

Project Completion Report

on The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities in Bangladesh (TSUIB)

February 2025

**Japan International Cooperation Agency
(JICA)**

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Contents of the Project Completion Report

I. Basic Information of the Project

1. Country:

People's Republic of Bangladesh

2. Title of the Project:

The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities in Bangladesh (TSUIB).

3. Duration of the Project (Planned and Actual)

3.1 Original Plan

From: The day of the first arrival of Japanese expert.

To: 31st July, 2021.

3.2 Actual

From: 1st August, 2016 (The day of the first arrival of Bangladeshi researchers, based on JICA's suggestion.).

To: 31st July, 2022.

Due to the incident occurred on 1st July 2016, the first visit of Japanese expert team to Dhaka was delayed and the start of TSUIB project was accordingly delayed. After the incident, JICA suspended dispatching Japanese experts and decided that TSUIB project starts from 1st August 2016 at when Bangladeshi researchers first invited to Japan.

The date of the project completion was postponed to 31st July, 2022 due to the world wide pandemic of COVID-19.

4. Background (from Record of Discussions(R/D)):

Bangladesh is in significant economic development and cities like Dhaka have been densely populated during the last decade. It is located in potentially seismic zone but more than 100 years have passed since the last damaging earthquake occurred in Dhaka.

GOB officially enforced the Bangladesh National Building Code (hereinafter referred to as "BNBC") prepared by Housing and Building Research Institute in 2006, however, there are still many vulnerable buildings which are still not following the BNBC. Moreover, due to the low concrete strength, poorly provided/

detailed reinforcing bars, some of those buildings are even vulnerable enough to collapse before earthquake as shown in the accident of Rana Plaza which occurred in 2011 and caused more than 3,000 dead and wounded.

JICA has launched a technical cooperation project, “Project for Capacity Development on Natural Disaster Resistant Techniques of Construction and Retrofitting for Public Buildings (hereinafter, referred to as “CNCRP”)", in partnership with MoHPW and Public Works Department (hereinafter, referred to as “PWD”) on 2011, and started capacity development of PWD engineers to evaluate the seismic performance properly and implement retrofitting on vulnerable buildings.

Although capacity building of the evaluation and retrofitting is achieved by CNCRP, due to the differences in design practices and structural system between Japan and Bangladesh, Japanese conventional retrofit schemes may not be the best and effective solution to strengthen buildings in Bangladesh. Hence practical application oriented researches for construction materials and retrofitting schemes are needed.

The GOB requested GOJ for implementing the Project under the scheme of SATREPS (Science and Technology Research Partnership for Sustainable Development), which aims to develop technologies for enhancing structural resilience of buildings especially reinforced concrete buildings in Dhaka and to propose their effective implementation scenarios.

In the “Sixth Five Year Plan” of Bangladesh, construction of seismic resistant buildings and retrofitting are noted as a priority measures in the section related to Disaster Risk Reduction. Furthermore, in the “National Plan for Disaster Management 2010-2015”, strengthening the resilience to the earthquake disaster is noted as one of the four main strategic goals. Thus raising resilience of the buildings in Bangladesh by promoting BNBC is the urgent issue to be tackled. In the Country Assistance Policy for Bangladesh made by GOJ, support for Disaster Risk Reduction and Management is noted as one of the priority policy for overcoming social economic vulnerability of Bangladesh. Thus, the Project is in line with policies of GOJ and GOB.

5. Overall Goal and Project Purpose (from Record of Discussions(R/D))

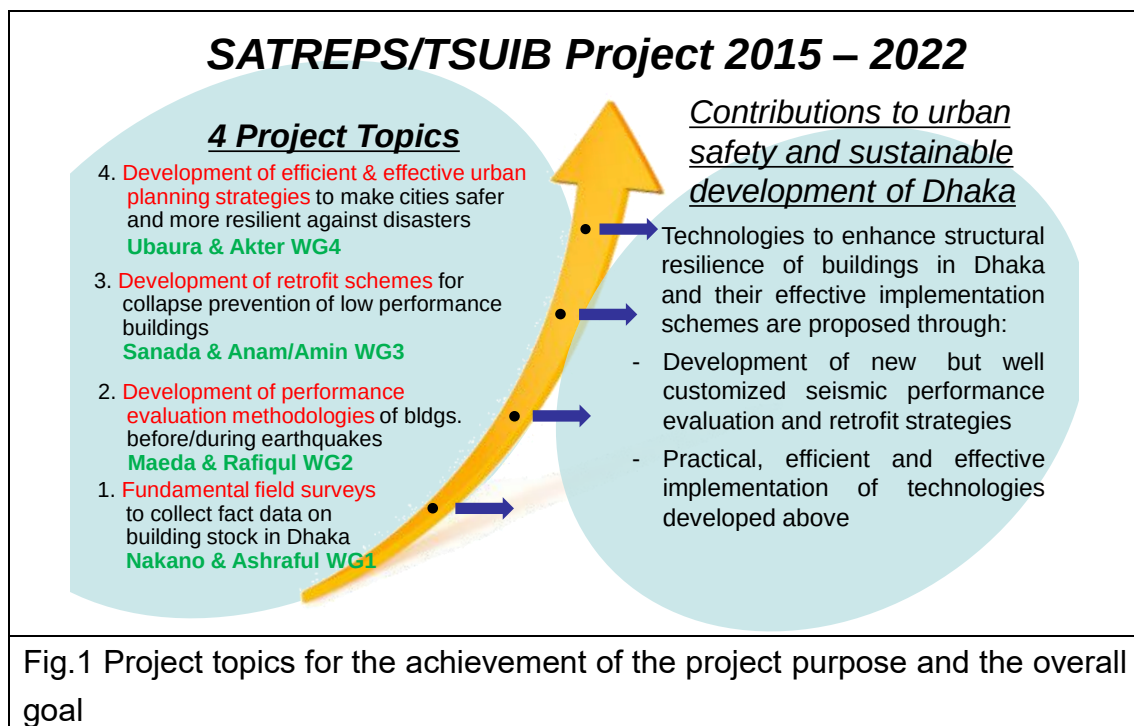
The overall goal of TSUIB project is “Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh. (copied from R/D)”, and the project purpose of TSUIB project is “Technologies for

enhancing structural resilience of urban area and buildings in Dhaka and their effective implementation schemes are proposed. (copied from R/D)".

Four expected outputs are defined in Project Design Matrix (PDM), as below.

1. Building characteristics governing its performance are identified, and research target areas and buildings are determined.
2. Performance evaluation methodology against collapse is established and applied to pilot buildings.
3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings.
4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.

The relationship between those expected output and the project purpose is shown in Fig.1.



6. Implementing Agency

The project is headed by Housing and Building Research Institute (HBRI, Bangladesh side) and The University of Tokyo (UTokyo, Japan side). The implementing agencies and the related research topics are shown in Fig. 2. The scheme of the research, relationships between research and implementation is outlined in Fig.3. The outcomes which are developed by TSUIB project (seismic

evaluation method, retrofit scheme, prioritization method, etc.) are utilized and implemented through ODA project and by local engineers.

