# ERS Research Seminars Apr./2019 - Mar./2020

■ Schedule of research seminars

| Schedule | Nakano | Kiyota | Kawaguchi | Koshihara | Meguro | Kuwano | Numada |
|---|---|---|---|---|---|---|---|
| 5/17 (Fri) | ○ | ○ | | | | ○ | |
| 7/5 (Fri) | | | ○ | | ○ | | ○ |
| 9/13 (Fri) | ○ | | | ○ | | | ○ |
| 12/20 (Fri) | | | ○ | ○ | | ○ | |
| 2/21 (Fri) | | ○ | | | ○ | | |

1st seminar on May 17th

## 【Nakano laboratory】

ADNAN S M Naheed (M2)

Title :Experimental studies on RC frames with URM infill

Abstract : In many developing countries, numerous buildings using low quality construction materials have been designed and constructed without following proper guidelines. Therefore, they possess a high risk of collapse during earthquakes and need to be seismically evaluated and retrofitted. Bangladesh is a densely populated country which lies in a seismically active zone. Numerous buildings can be found in Bangladesh which have been constructed using low quality construction materials and without following any proper guidelines. Especially, many buildings lack seismic detailing and common features of these buildings are straight anchorage of beam longitudinal reinforcements and no transverse reinforcements in beam-column joints, 90° hooks in ties and stirrups, etc. Another major feature of the buildings in Bangladesh is the use of masonry infill walls as a partition wall, which is not used in Japan. In design practice, unreinforced masonry walls (URM) are assumed as non-structural elements hence their contribution to structural performance is not considered. However, many research has shown that masonry infill walls (MIW) act as a structural element and affect seismic performance significantly. Additionally, concrete of many old buildings have low strength thus the columns have a very high axial force ratio.

In this study, two reinforced concrete frames (with and without masonry infill walls) which are often found in Bangladesh are tested under static loadings with a very high axial force ratio in columns to simulate the aforementioned conditions and their seismic performances are discussed. The failure mechanism of the specimens is then investigated based on the curvature distribution of columns derived from the strains of column longitudinal bars or equilibrium of nodal moment and MIW contribution. Based on the mechanism the strength of the specimens is calculated and compared with test results. The maximum strengths of the specimen with MIW are calculated with sufficient accuracy while the calculation for specimen without MIW slightly overestimates the recorded results.

## 【Kuwano laboratory】

Dayani Sanjeewani (D3)

Title : Study on the performance of surplus soil as improved soils and their long term behavior

Abstract : In Japan, re-utilization of surplus soils in earthworks is highly promoted. One of the ways to use low-quality surplus soil is to improve them by applying chemical stabilization using cement or lime and utilize as a filling or embankment material in road embankments. Generally, the improved soils used in road embankments are low in binder contents and are susceptible to penetration of rainwater or ground water. In general, it is well known that the strength of the improved soils increases with the curing period under controlled laboratory conditions. However, according to the site investigation conducted on a high embankment in Japan, unconfined compressive strength at a

certain depth below the ground water level was hardly increased from the strength nine years ago (Miyashita et al 2018). Therefore, in this study, the effect of soaking on the long-term behavior of improved surplus soils was studied by conducting unconfined compression test and the needle penetration test periodically up to 2 years under sealed and soaked curing conditions. Several researchers have been reported dissolution of calcium as one of the major causes in strength reduction under sea water. Therefore, in this study, X-ray fluoresce spectrometer (XRF) and Electron Probe micro analysis (EPMA) was applied to quantify the remaining calcium ion in the soil specimen. In addition to that X-ray Diffraction (XRD) analysis was applied to evaluate the remaining minerals. From needle penetration test results and chemical testing results, it was found that soaking has caused in deterioration of the improved surplus soils due to the leaching of calcium-based hydration products. After two years effect of soaking on the strengths appeared obviously in the cement treatment rather than lime treatment.

