PROCEEDINGS

The 6th
Civil Engineering Conference
In The Asian Region
and Annual HAKI Conference
2013
EMBRACING THE FUTURE

20-22 August 2013
HOTEL BOROBUDUR
JAKARTA

Welcome To

The 6th Civil Engineering Conference in The Asian Region and Annual HAKI Conference 2013

Embracing the Future Through Sustainability

Organized by

Asian Civil Engineering Coordinating Council (ACECC)

Hosted by

Indonesian Society of Civil and Structural Engineering (HAKI)

Secretariat (HAKI)

Jl. Tebet Barat Dalam X/5
Jakarta 12810
Indonesia
info@cecar6.com
www.cecar6.com

Editor

Muhammad Abduh
Iswandi Imran
Muslinang Moestopo
Ediansjah Zulkifli
Dina R. Widarda
Ali Awaludin
Dedi Apriadi

Co-Hosted By:

Search

- HOME
- ACCOMMODATION
- COMMITTEES
- REGISTRATION
- SPEAKERS
- PROGRAMS
- CONTACT

- Home
- Accommodation
- Committees
- Registration
- Speakers
- Programs
- Introduction
- Venue
- Theme
- Supporters
- Registration Fees
- Important Dates
- Papers
- Participants

Featured Projects

- Bali Beach Conservation Project (ACECC's Award Winning Project)
- Delhi Metro Rail Corporation (ACECC's Award Winning Project)
- Incheon Bridge (ACECC's Award Winning Project)
- Jatigede Dam's Project
- MRT Project in Jakarta
- Sumatra Java Link
- Surabaya – Madura Link

Committees

International Scientific Committee

- Luh – Maan Chang
- Moonkyung Chung
- Ganzorig Erdene
- Kenichi Horikoshi
- Ronaldo Ison
- Phan Huu Duy Quoc
- Davy Sukamta
- Sohan Lal Swamy
- Barry Tonkin
- Albert T. Yeung

Local Advisory Committee

- Enri Damanhuri
- Bambang Goeritno
- Harjanto
- Sri Hendarto
- Dradjat Hoedajanto
- Bigman Hutapea
- Irwan Katili
- Benjamin Lumantarna
- Sidjabat
- Roesdiman Soegiarso
- Saptahari Soegiri
- Indratmo Soekarno
- Biemo W. Soemardi
- Bambang Suhendro
- FX. Supartono
- Priyo Suprobo
- Bambang Suryoatmono
- Bambang Susantono

Organizing Committee

Chairman:

- Iswandi Imran

Vice Chairman:

- Muslinang Moestopo

Executive Secretary:

- Muhamad Abduh

Members:

- Iwan K. Hadihardaja
- Dedi Apriadi
- Dina Rubiana Widarda
- Imam Aschuri
- Rildova
- Ali Awaludin
- Harmein Rahman
- Joko Nugroho
- Djwantoro Hardjito
- Agus Jatnika
- Nyoman Suaryana
- Ari Setyadi

KEYNOTE SPEAKERS

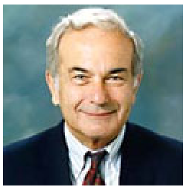
- 
- 
- 
- 
- 
- 
- 
- 

TABLE OF CONTENT

KEYNOTES

PRESIDENTIAL

SHORT COURSE

SPECIAL SESSION

1. ANTI CORRUPTION

2. LONG SPAN BRIDGE

3. TSUNAMI –LESSONS LEARNED FROM PAST DISASTERS

4. BUILDING INFORMATION MANAGEMENT

5. PRECAST CONCRETE STRUCTURES

6. DISASTER MITIGATION, ADAPTATION, PREPAREDNESS STRATEGIES

TECHNICAL SESSION

1. ANALYTICAL AND DESIGN METHODS

1A. Performance Based Design

2B. Innovative Construction Products, Systems, and Practices

2C.Underground Construction Technologies

3. CONSTRUCTION ENGINEERING AND MANAGEMENT

3A. Applications of Information Technology

4. CLIMATE CHANGE
4A. Environmental Impact

6. GEOTECHNICAL AND FOUNDATION ENGINEERING

7. BRIDGE ENGINEERING

14. SUSTAINABLE INFRASTRUCTURE

POSTER SESSION

Proceeding the 6th Civil Engineering Conference in Asia Region: Embracing the Future through Sustainability
ISBN 978-602-8605-08-3