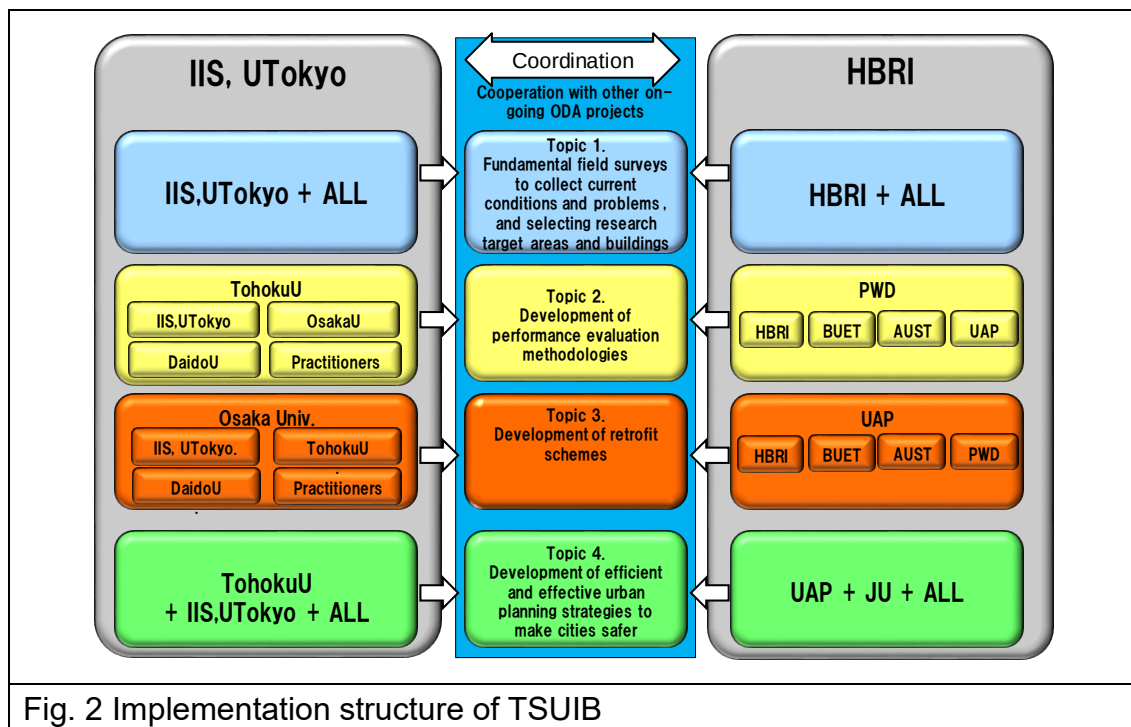


Fig. 2 Implementation structure of TSUIB

Where,

HBRI: Housing and Building Research Institute

PWD: Public Works Department

BUET: Bangladesh University of Engineering and Technology

AUST: Ahsanullah University of Science and Technology

UAP: University of Asia Pacific

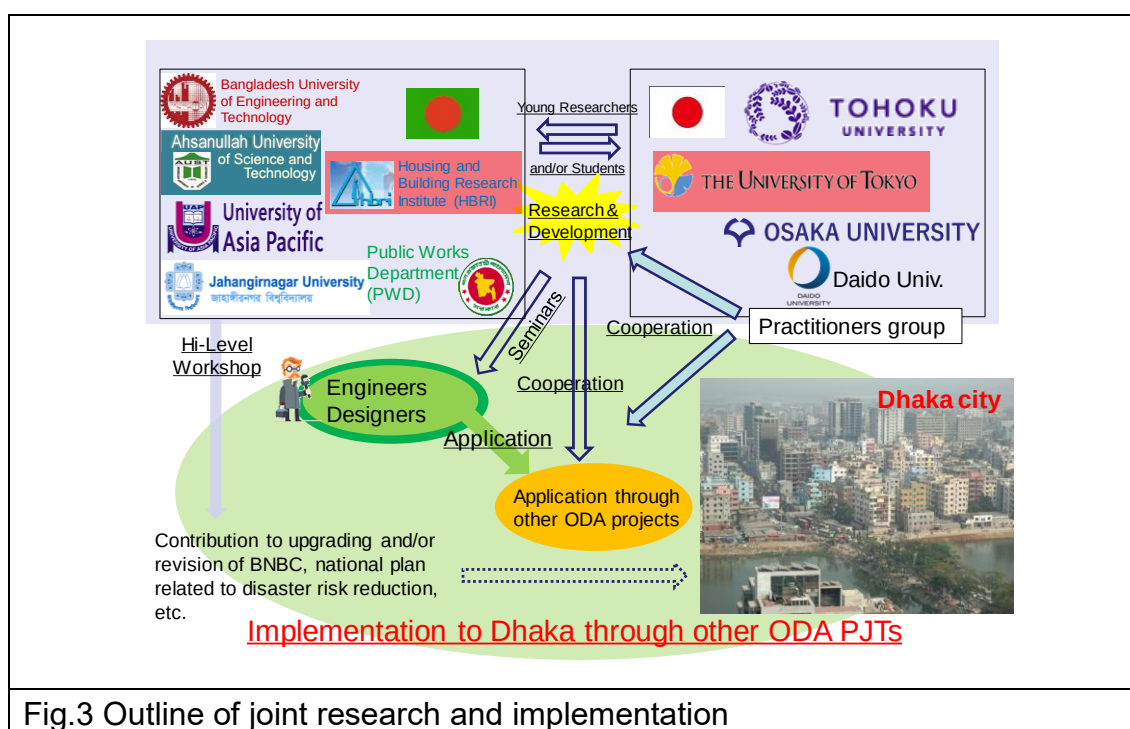
JU: Jahangirnagar University

IIS, UTokyo: Institute of Industrial Science, The University of Tokyo

TohokuU: Tohoku University

OsakaU: Osaka University

DaidoU: Daido University



II. Results of the Project

1. Results of the Project

1-1 Input by the Japanese side (Planned and Actual)

1-1-1 Experts

In TSUIB project, four working groups (WGs) are organized (WG1 to 4) and each WG is responsible for Output1 to 4, respectively. The summary of the number of dispatched days using JICA budget (and JST budget) is shown in **Table 1**. As a result, JICA Experts were dispatched total 741 days and the other researchers were dispatched total 114 days under JST budget.

Table 1 Outline of dispatched experts

WGs Corresponding research group of Japanese side	JICA Experts (Researchers, who are not dispatched as JICA Expert are dispatched under JST budget)	No. of days dispatched under JICA budget (JST budget)
WG.1 Prof. Yoshiaki Nakano and his sub group	Yoshiaki Nakano Kazuto Matsukawa	302 (0)
WG.2 Prof. Masaki Maeda	Masaki Maeda Matsutaro Seki	169 (76)

and his sub group	Tomoya Nishiwaki Debasish Sen (Kiwoong Jin) (Shafiul Islam) (Hamood AlWashali) (Zasiah Tafheem)	
WG.3 Prof. Yasushi Sanada and his sub group	Yasushi Sanada Susumu Takahashi (Rokhyun Yoon) (Nandita Saha)	132 (33)
WG.4 Prof. Michio Ubaura and his sub group	Michio Ubaura Mihoko Matsuyuki Fumihiko Seta Osamu Murao Kazuki Hanaoka Das Sangita (MD Anisuzzaman)	138 (5)

(See Annex 1-1)

1-1-2 Equipment

The procurements of equipment listed in the Plan of Operation (PO) were completed as below. The bold cases are the corresponding items listed in the PO.