Reference: Y. Miyashita, G. Inoue, *Deep foundations and ground improvement,* 1151-1159 (2018)

## 【Kiyota laboratory】

Risqi Faris Hidayat (D3)

Title : Preliminary Site Investigation on Liquefaction-induced- flow failure triggered by the 2018 Mw 7.4 Sulawesi Earthquake, Palu, Indonesia

Abstract : The $M_w$ 7.4 Sulawesi Earthquake 2018 had resulted in several catastrophic disasters and large numbers of casualties. This reconnaissance aimed to investigate the damages of liquefaction-induced-flow failure occurred in three places in Palu City, which are Petobo, Balaroa, and Jono Oge. It was found that this flow failure occurred on wide scopes with a very gentle ground inclination, ranging from 1-4%. In order to understand the soil layers on these specific locations, a portable Dynamic Cone Penetration Test have been conducted in Petobo. The results showed that soil layers inside the affected area were in a loose state compared to the non-affected areas. Furthermore, some spots of freshwater inundation were recognized in Petobo and Balaroa, even two weeks after the disaster. Based on this evidence, a mechanism of liquefaction-induced-flow failure by confined aquifer is proposed.

Further studies have been done to examine the viability of this mechanism using Triaxial strain-controlled apparatus IIS Type. In this study, several series of creep tests, so-called static liquefaction test, are employed to soil specimens to observe the extent of flow failure.

2nd seminar on July 5th

## 【Kawaguchi laboratory】

Yuki Takahashi (D1)

Title : Research on steel dumping device for wooden houses using thin steel plates with origami-inspired three-dimensional resistance mechanism

Abstract : Many dumping devices have been developed in recent years. Existing damping devices can be classified into joint type and bracing type according to their shapes. Although the joint type dampers can be used with openings, it is difficult to increase their rigidity. By contrast, the bracing type dampers can easily increase their rigidity. However, no opening can be used, and pull-out force of columns will increase when the column spacing is narrow. For this reason, few dumping devices can be used for narrow walls of 600 mm width or less. As for the damping mechanism, many of the hysteresis type dampers are made of low yield point steels and it causes the cost increase. When focusing on the damping mechanism used in the field of automobile, impact energy absorbing mechanism called “crash boxes” have been developed [1]. This device absorbs the impact energy and increase the plasticized area by changing its shape like Origami folding when it crushed.

In this research, we propose a new low-cost damper system using thin steel plates with origami-inspired three-dimensional resistance mechanism that can be applied to narrow walls having openings. To verify the mechanical properties of the proposed damper, the finite element analysis and experiments were conducted. In the case of the flat steel plate type, large out-of-plane deformation with hinge lines was observed in both the analysis and experiments. This deformation makes it difficult to improve the damper stiffness. Therefore, we creased the plates to restrain the deformation. Both the analysis and experiment results showed that the crease intersecting the hinge line greatly increase the damper stiffness.

[1] Zhou C., Wang B., Ma j., You Z., 2016. Dynamic axial crushing of origami crash boxes, International Journal of Mechanical Sciences 118, pp.1-12

## 【Meguro laboratory】

Khin Myat Kyaw (D2)

Title : Soil-structure-interaction Effects on the Damage State of Typical Buildings in Yangon

Abstract : More than 70% of the fatalities of the deadly earthquake events between 1968 and 2008 are caused by the partial or fully collapse of the buildings (source; Kristin D. Marano et. al, 2008). Therefore, the earthquake resistance capacity of the buildings should be ensured especially for the earthquake prone areas. For the new buildings, building design can be improved to be earthquake resistant one, but it is challenging work for the cases of existing buildings. In Yangon, there are many existing buildings whose seismic resistant capacity are unknown, and the recent rapid urbanization and mass construction, making the city more vulnerable to earthquake. The building vulnerability assessment work can help the relevant authority to understand the damage probability for a specific area and

prioritizes the mitigation measures in case of an expected earthquake event. Different input parameters, such as seismicity of the region, building and geotechnical information, are used in the building vulnerability assessment work along with different analysis procedures. Based on the inputs parameters, their accuracy and analysis procedure used, the vulnerability assessment result such as dynamic characteristics and damage state will be different. Conventionally, geotechnical inputs (simply say foundation flexibility and soil conditions) are not fully incorporated into the assessment work (except in the special-occupancy class buildings) because of its complexity in analysis procedure and time-consuming process. In this research, the geotechnical inputs will be considered in the vulnerability assessment work and the difference in the damage state between the conventional way (fixed base) and the geotechnical inputs considered way (flexible base) will be identified for the typical building types in Yangon. Typical buildings types from building inventory data and the actual material testing results will be used in the analysis and the relevant damage state will be analyzed for the expected earthquake event. It is intended to develop the damage state with the corresponding typical building types, foundation, soil conditions and relevant PGA values for each township in Yangon. The results will help the relevant authority to take into consideration the soil conditions for the city extension plan.