DEFLECTION ANALYSIS OF NAILED-SLAB SYSTEM WHICH REINFORCED BY VERTICAL WALL BARRIER UNDER REPETITIVE LOADINGS

Anas Puri[1], Hary C. Hardiyatmo[2], Bambang Suhendro[2], and Ahmad Rifa'i[2]

[1]Department of Civil Engineering, Islamic University of Riau, Jl. Kaharuddin Nasution 113 Pekanbaru
Doctoral Candidate of Civil Engineering, Gadjah Mada University, Yogyakarta 55281
Email: anaspuri@yahoo.com
[2]Department of Civil and Environmental Engineering, Gadjah Mada University, Jl. Grafika 2 Kompleks UGM, Bulak Sumur, Yogyakarta 55281, E-mail: harychristady@yahoo.com; bbsuhendro@yahoo.com; ahmad.rifai@tsipil.ugm.ac.id

ABSTRACT

The Nailed-slab System is a new proposed method to solve the problem of rigid pavement on soft soils. In this paper, Nailed-slab model tests were conducted to learn the behavior of this system. The models are presented as strip section of rigid pavement on soft clay and consist of concrete slab, short friction piles which installed under the slab, and vertical wall barrier at the end of slab. The models were loaded by repetitive loadings. Tests result will be compared to the calculated deflection by using Finite Element analysis. Further discussion about the comparison of slab deflection related to vertical wall barrier under repetitive loadings will be presented.

Keywords: *Nailed-Slab System, Soft Clay, Vertical Wall Barrier, Deflection, Repetitive Loading.*

INTRODUCTION

The Nailed-slab System was proposed as an alternative to solve the problem of rigid pavement on soft soils (Hardiyatmo, 2008). Hardiyatmo (2008) introduced the dimensions of Nailed-slab System which consists of 15cm-20cm pile diameter, 1.00m-1.50m pile length, and 1.00m-2.00m pile spacing. The main function of the piles is to make the pavement slab keeps in good contact with the subgrade (Puri, *et.al*., 2011b)-it can reduce the slab vibration. Other function of the piles is to stiffer the pavement slab and it can reduce the differential settlement (Hardiyatmo, 2008). The slab, piles, and soil surrounding the piles develop a composite system which increases the bearing resistance. This system was also affected in reducing the slab thickness. Reducing in the slab thickness means reducing self weight of the construction and it will be beneficial for soft soils (Hardiyatmo and Suhendro, 2003). In other words, we can say that it is not about soil improvement but how to gain the pavement slab performance on the soft soils.

The critical position of loads on rigid pavement on the soft soils is on the edge of pavement slab. This part tends to experience the maximum deflection and can also damage the pavement slab such as slab cracks/ fractures, and developing the voids under the slab that can be followed by pumping. The edge of slab can be reinforced by a kind of concrete vertical wall barrier. The vertical wall barrier can significantly reduce the slab deflection of the Nailed-slab System (Puri, *et.al*., 2011b) in case of edge loadings. The vertical wall barrier is a reinforced concrete with 10cm-12cm thickness, and is constructed vertically with 40cm-50cm in height (Hardiyatmo, 2010). The beneficial of a vertical wall barrier are: (a) to stiffer the edge of slab, since this part is a weaker part when loaded, (b) to avoid the voids development between subgrade-slab interface for life time serviceability, which is an effect of vehicle wheels that go out from the pavement and go in to the pavement repeatedly, (c) reduce the disturbance to the road shoulder, (d) as an vertical moisture barrier which is isolate the negative effects from the moisture changing of road shoulder in order that the water will not penetrate into the soil under the pavement for expansive soil subgrade.