- A **microtremor observation system** (one data logger and five sensors) was handed over to HBRI on 4th December, 2017.
- A system of **hydraulic jacks with electrical controllers** (four 500kN jacks, including load cells, step-down-transformer, etc.) was delivered to Bangladesh on 14th December 2017 and handed over to HBRI at the end of the project. Next system (two 500kN and one 250kN jacks, including load cells etc.) was delivered on 18th April 2018 and handed over to HBRI at the end of the project.
- A **L-shaped reaction frame** and a **hydraulic jack with manual controlling** were handed over to HBRI on 30th April, 2019.
- A **Box-shaped reaction frame** and a **hydraulic jack with manual controlling** were handed over to HBRI in December, 2019.
- **Survey tools**, a set of schmidt hammers was handed over to HBRI on 4th December, 2017. Two laser levels were handed over to HBRI on 13th

February, 2018. CAD softwares were handed over on 4th February, 2019. Drawing softwares were handed over to HBRI on 16th May, 2019.

- **Measurement systems** (three data loggers, three switch boxes, measurement software, displacement transducers) were handed over to HBRI (January 2018). The second lot was handed over to HBRI on 17th February, 2019. The third lot (compressometer etc.) was handed over to HBRI in March 2020.
- Eleven **computers** for analysis were handed over to HBRI on 21th December 2017.
- A **printer** was handed over to HBRI.
- A **pantograph** was purchased and delivered to Bangladesh 18th April, 2018.
- Some of **member specimens** (column) were manufactured at BUET and handed over in Dec. 2018.
- Seven **frame specimens** were handed over to HBRI on March 2020.
- A **GIS software** (5 users, 3 years subscription) were handed over to HBRI on 19th May 2019.

Those equipment has actively used to develop a seismic evaluation method, retrofit schemes, etc., as shown in **Pics 1 to 3**.



Pic.1 Column tests at BUET (provided jack systems, measurement systems, member specimens, reaction frames are under use) (July-December 2018).



Pic.2 RC+ Masonry wall test at HBRI (February 2019).



Pic.3 Operation instruction of the microtremor observation system.

1-1-3 Training

As mentioned above, JICA has suspended dispatching JICA Experts to Bangladesh for six months after the incident on 1st July, 2016. In addition, due to the pandemic of COVID-19, severe travel restrictions have been imposed since March 2020. This project has been always under several restrictions to the present and our activities in the field has been restricted. Therefore, number of travels by Japanese researchers was extremely reduced and, instead, number of travels by Bangladeshi researchers was increased to jointly conduct WG meetings and preliminary experiment in Japan. Those invited researchers had worked together for several days with Japanese researchers at their universities and the number of such business trip stay is totaled as 356 days (see Annex 1-2).

In addition, we have been promoting the project by accepting Bangladeshi young researchers using not only JICA Long (or Short) Term Training program but also MEXT scholarship, etc., as shown in **Table 2**.

Table 2 A list of young researchers studied in Japan under this project

No.	Name	Org. in Bangladesh	Program	Duration of RS	Univ. and lab. for RS	Duration of GS	Univ. and lab. for GS
1	Nandita SAHA (F)	UAP	MEXT ER	2016.4-2017.3	UTokyo, Nakano lab.(RS)	2017.4-2019.3	OsakaU, Sanada lab. (M)
2	MD. Shafiul ISLAM (M)	PWD	MEXT SATREPS			2016.10-2019.9	TohokuU, Maeda lab.(D)

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3	Golam SAMDANI (M)	UAP	MEXT			2017.10-2022.9	OsakaU, Sanada lab. (M, D)
4	Debasish SEN (M)	AUST	JICA LTT	2017.4-2017.9	TohokuU, Maeda lab.(RS)	2017.10-2020.9	TohokuU, Maeda lab.(D)
5	S.A.M. Nassif ZUBAYER (M)	PWD	JICA LTT	2017.4-2017.9	UTokyo, Nakano lab. (RS)	2017.10-2019.9	UTokyo, Nakano lab. (M)
6	Zasiah TAFHEEM (F)	AUST	MEXT SATREPS			2018.10-2021.9	TohokuU, Maeda lab.(D)
7	Sadia AFROSE (F)	BUET URP	JICA LTT	2018.3-2018.9	TohokuU, Ubaura lab.(RS)	2018.10-2020.9	TohokuU, Ubaura lab.(M)
8	Maisha MALIHA (F)	BUET CE	MEXT ER	2018.4-2018.9	TohokuU, Nishiwaki lab.(RS)	2018.10-2020.9	TohokuU, Nishiwaki lab.(M)
9	S.M. Naheed ADNAN (M)	BUET CE	JICA LTT	2018.6-2018.9	UTokyo, Nakano lab. (RS)	2018.10-2020.9	UTokyo, Nakano lab. (M)
			SEUT-RA JSPS DC1			2020.9-	UTokyo, Nakano lab. (D)
10	Murshalin Ahmed (M)	BUET CE	MEXT			2018.10-2020.9	OsakaU, Sanada lab. (M)
11	Radia Tahmeem KABIR (F)	BUET CE	MEXT ER	2019.4-2019.9	UTokyo, Nakano lab. (RS)	2019.10-2021.9	UTokyo, Nakano lab. (M)
12	Md. Khairu HASAN (M)	BUET CE	MEXT ER	2019.4-2019.9	UTokyo, Nakano lab. (RS)	2019.10-2021.9	UTokyo, Nakano lab. (M)
13	Mozrul Islam (M)	BUET CE	MEXT ER	2020.4-2020.9	UTokyo, Nakano lab. (RS)	2020.10-2022.9	UTokyo, Nakano lab. (M)
14	Afsana Ema (F)	BUET CE	MEXT ER	2021.9- ~~2022.9~~	UTokyo, Nakano lab. (RS)	~~2022.9~~ - ~~2024.9~~	UTokyo, Nakano lab. (M)
15	Masudur Rashied (M)	JU	MEXT ER			~~2022.04-~~ ~~2025.03~~	TohokuU, Ubaura lab.(D)
16	A. K. M. Sajadur Rahman (M)	PWD	MEXT ER	2020.4-2020.9	TohokuU, Maeda lab.(RS)	2020.10- ~~2023.9~~	TohokuU, Maeda lab.(D)

JICA LTT: JICA Long-term training program. MEXT: Scholarship of Ministry of Education, Culture, Sports, Science and Technology, Japan. ER: Embassy recommendation. SATREPS: Special program for SATREPS related universities and laboratories. RS: Research student. M: Master's student. D: Doctoral student. Red color cases here mean expected future schedule.

Furthermore, two young researchers from HBRI supported by IISEE (International Institute of Seismology and Earthquake Engineering) Training program, which is jointly organized by the Building Research Institute of Japan and JICA, had studied in Nakano lab. (UTokyo) and Maeda Lab. (TohokuU).