Keywords; soil-structure-interaction, damage state, building vulnerability, brick-nogging, reinforced concrete, nonlinear dynamic analysis

【Numada laboratory】

Chaitanya Krishna (Project Research Associate)

Title : Damage and stiffness of building using modal analysis

Abstract : The objective of this research is to evaluate the feasibility of damage and physical properties of buildings using Operational Modal Analysis (OMA) and Experimental Modal Analysis (EMA). This approach is very useful in bridging the gap between real world and theoretical world categorized into geometric properties, material properties, structural capacities and failure behavior. The fundamental component of this includes the identification of material and geometric properties using appropriate field tests. In this study, this is achieved by vibrational analysis, whereby obtaining frequencies and mode shapes, which has to be translated to the physical components stiffness and mass. In this research a two-step algorithm has been developed for identification. An appropriate scaling is done to convert the unscaled mode shapes using forced vibrations. This is evaluated for the required number of modes for the analysis and its accuracy is checked through hypothetical simulations. The outcomes of this study includes the development of algorithms for physical property identification in case of limited modes, identifying major challenges such as non-availability of modes satisying UMM and development of a minimalist procedure using a vibrating shaker for modal testing This preliminary study suggests feasibility of using a shaker for obtaining scaled mode shapes.

3rd seminar on September 13st

## 【Nakano laboratory】

S.A.M. Nassif Zubayer (M2)

Title : Analytical Modelling for Reproducing Seismic Performance of Inappropriately Designed and Constructed RC Building Structures in Developing Countries

Abstract : A large stock of inappropriately designed and constructed buildings is available in developing countries. These buildings were designed without following any code properly and constructed ignoring quality control/ quality assurance issues at the absence of any proper guideline like national building code. Such buildings are the matter of interest of this research work. Bangladesh is considered as a representative developing country having such buildings in abundance.

The objective of this research is to propose suitable modeling method for such vulnerable structure in the context of typical design and construction practice for old buildings in Dhaka, Bangladesh before any national building code was published. Laboratory experiment was conducted on test specimen (two-story, two-bay bare frame) to assess seismic performance of such buildings. Typical very critical issues and flaws associated with design and construction of such old buildings in Dhaka were taken account of in design and construction of the test specimen. Major issues were low-strength concrete, high axial load ratio on columns and straight anchorage of longitudinal rebars in beam-column joints. Different analytical models were constructed with a view to simulating behavior of test specimen to figure out the model that exhibits performance closest to the test specimen.

The research shows that (1) the reduced modulus of elasticity of concrete is an essential parameter for good modelling if the axial load ratio is high, and (2) consideration of pullout phenomenon and pullout load is very important in case of straight anchorage in joint. Even though the old buildings are not properly designed and constructed, their behavior can be satisfactorily simulated if appropriate computational modeling can be made considering these phenomena.

## 【Koshihara laboratory】

Yao Chih Chien (M1)

Title : Assessment of wave velocities of various granular materials using planar piezo-ceramic transducers

Abstract : The tests are part of works toward practical use of CLT panel-glulam hybrid construction, aiming for realizing 3-story school buildings using CLT panels as bearing walls, instead of diagonal braces. The two-story frame specimens, which is the center part of 1st and 2nd floor of the school building, consist of CLT panel, glulam beam, and box-shape fasteners, PC steel bars were used to join the frame. During the tests, static seismic loads calculated by $A_i$ distribution were implemented. From story deformation angle 1/450 rad. to 1/50 rad., the alternating loads of “push” and “pull” directions were both applied 3 times, and until 1/15 rad., only “push” loads were applied.

Through the tests, basic properties like stress-strain relationship, structure coefficient (Ds) and shear resistance against temporary loading is calculated, and the results show that the performance satisfies the demands toward different magnitude of earthquakes. Also, elements stresses and displacements like embedment and uplift of CLT panels were measured, in order to track specimens’ behavior and the failure process. However, some unpredicted behavior during the tests happened,

including the lateral tension failure of glulam beam from shear key. Finally, further tasks are revealed, for example, the investigation of shear key's mechanical properties, and the enhancement of embedment stiffness.