Dewi (2009) and Hardiyatmo (2011) introduced the equivalent modulus of subgrade reaction for analysis of Nailed-slab System. Hardiyatmo (2011) was proposed the method to define the additional modulus of subgrade reaction. Hardiyatmo method is modified for practical purposes by considering the fully mobilized pile friction resistance and the tolerable settlement of rigid pavement slab (Puri, *et.al*., 2012a). These methods were successfully applied for prediction the pavement slab deflection of Nailed-slab System models by using Beam on Elastic Foundation theory (Hardiyatmo, 2011; Puri, *et.al*., 2011b, 2012a, 2012b, 2013). The Modified Hardiyatmo method can also well predict the deflection of the

Nailed-slab under repetitive loadings. Finite Element analysis has not been conducted to analyse the Nailed-slab which consider pile rows, except Puri, *et.al*. (2013).
This paper is aimed to discuss the comparison of the slab deflection behavior between the Nailed-slab under repetitive loadings and monotonic loadings. The Nailed-slab models consider the vertical wall barrier on each end of slab. The experimental was conducted by model tests of one row pile Nailed-slab system.

TESTING INVESTIGATION

Soil and Nailed-slab Models Tests

Soft clay parameters are given in Puri, *et.al*. (2011b). The nailed-slab model with one row of piles consists of 6 piles, 120 cm × 20 cm × 3 cm slab, 20 cm pile spacing (s/d = 5), pile diameter d = 4 cm, and pile length L_p = 40 cm. The spacing between edge pile and the end of slab is a half of pile spacing ($a=s/2$). The loading test set up and Nailed-slab models (concrete slab supported by piles) are shown in Fig. 1. Slabs and piles are made by reinforced concrete. Slab reinforcement was wire mesh with 3 mm-wire diameters, and 5 cm × 5 cm meshing. Pile models were reinforced by 3mm-aluminium wire diameter. Model scale for geometry was 1 : 5. Piles and vertical wall barriers were connected monolithically to the slab. All models are presented as strip section of the rigid pavement. The Nailed-slab model was consisted of a Nailed-slab which the slab ends with vertical wall barrier (see detail on Fig.1). Loading type was monotonic and repetitive loadings. The dimension of vertical wall barrier was 2.4 cm in thickness and 10 cm depth. The photograph of the Nailed-slab testing is shown in Fig. 2 for edge loading.

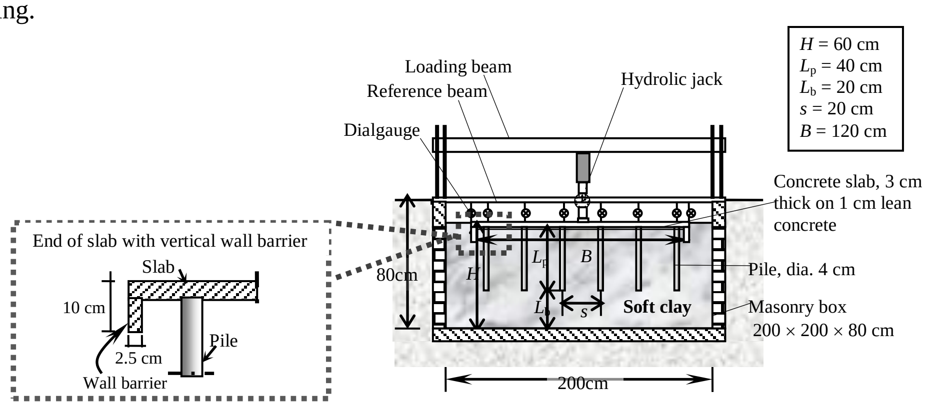


Fig. 1: Schematic cross section set-up of loading test on Nailed-slab System model.