As mentioned above, one of the remarkable achievements of this project is accepting many (16 in Table 2 and +2 from IISEE) Bangladeshi young researchers to Japan and promoting technology transfer to them who would be the future leaders of the country. Among the young researchers in Table 2, Md. Shafiul ISLAM (PWD -> TohokuU) achieved high research results, including receiving the “Encouragement Award for annual conference” from the Japan Concrete Institute for two consecutive years. Debasish Sen (AUST -> Tohoku University) received his PhD (Engineering) degree in September 2020 and is working at AUST from September 2020. He is in charge of the design and construction of the ferrocement retrofit which was his research theme in his doctoral course.

1-2 Input by the Bangladesh side (Planned and Actual)

1-2-1 Experts

In the TSUIB project, research activities were divided into four working groups (WGs). Each WG is responsible for output 1 to 4 respectively. Two Senior consultants and Seven Junior consultants were appointed on full time basis from GOB (Government of Bangladesh) budget, to assist the research works of all the WGs. Summary of the researchers and consultants dispatched are shown in Table 3.

Table 3. Summary of the dispatched researchers and consultants.

WGs Corresponding research group of Bangladesh side	Name of the Researchers or Consultant	Period	Remarks
WG.1 Md. Ashraful Alam and his sub group	Md. Ashraful Alam		DG, HBRI & PD, TSUIB.
	Sakhawat Hossain		PRE, HBRI
	A.F.M. Saiful AMIN		Prof., BUET
	Md. Rafiqul Islam		SE, PWD

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	Iftekhar ANAM		Prof., UAP
	Sharmin Reza Chowdhury		Prof., AUST
	Fatema-Tuz-Zahura		Associate Prof., AUST
	Md. Arifujjaman		SRE, HBRI
	Md. Mizanur Rahman		Prof., BUET
	Md. Abdul Malek Sikder		SC, TSUIB, HBRI
	Md. Abdur Rahman Bhuiyan		SC, TSUIB, HBRI
	Farjana Khanam	Mar 2018 to Jan 2022	JRC, TSUIB, HBRI
	Anik Das		JRC, TSUIB, HBRI
	S. M. Muhaiminul Islam		JRC, TSUIB, HBRI
	Md. Ariful Islam	Mar 2018 to May 2021	JRC, TSUIB, HBRI (Assigned to BUET)
	Md. Ariful Islam	Dec 2020 to Dec 2021	JRC, TSUIB, HBRI (Assigned to HBRI)
	Zannatul Alam	Feb 2019 to Jan 2021	JRC, TSUIB, HBRI
	Md. Jobaer Uddin	May 2018 to Jun 2019	JRC, TSUIB, HBRI
	Ishrat Baki Borno	Mar 2018 to Jan 2019	JRC, TSUIB, HBRI
	Md. Imam Hossain	Starting from Jan 2022	JRC, TSUIB, HBRI
	Saumik Mallik	Starting from Jan 2022	JRC, TSUIB, HBRI

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			(Assigned to BUET)
	Md. Ibnul Warah		RE, HBRI
WG.2 Md. Rafiqul Islam and his sub group	Md. Rafiqul Islam		SE, PWD
	A.F.M. Saiful AMIN		Prof., BUET
	Iftekhar ANAM		Prof., UAP
	Fatema-Tuz-Zahura		Associate Prof., AUST
	Debasish SEN		Asst. Prof., AUST
	Md. Mizanur RAHMAN		Prof., BUET
	Md. Ashraful Alam		DG, HBRI & PD, TSUIB.
	Sakhawat Hossain		PRE, HBRI
	Md. Shafiul Islam		SRE, HBRI
	S.A.M Nassif ZUBAYER		AE, PWD
	Md. ARIFUJJAMAN		SRE, HBRI
	Md. Jahidul Islam Khan		EE, PWD
	Humaira Binte Hasan		SDE, PWD
	Md. Raquibul Hasan		SDE, PWD
	Md. Iftekharul Islam		AE, PWD
	Md. Abdul Malek Sikder		SC, TSUIB, HBRI
	Md. Abdur Rahman Bhuiyan		SC, TSUIB, HBRI
	Farjana Khanam	Mar 2018 to Jan 2022	JRC, TSUIB, HBRI
	Anik Das		JRC, TSUIB, HBRI
	S. M. Muhaiminul		JRC, TSUIB,

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	Islam		HBRI
	Md. Ariful Islam	Mar 2018 to May 2021	JRC, TSUIB, HBRI (Assigned to BUET)
	Md. Ariful Islam	Dec 2020 to Dec 2021	JRC, TSUIB, HBRI (Assigned to HBRI)
	Zannatul Alam	Feb 2019 to Jan 2021	JRC, TSUIB, HBRI
	Md. Jobaer Uddin	May 2018 to Jun 2019	JRC, TSUIB, HBRI
	Ishrat Baki Borno	Mar 2018 to Jan 2019	JRC, TSUIB, HBRI
	Md. Ibnul Warah		RE, HBRI
	Md. Imam Hossain	Starting from Jan 2022	JRC, TSUIB, HBRI
	Saumik Mallik	Starting from Jan 2022	JRC, TSUIB, HBRI (Assigned to BUET)
WG.3 Prof. Dr. A.F.M. Saiful Amin and his sub group	Prof. Dr. A.F.M. Saiful Amin		Prof., BUET
	Iftekhar ANAM		Prof., UAP
	Dr. Md. Ashraful Alam		DG, HBRI & PD, TSUIB.
	Syed Jamal Uddin AHMED		Asst. Prof., UAP
	Md. Jihad MIAH		Asst. Prof., UAP
	Md. Ashraful Alam		DG, HBRI & PD, TSUIB.
	Sharmin Reza Chowdhury		Prof., AUST
	Fatema-Tuz-Zahura		Associate

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		Prof., AUST
Debasish Sen		Asst. Prof., AUST
Zasiah TAFHEEM		Asst. Prof., AUST
S.A.M Nassif ZUBAYER		AE, PWD
Md. ARIFUJJAMAN		SRE, HBRI
Md. Shafiul Islam		SRE, HBRI
Md. Abdul Malek Sikder		SC, TSUIB, HBRI
Md. Abdur Rahman Bhuiyan		SC, TSUIB, HBRI
Nandita Saha		Lec., UAP
Farjana Khanam	Mar 2018 to Jan 2022	JRC, TSUIB, HBRI
Anik Das		JRC, TSUIB, HBRI
S. M. Muhaiminul Islam		JRC, TSUIB, HBRI
Md. Ariful Islam	Mar 2018 to May 2021	JRC, TSUIB, HBRI (Assigned to BUET)
Md. Ariful Islam	Dec 2020 to Dec 2021	JRC, TSUIB, HBRI (Assigned to HBRI)
Zannatul Alam	Feb 2019 to Jan 2021	JRC, TSUIB, HBRI
Md. Jobaer Uddin	May 2018 to Jun 2019	JRC, TSUIB, HBRI
Ishrat Baki Borno	Mar 2018 to Jan 2019	JRC, TSUIB, HBRI
Md. Imam Hossain	Starting from Jan 2022	JRC, TSUIB, HBRI