## 【Numada laboratory】

Chaitanya Krishna (Project Research Associate)

Title : Damage and stiffness identification of building using model analysis

Abstract : The underground structures have experienced severe damages in recent earthquakes such as the 1999 Chi-Chi Earthquake and 1995 Kobe Earthquakes. This study starts with an aim to upgrade underground structures by retrofitting to withstand large earthquakes. Retrofitting structures for 'maximum considered earthquake (MCE)' or to a demand unlikely to occur at the site of interest due to varying site conditions becomes unjustifiable at the economic point of view. Besides, historically, the underground structures have experienced lesser damages as compared to surface structures. It is indeed essential to find a retrofitting solution for an optimum risk involved with the underground structures. As a first step, structural engineers know that the seismic demand on the structures is mainly dependent on the size of the earthquake considered and the site properties of the structure. Though the former one could be assumed based on approaches determined by the concerned stakeholders; the latter depends on the soil profile and the frequency content; which is also variable across a region. A methodology is developed to achieve the goal of risk assessment of underground structures comprising three components. First, an area for this study is selected, and a set of site and spectrum compatible accelerograms are developed. Second, convoluting the demand accelerograms at different locations in the region, the ratios of maximum displacements are estimated. Finally, the predicted deformations are transformed into strains using numerical modeling in the tunnel linings to evaluate if it could withstand it.

In this study, we are emphasizing on the second part, which would show the regional risk of the ratio of shear deformation along the vertical cross-section of the structures. A case study of Tokyo Metropolitan area is considered with ground motion data collected along subway for 40 years is used in this study. It has also been found that the ground accelerograms developed using different sources exhibit different energies.

4th seminar on December 20th

【Special seminar】

Special seminar summary:

About typhoon No.15 and strong wind damage and a flood by No.19, I look back on the cause and influence and have you give a lecture on useful information for future resilience reinforcement.

Special seminar title :

「Seminar about the storm and flood damage of 2019 years the typhoon No.15 and No.19」

Speaker and title:

Professor Masahiro Matsui (Tokyo Polytechnic University)

Title : Strong wind damage of 2019 years typhoon No.15 and 19

Associate professor Shinichiro Nakamura (Nagoya University)

Title : Flood damage caused by the 2019 years typhoon No.19

* It was switched from normal ERS seminar to ERS special seminar by the invited guest.

5th seminar on February 21th

【Meguro laboratory】

Xue Jian (D1)

Title : Study on the characteristics of underwater explosion bubble near perforated solid wall

Abstract : In the actual ocean war, the wounded ships may be damaged by the second attack of underwater weapons. Therefore, studying on the shock wave propagation and bubble movement characteristics of the underwater explosion near the damaged structure is of great significance to the structural design of the warship and the naval combat strategy. This paper based on the Autodyn ALE fluid-solid coupling, the situation of underwater explosion near the intact solid structure and underwater explosion near solid structure with hole were studied. The weight of explosive, water depth, distance from the center of the explosive to the structure, vertical distance of the hole and the radius of the hole influence on the peak pressure, the velocity of the bubble boundary, the pressure of the water jet, the center movement of the bubble and the period of the bubble pulsation were analyzed. This paper first introduces the research background and significance of the research, presents the development of underwater explosion bubble motion theory, describes the mainstream military underwater explosion experiment and laboratory scale underwater explosion experiment method, and introduces the current process of commercial numerical simulation software and methods which can simulate non-spherical bubble movement well. The underwater explosion conditions of free field under different mesh densities, different model sizes, and different boundary conditions
are simulated. Compared with the empirical formulas of shock wave pressure, maximum expansion radius of bubble pulsation, and bubble pulsation period, the existing experimental data are used to verify the reliability of numerical simulation. Get the suitable mesh density with the highest computational efficiency which can guarantee the calculation accuracy, the empirical formula for the overpressure of the shock wave in contact underwater explosion situation is fitted. Based on the previous text, the calculation model of axial symmetry model of underwater explosion with nearly intact structure, model of near broken rigid structure, non-axisymmetric underwater explosion model near rigid wall with the hole are established, the pressure measuring point is set on the rigid wall, horizontal distance non-dimension parameter $\gamma f$ , analyze the vertical non-dimension parameter $\gamma h$ and the radius nondimension parameter $\theta$ ss influence on shock wave propagation, bubble pulsation and the water jet phenomenon of underwater explosion, then study the dynamic behavior of bubbles after water jet. The purpose of this paper is to achieve numerical simulation methods for near-structure and near-break underwater explosion under different working conditions. This method is used to analyze the near-field underwater explosion shock wave and coupling the effects of structures, at the same time, to explore the less research condition of wall-attached jets of bubbles in the near-field and contact underwater explosion, and the interaction between the wall jets and the hole jets are discussed. Finally, the research work and deficiencies of this paper are summarized, and suggestions for further research are given.