Puri, *et. al*. (2011a) reported that the slabs and piles have modulus of elasticity E_c = 17,000 MPa. Soft clay properties are presented in Table 1. The load was worked on the slab through a circular steel plate with 6.0 cm in diameter and 1.0 cm in thickness. Load positions were on the point A (centric load) and point B (edge load) as shown in Fig. 3a but they worked in different loading time.

Analysis of Deflections

In the 2D finite element analysis (FEM), soft soil model was employed in the study. Likewise, the soil and material properties (model plate and pile) adopted in the model are shown in Table 1 and 2 respectively. The material properties were adjusted due to the plain strain case. The slab width is 120 cm and the length of considered section is 20 cm (perpendicular to cross section). A used mesh in plain strain FEM analysis is shown in Fig 2a. Fig 2b is one of deformed shape output.

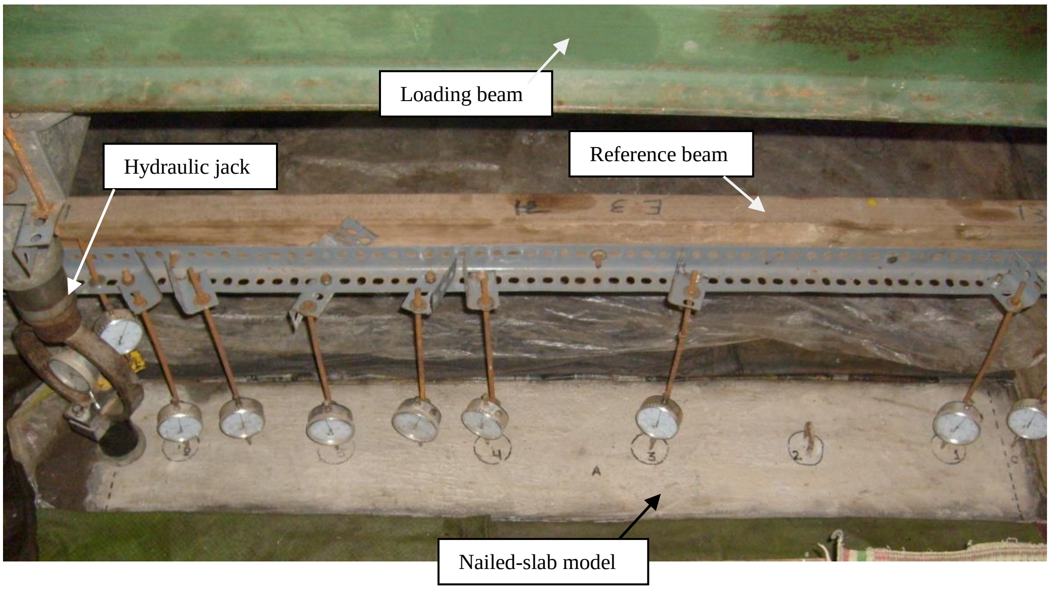


Fig. 2: A bird's-eye view of Nailed-slab model with vertical wall barrier on the each end of slab (indicated by dash-line).

Tab. 1: Soil properties in FEM analysis input (Puri, *et. al*., 2013)

Parameter	Name	Clay	Unit
Material model	Model	Soft soil	-
Material behavior	Type	Undrained	-
Soil behavior under phreatic level	γ	17.00	kN/m^3
Young's modulus	*E*	1,870.00	kPa
Poisson's ratio	*v*	0.35	-
Cohesion	*c*	21.00	kPa
Friction angle	ϕ	1.00	o
Dilatancy angle	ψ	0.00	o
Initial void ratio	e_0	0.92	-
Modified compression index	$\lambda*$	0.05	-
Modified swelling index	$\kappa*$	0.01	-
Interface strength ratio	*R*	0.80	-

