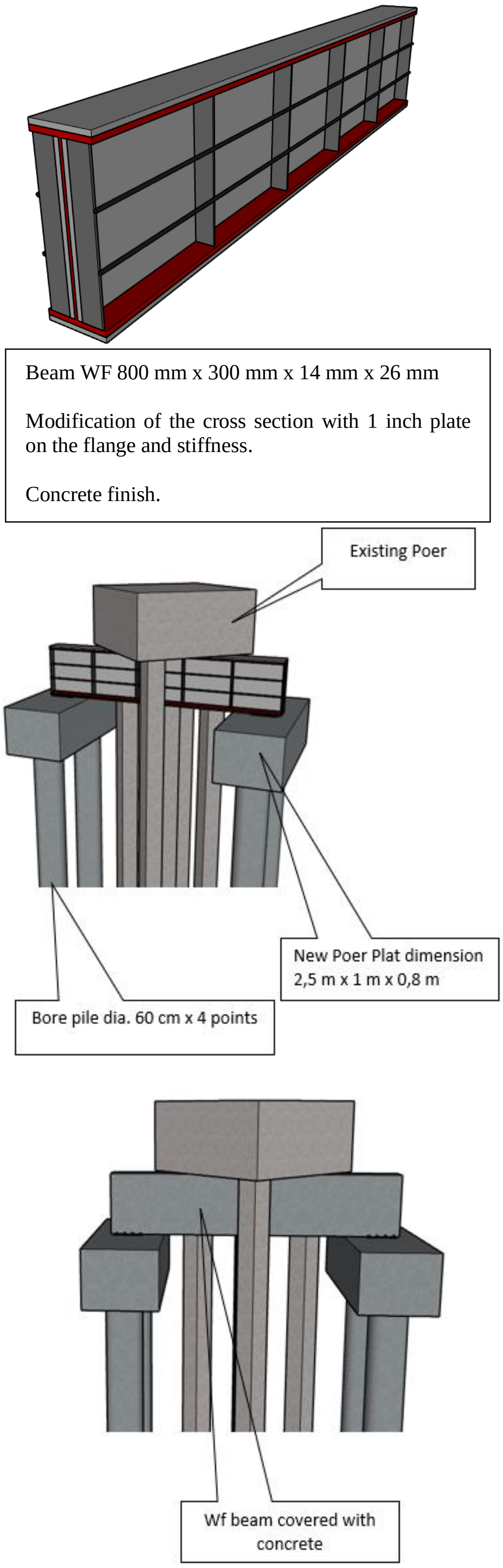

Fig. 10. Portal reinforcement illustration 2-2

V. Conclusions and Recommendations

A. Conclusions

From the research results obtained several conclusions, namely:

1) The cause of damage to the Bappeda Kutai Kartanegara building, namely in the form of cracked walls, broken glass doors and windows, cracked tiled floors, and part of the ceiling collapsed was caused by a decrease in the foundation on the north/back side of the building.
2) The occurrence of settlement in the foundation due to the carrying capacity of the soil around the pile foundation is smaller than the axial load of the building. Thus, the foundation needs to be strengthened so that it does not continue the settlement.
3) The strengthening method used to repair the foundation is by adding 2 bore pile foundations on the right side of the foundation with a diameter of 60 cm a depth of 32 m and on top of that a beam of WF 800 mm x 300 mm x 14 mm x 26 mm which is wrapped in concrete which functions as the pedestal of the existing foundation.

B. Suggestions

From the research results, suggestions are given, namely:

1) Follow-up research can be carried out, including on repair methods for the walls of the Bappeda building in Kutai Kertanegara Regency which have severe cracks.
2) Routine monitoring is carried out regarding the condition of the building, especially on reinforced foundations, so that prompt action can be taken if the foundation shows signs of further decline.

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