Comparison of laboratory test and in-situ test results against bored pile foundation bearing capacity at Sido Mukti II Bridge Foundation Gorontalo Province

F Achmad*
Jurusan Teknik Sipil Universitas Negeri Gorontalo, Jl. B. J. Habibie Desa Moutong Kecamatan Tilongkabila Kabupaten Bone Bolango Provinsi Gorontalo, Indonesia
*fadly@ung.ac.id

Abstract. The purpose of this study is to compare the bearing capacity of the bored pile from the results of laboratory tests and in situ tests. Soil investigations conducted in the field in the form of a Standard Penetration Test (SPT), and drilling. SPT test to obtain variations in soil density. While drilling is used to describe the soil profile at a certain depth. The research method is in the form of analysis of bearing capacity based on comparison of the results of in-situ tests and laboratory tests. Soil results from drilling are taken in 2 conditions namely disturbed conditions to describe each layer and undisturbed samples to be tested in a laboratory with a direct shear test or unconfined compressive strength. Based on the comparison of the value of the allowable bearing capacity is found that the analysis of the results of the in-situ test gives a value of the allowable bearing capacity more than the laboratory tests. This is due to the soil condition in the field at the testing experiencing compaction due to blow SPT.

1. Introduction
According to Hardiyatmo the bearing capacity of the soil can be interpreted as the ability of the soil to support the foundation load of the structure located above it [1]. In analyzing the bearing capacity of the soil, it is certainly inseparable from direct research in the field. Information about how much soil support for the foundation can be obtained from the results of the soil investigation. Soil investigation that can be done in the form of an investigation using the Standard Penetration Test (SPT).

2. Methods
The research method is in the form of a comparison of soil bearing capacity analysis based on in-situ tests and laboratory tests. Field test with SPT test, while laboratory tests based on direct shear test data because the soil is dominantly grained. The types of testing can be seen in table 1.

Table 1. Testing details.

| Test       | Volume | Unit  |
|------------|--------|-------|
| Coring     | 2 x 20 | M     |
| SPT        | 2 x 10 | Test  |
| Triaxial   | 1      | Sample|
| Direct shear | 3      | Sample|
3. Results and discussion

3.1. Stratigraphy
Based on the regional geological map of the Tilamuta sheet by Bachri et al (Figure 1) [2], rock groups from the oldest in the Banuroja area and its surroundings consist of the Bumbulan Granodiorite Formation (Tpb), Tinombo Formation (Teot), Randangan Formation (Tmr), Pani Volcano Rock Formation (Tppv), Wobudu Breksi Formation (Tpwv), Pinogu Volcano Rock Formation (TQpv), Old River Sediment Formation (Qpr), and Aluvium Formation (Qal).

![Figure 1: Geological Map of Banuroja and Surroundings [2].](image1)

3.2. Geological structure
The largest fault in the Gorontalo area is the Gorontalo fault that stretches from Kwandang through Gorontalo City to Tomini Bay (figure 2), which is trending southeast - northwest, which is an active dextral transtension fault with a movement speed of 8 to 11 mm/year [3].

![Figure 2: Map of the Geological Structure of the Banuroja Area and Surroundings [2].](image2)

3.3. Analysis of engineering drilling data
Based on the drilling data (log drill) from the BH 01 and BH 02 drill point obtained:

- BH 01 (abutments on the Trans Sulawesi side): on the surface starting from 0.00 - 3.0 meter depth, gravelly clay with N-SPT value 4; at the bottom, at a depth of 3.0 - 20.0 meters, is composed of sandy clay - gravelly, clayey sand - gravelly, clay with N-SPT ranging from 14 - >60. The results of the analysis can be seen in table 2 and figure 3.

- BH 02 (abutments on the Banuroja side): on the surface starting from 0.00 - 6.0 meter depth, is composed of clay, silty clay - gravelly with N-SPT ranging from 19 – 26; at the bottom, at a
depth of 7.0 - 20.0 meters, is composed of silty clay - sandy - gravelly – stone, gravelly sand, stone with N-SPT ranging from 42 - >60. The results of the analysis can be seen in table 3, table 4, figure 4 and figure 5.

Table 2. Results of allowable bearing capacity analysis based on in-situ test (BH 01).

| L  | d  | N     | N'   | N''  | A2   | f2   | Qa   | Qa'  | Qa'' | z   | Qa*' | Qa** | Qa*** |
|----|----|-------|------|------|------|------|------|------|------|-----|------|------|-------|
| m  | m  |       |      |      |      |      |      |      |      |     |      |      |       |
| 0  | 0  | 0     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0   | 0    | 0    | 0     |
| 2  | 0.80| 4     | -    | -    | 0.5  | 553.00| 76.91| 5.03 | 0    | 0.02| 25.13| 25.13| 51.77|
| 4  | 0.80| 6     | -    | -    | 0.5  | 553.00| 76.91| 5.03 | 0    | 0.02| 25.13| 25.13| 51.77|
| 6  | 0.80| 6     | -    | -    | 0.5  | 553.00| 76.91| 5.03 | 0    | 0.02| 25.13| 25.13| 51.77|
| 8  | 0.80| 2     | 24.28| 0.47| 0.5  | 3039.00| 1039.56| 15.08| 28.94| 14.47| 0.05| 592.78| 80.35| 156.65|
| 10 | 0.80| 4     | 24.28| 0.47| 0.5  | 3039.00| 1039.56| 15.08| 28.94| 14.47| 0.05| 592.78| 80.35| 156.65|
| 12 | 0.80| 4     | 24.28| 0.47| 0.5  | 3039.00| 1039.56| 15.08| 28.94| 14.47| 0.05| 592.78| 80.35| 156.65|
| 14 | 0.80| 4     | 24.28| 0.47| 0.5  | 3039.00| 1039.56| 15.08| 28.94| 14.47| 0.05| 592.78| 80.35| 156.65|
| 16 | 0.80| 4     | 24.28| 0.47| 0.5  | 3039.00| 1039.56| 15.08| 28.94| 14.47| 0.05| 592.78| 80.35| 156.65|