Tab. 2: Model slab and pile properties in FEM analysis input

Parameter	Name	Slab	Wall Barrier	Pile	Unit
Material model	Model	Plate	Plate	Plate	-
Material behavior	Type	Elastic	Elastic	Elastic	-
Normal stiffness	*EA*	122,400.00	8,500.00	54,400.00	kN/m
Flexural rigidity	*EI*	9.18	0.44	7.25	kNm^2/m
Equivalent thickness	*d*	0.03	0.025	0.04	m
Weight	*w*	0.70	0.58	0.92	kNm/m
Poisson's ratio	*v*	0.20	0.20	0.20	-

B

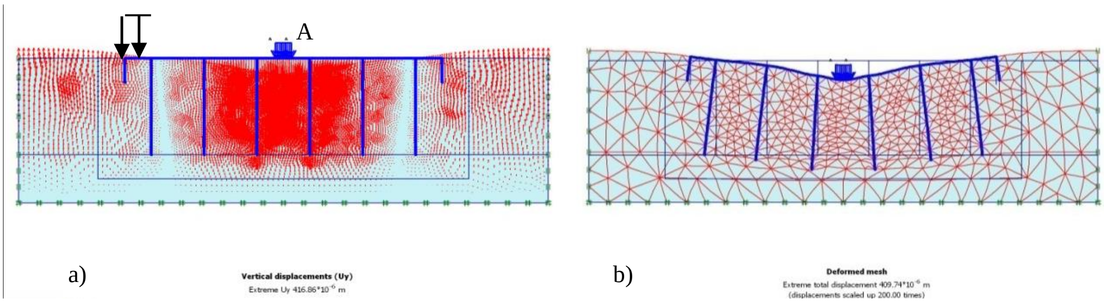
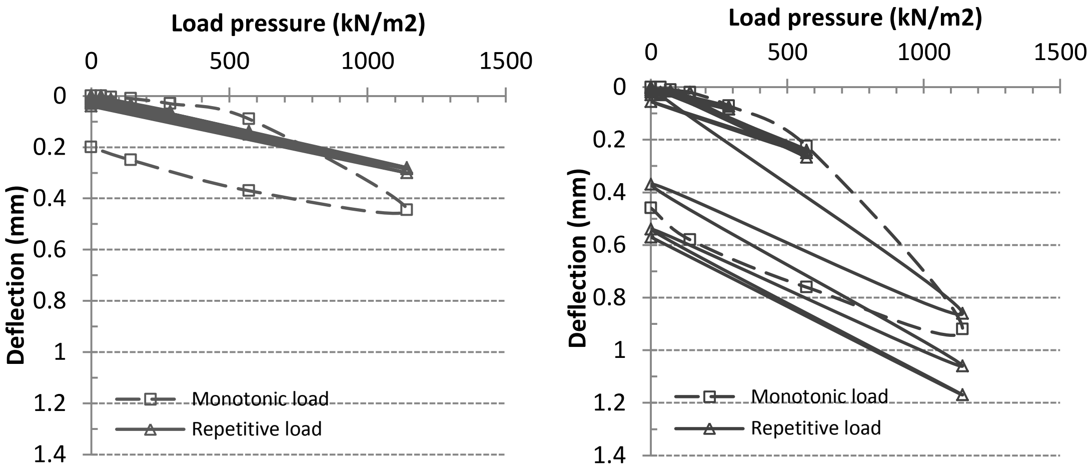


Fig. 2: Nailed-slab with vertical wall barrier in FEM analysis of plain strain: a). total displacement and undeformed shape which also shows position for center (point A) and edge (point B) loading. b). deformed shape output.