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	Saumik Mallik	Starting from Jan 2022	JRC, TSUIB, HBRI (Assigned to BUET)
	Md. Ibnul Warah		RE, HBRI
WG.4 Prof. Md. Akter Mahmud and his sub group	Prof. Md. Akter Mahmud		Prof., JU
	Khurshid Zabin Hossain TAUFIQUE		Director, UDD
	Israt JAHAN		RO, UDD
	Ishrat ISLAM		Prof., BUET
	Mohammad Shakil AKTHER		Prof., BUET
	A.F.M. Saiful AMIN		Prof., BUET
	Md. Mizanur RAHMAN		Prof., BUET
	Dr. Md. Ashraful Alam		DG, HBRI & PD, TSUIB.
	Sakhawat Hossain		PRE, HBRI
	Iftekhar ANAM		Prof., UAP
	Md. Rafiqul ISLAM		SE, PWD
	Md. Abdul Malek SIKDER		SC, TSUIB, HBRI
	Masudur Rashied		JRC, TSUIB, HBRI
	Sadia AFROSE		JRC, TSUIB, HBRI
	Anik DAS		JRC, TSUIB, HBRI
	S. M. Muhaiminul ISLAM		JRC, TSUIB, HBRI
	Farjana KHANAM	Mar 2018 to Jan 2022	JRC, TSUIB, HBRI
	Md. Ariful ISLAM	Mar 2018 to May 2021	JRC, TSUIB, HBRI

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			(Assigned to BUET)
	Md. Ariful ISLAM	Dec 2020 to Dec 2021	JRC, TSUIB, HBRI (Assigned to HBRI)
	Zannatul Alam	Feb 2019 to Jan 2021	JRC, TSUIB, HBRI
	Md. Jobaer Uddin	May 2018 to Jun 2019	JRC, TSUIB, HBRI
	Ishrat Baki Borno	Mar 2018 to Jan 2019	JRC, TSUIB, HBRI
	Md. Imam Hossain	Starting from Jan 2022	JRC, TSUIB, HBRI
	Saumik Mallik	Starting from Jan 2022	JRC, TSUIB, HBRI (Assigned to BUET)
	S. M. Nawshad Hossain		Associate Prof., JU
	Mohammad Mizanur Rahman		Ass. Prof., JU
	Dr. Sayeda Saika Binte Alam		Asst. Architect, HBRI
	Md. Muktadir Abedin		Asst. Architect, HBRI
	Monjur Parves		RA, HBRI
	Nahid Ferdous Dristy		RA, HBRI
	Asif Khan		RS, JU
	Md. Tawshif Islam		RS, JU
	Sharmin Nahar		RS, JU
	Arnob Chakrabarty		RS, JU

*Abbreviation

DG- Director General	Prof.- Professor
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PD- Project Director	AE- Assistant Engineer
PRE- Principal Research Engineer	SC- Senior Consultant
SRE- Senior Research Engineer	JRC- Junior Research Consultant
RE- Research Engineer	Asst.- Assistant
SE- Superintending Engineer	RA- Research Associate
EE- Executive Engineer	RS- Research Student
SDE- Sub-divisional Engineer	RO- Research officer
Lec.- Lecturer	

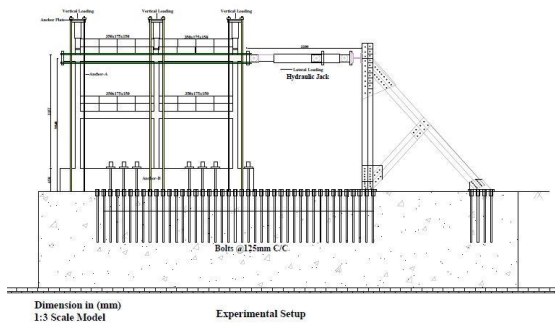
1-2-2 Equipment

Two reaction frames and a pantograph were received from JICA. The pantograph was installed at BUET laboratory and two reaction frame were installed at HBRI laboratory. The cost of installation of the two reaction frames, installed at HBRI was funded by HBRI from the project budget (GOB side). One overhead crane and three digital voltage monitors were procured by HBRI from the project budget (GOB side).

- Four concrete frame specimens were provided to BUET for the additional test plan inspired by TSUIB Project.
- Nine unreinforced masonry wall specimens (**Pic. 4**) were provided from the project budget (GOB side) for the test, as part of the research work titled “Development of a seismic assessment method for URM Buildings” taken by HBRI and triggered by TSUIB Project.
- Three “Two Bay-Two story” RC frame specimen (**Pic. 5 and Fig. 4**) were constructed, with project budget (GOB side) for the supplementary test by HBRI, inspired by TSUIB Project.



Pic.4 Masonry wall tests at HBRI (December 2021).

	
Pic.5 Construction of 2 bay 2 story frame at HBRI (November 2021).	Fig.4 2 bay 2 story frame setup system.

1-2-3 Training

On the job training to operate the hydraulic jack system and data acquisition using data logger was carried out for the consultants of the project and the Engineers of HBRI.

1-3 Activities (Planned and Actual)

Dhaka belongs to a seismically active region, but it has been more than a century since the last damaging earthquake, during which time the city has become increasingly dense. During the 2016 earthquake in Nepal, a small ground motion occurred in northeastern Bangladesh, but some buildings were seismically weak enough to be tilted despite the small ground motion.

In the ODA project conducting seismic evaluation and retrofit to buildings in Dhaka that started in 2011 (CNCRP: Capacity Development on Natural Disaster Resistant Techniques of Construction and Retrofitting for Public Buildings), several structural problems commonly found in Bangladesh such as extremely low concrete strength and inappropriate reinforcement, etc. have been pointed out. TSUIB project started for overcoming such problems and upgrading seismic integrity of buildings in Dhaka through research, development and social implementation.

Research Topic 1 is to identify the current status, seismic regulations, and construction practices of buildings in Dhaka through field surveys, literature review, and analysis of data provided by past projects. Through the activities above, research target buildings and areas are determined.

Research Topic 2 is to discover the structural shortcomings found in buildings in

Dhaka, and to develop a seismic evaluation method through structural tests and simulations. In Research Topic 3, several effective scheme to improve their seismic performance are developed through structural tests and simulations. The developed seismic evaluation methods and retrofit schemes are compiled as guidelines, and seminars (including video presentations on the web) are held to collect opinions and public comments from government engineers and academic experts, with the aim of authorizing them to be widely and effectively applied by the government. In order to effectively implement the seismic evaluation and retrofit for individual buildings developed in Research Topic 2 and 3, we have developed a method to determine the retrofit priority (retrofit scenario) according to the characteristics of each ward, the use of buildings, and the cost of reinforcement, etc., in Research Topic 4.

Project members has worked according to the planned activities that are defined in PDM. As shown below, Activity 1-1 – Activity 4-3 have been conducted. The planned and actual activities are explained as below.