KEY WORDS: underwater explosion, near-field, bubble pulsation, water jet, Autodyn

【Meguro laboratory】

Ryo Ito (M2)

Title : Fundamental study of bids and successful bids for restoration work by the local governments in affected areas due to the 2011 Great East Japan Earthquake and Tsunami Disaster

- Towards implementation of efficient disaster restoration works after the huge disaster in future –

Abstract : Nine years have passed since the Great East Japan Earthquake, and the end of recovery and reconstruction projects has been reached in many places. On the other hand, massive earthquakes that cause severe damage to Japan are expected. How should we prepare for this national crisis as depopulates in the future?

This study is a basic study to prepare a restoration process in advance and to review Japan's restoration and reconstruction policy and principles in preparation for a future earthquake and tsunami disaster such as the Nankai Trough earthquake. We will clarify what the bottlenecks in the recovery and reconstruction of large-scale disasters are and whether conventional recovery and reconstruction methods can be used in the future, based on analysis of restoration work in coastal areas affected by the Great East Japan Earthquake. The survey collected construction bid information, the number of city officials, the size of the construction market, and so on for 11 cities in coastal municipalities in Iwate and Miyagi prefectures.

The number of successful bids for construction work remained at a certain level in the whole affected area. Even if the number of bids is increased, bid failure occurred, and the number of construction works didn't change. From this, it is estimated that scramble for construction companies occurred in the stricken area. It was found that there was a very strong correlation between the number of construction bids and the number of city officials. The construction budget of municipalities more increased than the gross output of construction companies in the stricken area. As a result, the order-taking capacity of local construction companies has fallen significantly short of municipal construction demand. This suggests that construction work in the stricken area was heavily dependent on construction companies that were able to support other areas. Looking at the trends in the number of cases and the amount of money by classifying by type of construction, demand concentration was observed at different times for each type of construction, and demand concentration on specific types of construction was repeated. Therefore, the lack of construction capacity in the stricken area is a bottleneck for recovery and reconstruction. The lack of control over construction demand and significant disruption in demand-supply balance also harmed disaster recovery. Finally, before and after the Great East Japan Earthquake, the amount of civil engineering investment nationwide remained unchanged. In the Great East Japan Earthquake, the construction volume in the stricken area was about 6% of the national level, and support from all over the country increased to 16%. This increase can be attributed to support from other regions. Assuming similar conditions, the reconstruction of the Nankai Trough earthquake will be about 17 years. It is necessary to consider in advance the restoration process that avoids the concentration of demand in each affected local government and the entire affected area and to establish a construction support system for the affected area throughout Japan.

Keywords: Restoration work, Recovery, Reconstruction, Earthquake and tsunami.

【Kiyota laboratory】

Umar Muhammad ( Project Researcher )

Title : Post liquefaction deformation characteristics of sand in large strain torsional shear tests

Abstract : Post liquefaction behavior has been poorly understood mainly the inability to simulate large deformation behavior in the laboratory element test. Therefore, in this study, a modified large strain torsional shear apparatus capable of achieving a single amplitude shear strain of 160% was used to study post liquefaction behavior of Toyoura sand. The height of the hollow cylindrical specimen was kept constant to simulate as much as possible simple shear conditions for a wide variety of density and consolidation stress. All the specimens tested in modified torsional shear were prepared by air pluviation and subsequently consolidated isotopically. Afterward, the specimens were liquefied and then monotonically sheared to obtain a stress-strain response and compared with the test without damage strain. The multistage post liquefaction static behavior is differentiated into three regions during undrained monotonic loading. Region 1 spans from the state at which specimen develops shear strain under zero effective stress and negligible shear modulus (G1). Region 2 corresponds to the transition point after exceeding a critical shear strain ( $\gamma$ c). The specimen transited into a critical modulus (Gc) with the accelerated recovery in strength at a constant shear modulus (Gc). Region 3 commences with the change in the stress-strain curve slope and specimen transited into residual shear modulus (Gr) at a limiting shear strain ( $\gamma_{lim}$). A progressive degradation in the achieved peak strength irrespective of the density and consolidation stress. A correlation representing the degradation of post liquefaction undrained static strength with damage strain is proposed irrespective of initial density state and consolidation stress.