RESULTS AND DISCUSSIONS

Loading Test Results

The *P*-δ graph at loading point is presented in Fig. 3. It is shown that the repetitive load more influential at the higher loading which over 500 kN/m^2. The maximum permanent deflection from edge repetitive loading is little bit higher about 27.17% than deflection from monotonic loading. The slab tends to be critical under edge loading, especially under repetitive loading. It is concluded that the deflection of the slab for edge loadings are to be more than 2 times the deflection of the center loadings. Generally, there is no significant uplift of the slab end (Fig. 4 and Fig.5). It means that the installed piles tend to keep the slab contact with the soil. The capability of the nailed-slab system is higher due to center loading than the edge loading. In the centric loads, the system is not reached the plastic zone yet. Otherwise, the plastic zone is reached on the edge loading.



(a) Centric loads (b) Edge loads

Fig. 3: The *p*-δ relationship on the loading point

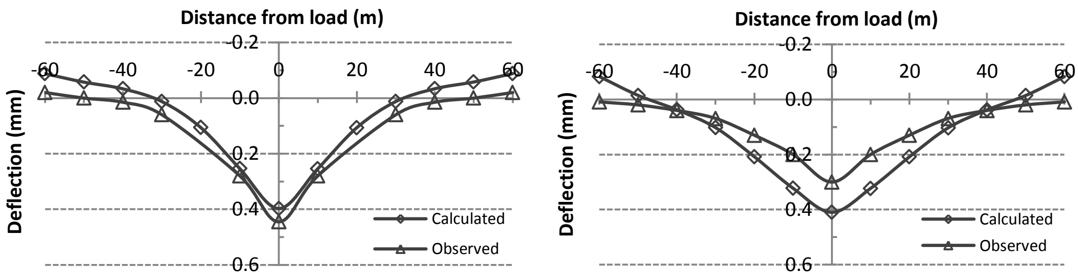
Results of Calculated Deflections

Table 3 shows the comparison of slab deflection between monotonic loading and repetitive loading on the loading point. Deflections tend to be under-estimated for higher load in case of both centric and edge monotonic loads. The deflections tend to be under-estimated for edge loadings in case of repetitive loads.
The distributed deflections along the slab are shown in Fig. 4 and 5 for different loading location. All results are shown the deflection shape in good agreement with observed for all loading types and locations. Calculated results show that the vertical wall barrier has less significant effect due to centric loads, because the end of slab was uplifted. In this case, FEM cannot differ between the edge monotonic

and repetitive loads. The deflection results are similar. The p-δ relationship on loading point of Nailed-slab under repetitive loadings with different loading location is shown in Fig. 6. As describe before, the deflection results is to be under-estimated for edge loading.

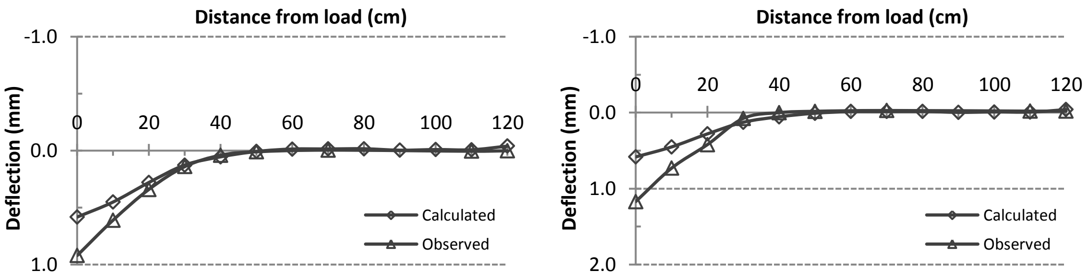
Tab. 3: Comparison of slab deflections on loading point for selected loads

Load		Load pressure (kN/m^2)		Setllement (mm)		Defference of deflection (%)
Type	Location	Original	Equivalent	Calculated	Observed	
Monotonic						
	Centric	1143	269	0,397	0,45	-11,78
	Edge	1143	269	0,582	0,92	-36,74
	Centric	571	135	0,173	0,09	92,22
	Edge	571	135	0,242	0,225	7,56
Repetitive (on 3rd repetition)						
	Centric	1143	269	0,41	0,3	36,67
	Edge	1143	269	0,582	1,17	-50,26
	Centric	571	135	0,214	0,15	42,67
	Edge	571	135	0,242	0,27	-10,37