Figure 3. Allowable bearing capacity (Qa) of based on in-situ test (BH 01).

The results of the analysis of allowable bearing capacity based on in situ test on BH 01 give greater value through improved foundation (table 2 and figure 3). However, at 8.0 m the value of allowable bearing capacity is actually reduced, this is due to the reduced density at depth.

Table 3. Results of allowable bearing capacity analysis based on in-situ test (BH 02).

| L  | d  | N     | N'   | N''  | A2   | f2   | Qa   | Qa'  | Qa'' | z   | Qa*' | Qa** | Qa*** |
|----|----|-------|------|------|------|------|------|------|------|-----|------|------|-------|
| m  | m  |       |      |      |      |      |      |      |      |     |      |      |       |
| 2  | 0.80| 12    | -    | -    | 0.5  | 726.75| 365.30| 5.93 | 0    | 1.00| 25.13| 25.13| 51.77|
| 4  | 0.80| 19    | -    | -    | 0.5  | 1142.40| 574.23| 10.05| 0    | 3.00| 86.27| 86.27| 172.54|
| 6  | 0.80| 18    | 24.28| 0.47| 0.5  | 1094.53| 550.17| 15.08| 28.94| 14.47| 0.05| 207.78| 207.78| 415.56|
| 8  | 0.80| 39    | 24.28| 0.47| 0.5  | 2357.46| 1184.99| 21.11| 57.38| 37.03| 0.05| 743.45| 743.45| 1486.90|
| 10 | 0.80| 39    | 24.28| 0.47| 0.5  | 2357.46| 1184.99| 21.11| 57.38| 37.03| 0.05| 743.45| 743.45| 1486.90|
| 12 | 0.80| 39    | 24.28| 0.47| 0.5  | 2357.46| 1184.99| 21.11| 57.38| 37.03| 0.05| 743.45| 743.45| 1486.90|
| 14 | 0.80| 39    | 24.28| 0.47| 0.5  | 2357.46| 1184.99| 21.11| 57.38| 37.03| 0.05| 743.45| 743.45| 1486.90|
| 16 | 0.80| 39    | 24.28| 0.47| 0.5  | 2357.46| 1184.99| 21.11| 57.38| 37.03| 0.05| 743.45| 743.45| 1486.90|
| 18 | 0.80| 39    | 24.28| 0.47| 0.5  | 2357.46| 1184.99| 21.11| 57.38| 37.03| 0.05| 743.45| 743.45| 1486.90|
| 20 | 0.80| 39    | 24.28| 0.47| 0.5  | 2357.46| 1184.99| 21.11| 57.38| 37.03| 0.05| 743.45| 743.45| 1486.90|
Figure 4. Allowable bearing capacity (Qa) of based on in-situ test (BH 02).

The results of the analysis of allowable bearing capacity based on in situ test on BH 02 give greater value through improved foundation (table 3 and figure 4).

Table 4. Results of allowable bearing capacity analysis based on laboratory test.

| L  | d  | C   | s   | t   | Nk  | A1  | A2  | A3  | B1  | B2  | B3  | Qs  | Q1  | Krg | U1  |
|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| m  | m  | (m) | (m) | (m) | (g/kw) | (g/kw) | (g/kw) | (g/kw) | (g/kw) | (g/kw) | (g/kw) | (g/kw) | (g/kw) | (g/kw) | (g/kw) |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 |
| 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 |

Figure 5. Comparison of allowable bearing capacity of based on in-situ test and laboratory tests.

The results of the analysis of allowable bearing capacity based on laboratory tests provide greater value as the depth increases (table 4 and figure 5). However, at a depth of 16.0 m the allowable carrying capacity is reduced, this is due to the reduced soil density at that depth. Overall, the allowable bearing capacity from in situ test results is greater than the allowable bearing capacity for laboratory test results (figure 5).
4. Conclusion

The conclusions of this study are as follows:

- The area of Banuroja and its surroundings contains morphology of marching hills with a slope of flat to steeply directed trending relative to the West-East that has experienced shifts along with the flow - the entire river flowing from North to South empties into Tomini Bay and the mature-old river stadia, this is caused by morphological lineaments which are interpreted as major horizontal fault structure patterns. Regionally composed of groups of Tinombo rocks and Pani volcano rocks in hilly areas, old river sediment dominates in the flat area.

- Based on the comparison of the value of the allowable bearing capacity is found that the analysis of the results of the in-situ test gives a value of the allowable bearing capacity more than the laboratory tests. This is due to the soil condition in the field at the testing experiencing compaction due to blow SPT.

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