Planned

Activity 1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances

Planned

Sub Activity 1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database

Sub Activity 1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database

Actual

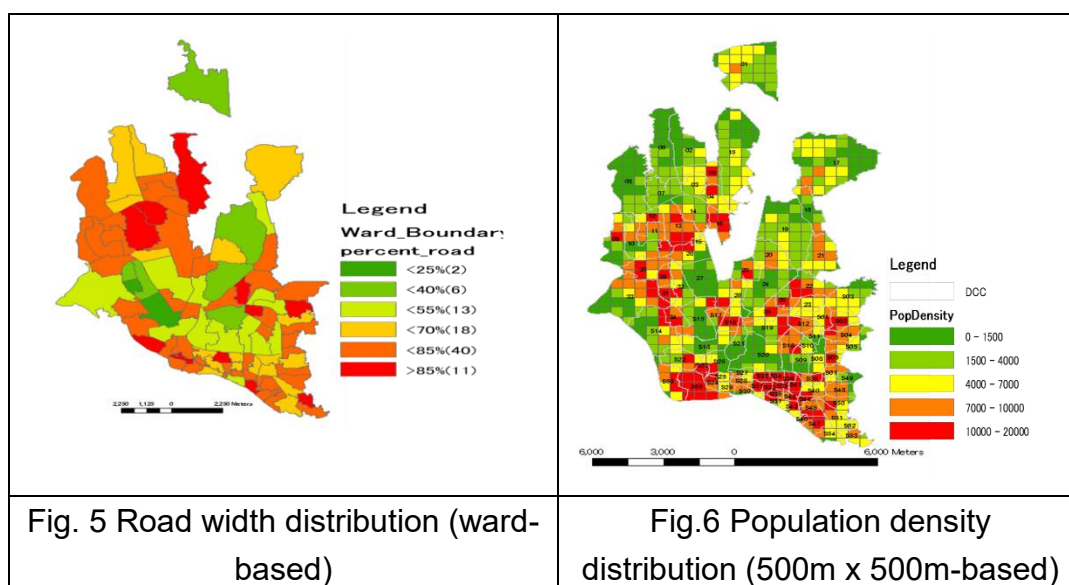
In this project, field surveys of Dhaka city for establishing database are difficult because of the activity restrictions imposed by JICA, after July, 2016. We therefore gave up establishing our own database, instead, received two existing databases from past projects. The latest version of the RAJUK (Rajdhani Unnayan Karttripakkha) database was obtained in FY2017. Using this database, WG4 performed a regional and spatial analysis of the characteristics of Dhaka city in terms of the distribution of road area, population, etc. in ward-based and 500m×500m mesh-based (**Fig.5 and 6**). These are individual elements for disaster vulnerability assessment. The database

contains data of 453,975 buildings with structure type (temporary, permanent, intermediate, or simple), use, year of construction, number of floors, etc., as well as infrastructures such as roads and open spaces.

In FY2017, WG1 received another database made by “Comprehensive Disaster Management Program 1 (CDMP1)” project which was Implemented by the United Nations Development Programme (UNDP). The database contains (simple) drawing data for 583 buildings surveyed under CDMP1.

In addition, WG2 conducted a survey on the structural properties of 21 public (governmental) buildings designed by PWD (Pic. 6) and 2 private buildings. WG2 prepared the as-built drawings of those buildings for the seismic evaluation and applied seismic evaluation method to those buildings, as described later in Activity 2-6.

Note: The aforementioned travel and activity restrictions due to the incident has long been imposed by JICA through the project duration. Under the influence of those restrictions, it is difficult to conduct the field survey in a wider area as envisioned at the beginning of the TSUIB project. In 2020, as the restrictions on activities had been gradually eased, building surveys in Sylhet city and ward 43 in Dhaka city were planned. However, the surveys were abandoned due to COVID-19 pandemic.





Pic. 6 Building survey to make as-built drawings

Planned

Activity 1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances

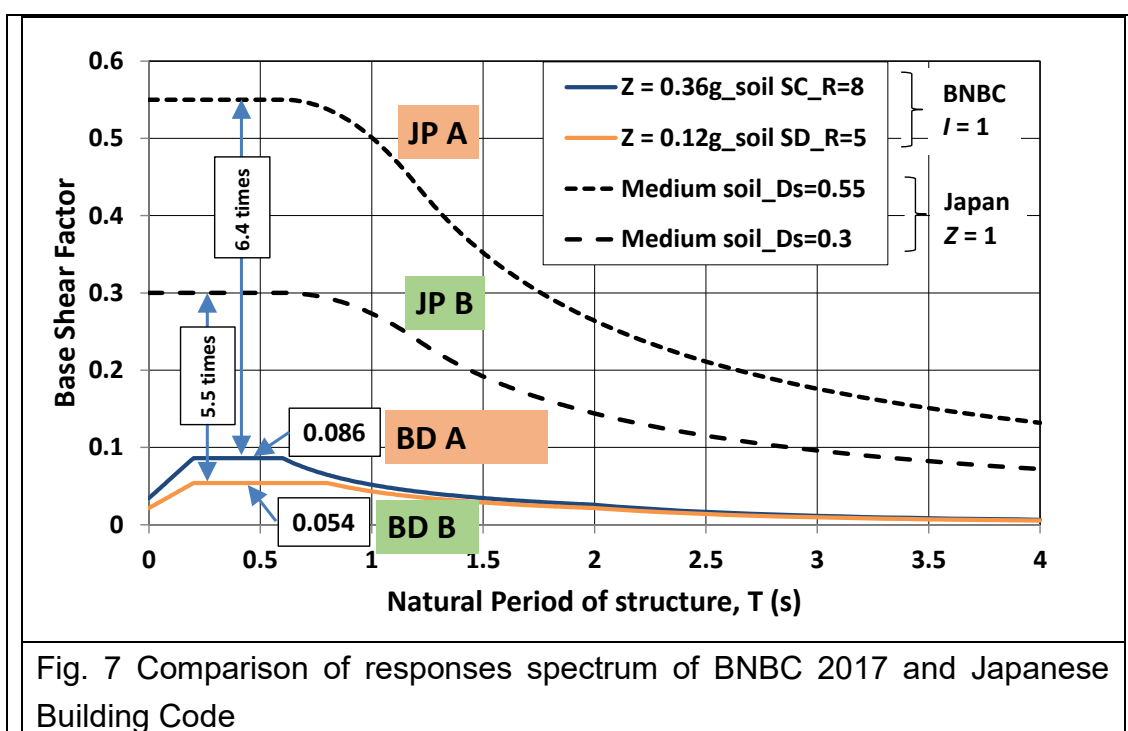
Planned

Sub Activity 1-1-2 Investigating seismic design code and practice
1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database

Actual

The latest version of BNBC (BNBC2017, which was the latest when this activity was performed) of which HBRI is in charge, was obtained. The WG1 compiled this into a report in terms of seismic design code.

As a result, it was found that the required performance of BNBC is approximately 1/1.5 to 1/3.7 for the elastic response acceleration level, approximately 1/4.4 to 1/1.5 for the response reduction factor, and finally approximately 1/5.5 to 1/6.4 (for the required base shear factor), compared to those of Japanese Building Code, as shown in **Fig. 7**.

**Planned**

Activity 1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances

Planned

Sub Activity 1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings

Actual

The process of the construction from the order to the completion of a building in Bangladesh was surveyed and reported by WG1 for the part related to PWD, which is an institution in charge of design and construction of public (governmental) buildings in Bangladesh. We have focused on public buildings only because BSPP's report about private buildings complementarily fulfilled our target. Therefore, there were no necessities for survey on private buildings by this project.