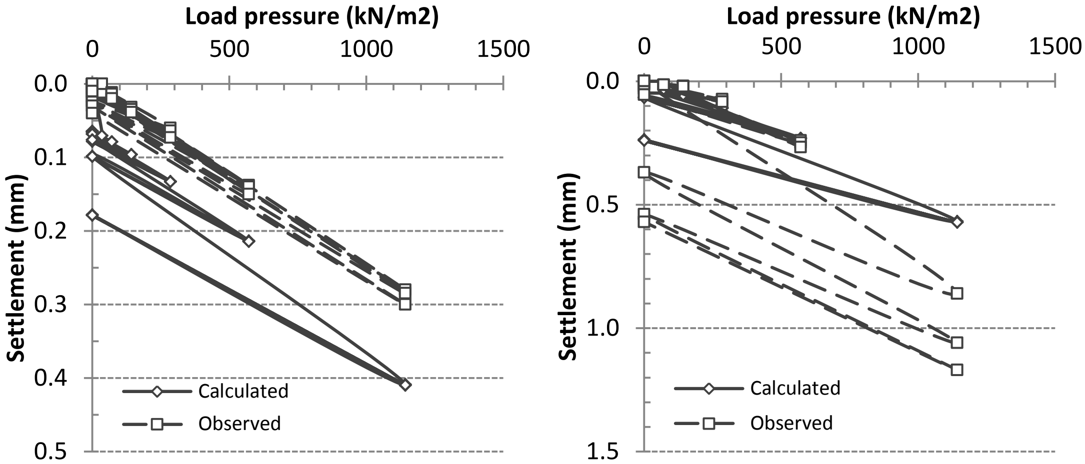
(a) Monotonic loading (b) Repetitive loading

Fig. 4: Distribution of predicted slab deflection for center loadings (p= 1,143 kN/m^2).



(a) Monotonic loading (b) Repetitive loading

Fig. 5: Distribution of predicted slab deflection for edge loadings (p= 1,143 kN/m^2).



(a) Centric loads (b) Edge loads

Fig. 6. The *p-δ* relationship of Nailed-slab model under repetitive loading with different loading location.

CONCLUSIONS

The model of Nailed-slab System which used vertical wall barrier structure was conducted and the observation and analysis of the slab deflections have been performed. The Nailed-slab model was loaded by repetitive loads. Good results are obtained in the sense of that the calculated settlement is in good agreement with observation. Although, calculated results show that the vertical wall barrier has less significant effect due to centric loads, because the end of slab was uplifted.

Technical analysis for FEM which consider the vertical wall barrier is recommended to be improved. And behavior of prototype of the Nailed-slab System under repetitive loadings is subjected to be studied for prototype Nailed-slab.

REFERENCES

Dewi, D.A. (2009). *Study on Effect of Single Pile Due to the Value of Equivalent Modulus of Subgrade Reaction from Full-scale Loading Tests*, Master Theses, Graduate Program of Engineering, Gadjah Mada University, Yogyakarta.

Hardiyatmo, H.C. (2008). Nailed-slab System for Reinforced Concrete Slab on Rigid Pavement, *Proc. of National Seminar on Appropriate Technology for Handling Infrastructures*, MPSP JTSL FT UGM., Yogyakarta, pp. M-1—M-7.

Hardiyatmo, H.C. (2009). Method to Analyze the Slab Deflection by Using Equivalent Modulus of Subgrade Reaction for Flexible Slab Structure, *Dinamika Teknik Sipil*, Vol.9 No.2, pp. 149-154.

Hardiyatmo, H.C. (2010). *Perancangan Sistem Cakar Ayam Modifikasi untuk Perkerasan Jalan Raya,* Gadjah Mada University Press, Yogyakarta, Indonesia.