Planned

Activity 1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances

Planned

Sub Activity 1-1-4 Knowledge sharing of results derived from relevant projects

Actual

As mentioned above, the database and knowledge developed in the past different projects were provided by CDMP1, RAJUK, BSPP, etc. and utilized in this project.

In addition, at the 4th JCC held in August 2018, four disaster reduction projects in Bangladesh including TSUIB (TSUIB, BSPP, UBSP (Urban Building Safety Project: JICA's project to make buildings safer) and SEEDs Asia (a NGO which works under JICA Partnership Program)) gathered to share their activities, objectives, and the current statuses. The participants confirmed that they would cooperate with each other for the future activities.

Planned

Activity 1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above

Actual

By the end of 2018, the research target area and buildings are determined as DNCC+DSCC (Dhaka North City Corporation + Dhaka South City Corporation) area and reinforced concrete structures (including those with masonry walls and flat plate structures), respectively.

Planned

Activity 2-1 Identifying problems needed to be resolved using results obtained from activity 1-1 and 1-2

Actual

Several problems of the building construction practice in Bangladesh pointed out by CNCRP project (see Fig.8) were shared with TSUIB members.

Those problems are; 1) use of low strength concrete, 2) high axial forces acting on columns, 3) use of 90° hooks for shear reinforcement in columns and beams, 4) straight anchorage of beam reinforcement in the exterior beam-column joint, 5) narrow beam-column joint, 6) no shear reinforcement in the beam-column joint, and 7) effect of the masonry wall on the RC frame structure has not been clarified, and 8) random position of splices. In addition to those problems already pointed out by CNCRP, as a TSUIB project, we highlighted 9) flat plate structures, which are one of the common structural types and are generally considered to be vulnerable to earthquakes. In order to solve the

above problems 1) to 7) and 9), which may directly affect the seismic performance, the seismic evaluation policy was determined in Activity 2-2 and the experimental plans were made in Activity 2-3.

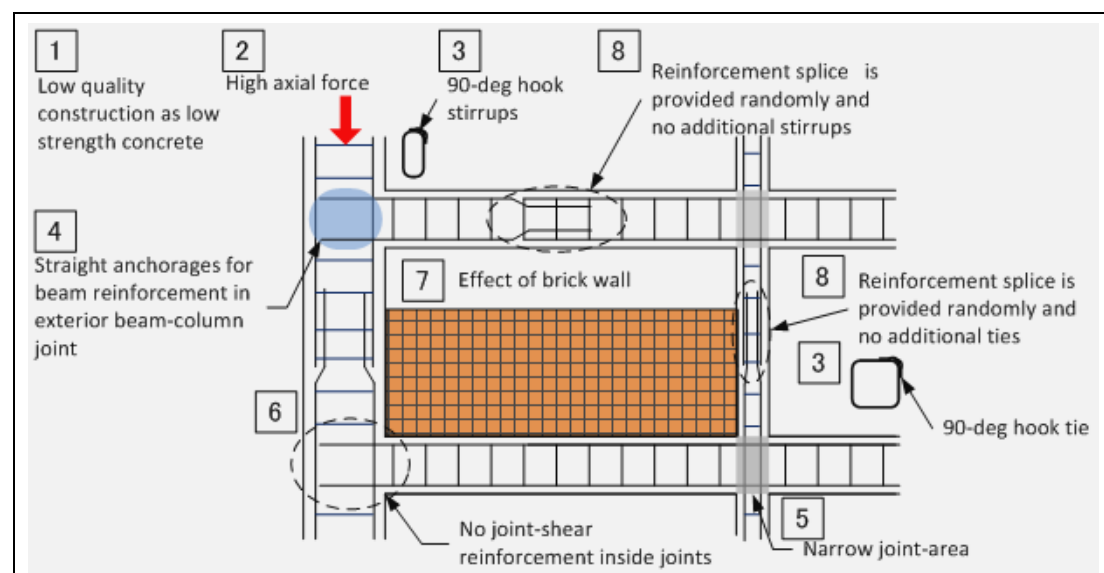


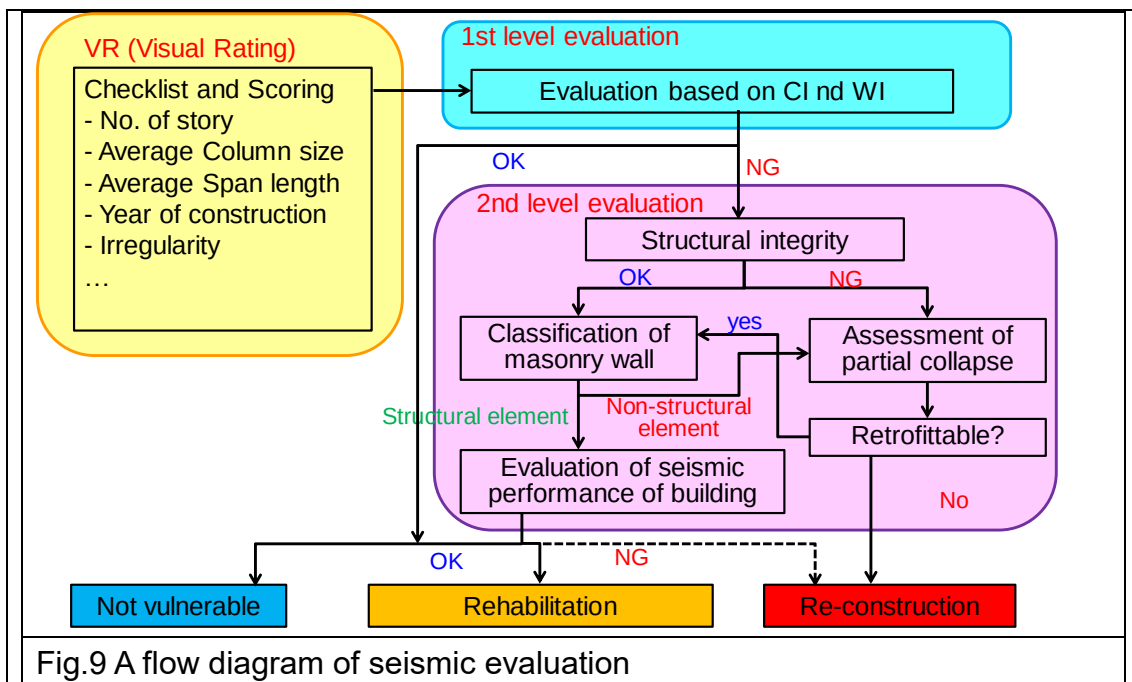
Fig. 8 Problems needed to be resolved identified by CNCRP project (ref. CNCRP report)

Planned

Activity 2-2 Developing performance evaluation policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects

Actual

By FY2017, the seismic evaluation policy is agreed as shown in Fig. 9, which includes the VR method as a preliminary step of the seismic evaluation. The VR method is a quick and rapid evaluation method to identify a necessity of detailed seismic evaluation (1st level and 2nd level screening). This is because it is not realistic to perform detailed (1st level and 2nd level screening) seismic evaluation for all the buildings (i.e., a huge number of building stock) in Dhaka.