Hardiyatmo, H.C. (2011). Method to Analyze the Deflection of the Nailed Slab System, *IJCEE-IJENS,* Vol 11. No. 4, pp. 22-28.

Hardiyatmo, H.C., and Suhendro, B. (2003). *Pile Foundation with Thin Pile Cap as an Alternative to Solve Problems of Building on Soft Soils*, Report of Competitive Grant Research of Higher Education, Institute for Research and Community Service, Gadjah Mada University, Yogyakarta.

Puri, A., Hardiyatmo, C.H., Suhendro, B., and Rifa'i, A. (2011a). Experimental Study on Deflection of Slab which Reinforced by Short Friction Piles in Soft Clay, *Proc. of 14th Annual Scientific Meeting (PIT) HATTI*, Yogyakarta, 10-11 February, pp. 317-321.

Puri, A., Hardiyatmo, H.C., Suhendro, B., and Rifa'i, A. (2011b). Contribution of Vertical wall Barrier to Reduce the Deflection of Nailed-Slab System in Soft Clay, *Proc. of 9th Indonesian Geotech. Conf. and 15th Annual Scientific Meeting (KOGEI IX & PIT XV) HATTI*, Jakarta, 7-8 December, pp. 299-306.

Puri, A., Hardiyatmo, H.C., Suhendro, B., and Rifa'i, A. (2012a). Determining Additional Modulus of Subgrade Reaction Based on Tolerable Settlement for the Nailed-slab System Resting on Soft Clay, *IJCEE-IJENS*, Vol. 12 No. 3, pp. 32-40.

Puri, A., Hardiyatmo, H.C., Suhendro, B., and Rifa'i, A, (2012b). Application of The Additional Modulus of Subgrade Reaction to Predict The Deflection of Nailed-slab System Resting on Soft Clay Due to Repetitive Loadings, *Proc. of 16th Annual Scientific Meeting (PIT) HATTI,* Jakarta, 4 December, pp. 217-222.

Puri, A., Hardiyatmo, H.C., Suhendro, B., and Rifa'i, A. (2013). Pile Spacing and Length Effects Due To the Additional Modulus of Subgrade Reaction of the Nailed-Slab System on the Soft Clay, *Accepted in International Symposium on Quality in Research (QiR).*

Taa, P.D.S. (2010). Effects of Installation of Group Pile Due to Slab Uplift of Nailed-slab Resting on Expansive Subgrade, *Master Theses*, Graduate Program of Engineering, Gadjah Mada University, Yogyakarta.

6 CECAR

ACECC For a Better Quality of Life | ASIAN CIVIL ENGINEERING COORDINATING COUNCIL

20 - 22 AUGUST 2013
HOTEL BOROBUDUR JAKARTA

CERTIFICATE

THE 6TH CIVIL ENGINEERING CONFERENCE IN THE ASIAN REGION

EMBRACING THE FUTURE THROUGH SUSTAINABILITY

This is to certify that

ANAS PURI

attended the conference as

PRESENTER

ISWANDI IMRAN
Chair, CECAR 6

DRADJAT HOEDAJANTO
Chair, Executive Committee ACECC

Hosted by: INDONESIAN SOCIETY OF CIVIL AND STRUCTURAL ENGINEERS

Co-Hosted by: AMERICAN SOCIETY OF CIVIL ENGINEERS; CHINESE INSTITUTE OF CIVIL AND HYDRAULIC ENGINEERING; ENGINEERS AUSTRALIA; THE INSTITUTION OF CIVIL ENGINEERS; JAPAN SOCIETY OF CIVIL ENGINEERS; KOREAN SOCIETY OF CIVIL ENGINEERS; PHILIPPINE INSTITUTE OF CIVIL ENGINEERS; MONGOLIAN ASSOCIATION OF CIVIL ENGINEERS; VIETNAM FEDERATION OF CIVIL ENGINEERING ASSOCIATIONS