**Planned**

Activity 2-3 Developing formulas for performance evaluation through experiments and analyses of structures

Actual

This activity is to develop the VR method and to develop the seismic evaluation method based on the structural experiments and analyses. All the experiments necessary for the development of seismic evaluation method have been completed.

Development of the VR method (TohokuU and PWD)

As mentioned above, it was difficult to survey a huge number of building stocks one by one in detail within a limited project duration, the VR method was developed by mainly WG2 members as a quick and rapid evaluation method to sort out buildings having higher necessity of detailed seismic evaluation. The developed VR method is a simplified version of the seismic evaluation method that can be used to evaluate buildings' performance based on items that can be visually surveyed. Dr. Shafiul Islam, who studied at Tohoku University with a scholarship from MEXT and previously worked at PWD, has greatly contributed to the development of this method. A research paper about the VR method was published in the Bulletin of Earthquake Engineering (S. Islam et al., 2019) which is one of the highest impact journal in the earthquake engineering field. As mentioned below, responding to their strong interest,

TSUIB organized an open forum about the VR method for Bangladeshi researchers (not only TSUIB members but also university professors and engineers not related to TSUIB) are strongly interested in the VR method.

Tests of the RC frame with problems raised in Activity 2-1 (UTokyo and HBRI)

Since it was difficult to carry out the full-scale experiment in Bangladesh in FY2018 due to the activity restrictions by JICA and delay of budget allocation of Bangladeshi side (TAPP), the loading test of two frame specimens which contain problems raised in Activity 2-1 was first carried out by UTokyo in Japan. Initially, because the full-scale experiment would clarify the problems in the Bangladeshi buildings, TSUIB members strongly supported to perform this test in Bangladesh in the beginning stage of the project. However, due to the delay of the TAPP and the restriction of activities, it was difficult to perform it. Therefore, the “full-scale experiments” were removed from the Activities in the PDM, and the problems of the Bangladeshi buildings were identified from **Fig. 8** provided by CNCRP. Hence, no significant influence occurred due to the delay of the test on the achievement of the project goals.

The frame specimens are 2 story 2 bay RC frame and the parameters of the two specimens were with and without masonry walls. **Pic. 7(top)** shows the final failure of the specimen with the masonry wall. The strength of the RC frame was relatively lower than that of the masonry wall, therefore, punching shear failure at the top of the column was observed. Besides, the pull-out behavior was observed at the end of the beam on the right side columns. This type of failure leads to catastrophic damage and is rarely found in Japan, Europe, and the United States, where strength of the RC structure is relatively high.

HBRI manufactured similar 2 story 2 bay specimens and loaded them in May, 2022 (**Pic.7 bottom**). This test was led by Bangladesh side in all processes (design, construction, set up and loading) and pointed out shortcomings of existing Bangladeshi buildings.



Pic.7 Failure pattern of the specimen with masonry wall

Tests of RC frame+ masonry infill wall (TohokuU, HBRI and AUST)

In TohokuU, several tests of RC+MIW structures were conducted in FY2016 - FY2018 (Pic. 8). Then tests of the same type of structures were conducted in Bangladesh in FY2018 and 2020 in collaboration with AUST, HBRI, and TohokuU (Pic. 9). From these tests, it was found that the failure pattern of reinforced concrete columns and masonry infill walls can be roughly estimated by the contact length of column and masonry wall. The corresponding strength and deformation capacity can be evaluated by a simple mathematical formula that would be very easy to use. This method was published in one of the leading journals in the field of structural engineering (Engineering Structure) (Alwashali et al. 2019), and was directly adopted in the developed seismic evaluation

method.



Pic.8 Failure pattern of a specimen tested by TohokuU in Japan (2016)



Pic.9 Failure pattern of a specimen tested by AUST, HBRI and TohokuU in Bangladesh (2018)

Tests of high axial force (+ low concrete strength) columns (UTokyo and BUET)

BUET and UTokyo strongly collaborated and performed tests of columns under axial force and seismic forces in Japan (FY2017, [Pic. 10](#)) and similar tests in Bangladesh (FY2017 (preliminary test) and FY2018 (main test), [Pic. 11](#)). The only difference between the specimens in Japan and Bangladesh is coarse aggregate of concrete where brick chips are used in Bangladesh instead of stones. Significant effects on shear strength were not observed even when brick chips are used. Based on these results, a strength and deformation capacity evaluation method for seismic evaluation was proposed by WG2. In addition, flexural failure type column specimens made with low strength concrete were tested in UTokyo in FY2018 to investigate the strength and deformation capacity of such columns.

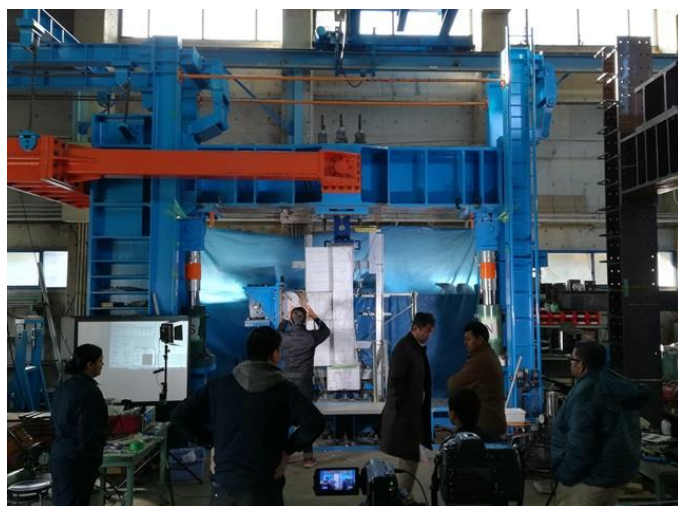


Pic.10 Failure pattern of column tested by UTokyo in Japan (2017)

Pic.11 Failure pattern of column tested by BUET in Bangladesh (2017)

Tests of beam-column joints (OsakaU, DaidoU and BUET)

OsakaU and DaidoU performed a series of seismic tests of beam-column joint in Japan in collaboration with BUET in FY2016 and 2017 (Pic. 12). In the beam-column joint with insufficient development of the beam reinforcement, which was a common practice in Bangladesh, the beam reinforcement would be easily pulled out from the column during an earthquake. This is undoubtedly unfavorable reinforcement arrangement because the structural frame loses its structural integrity to resist against earthquakes. In the test specimen reproducing this type of reinforcement, the pull-out failure of the beam rebar was observed (Pic. 13). In addition, a pull-out test of rebars embedded in concrete using brick chips was conducted at BUET in October-November 2018, especially for low-strength concrete (Pic. 14). The results of these tests are directly incorporated to develop the seismic evaluation method. In addition, BUET performed a series of beam-column joint tests using local materials in June, 2022. They simulated failure of the joint due to insufficient development.



Pic.12 Beam-column joint test (OsakaU)



Pic.13 Pull-out failure of beam longitudinal bar



Pic.14 Pull-out test (BUET)

Tests of flat plate structures (DaidoU, OsakaU and UAP)

The flat plate structures in Bangladesh is generally designed so that their exterior column-beam frames resist the seismic loads while interior columns, having no connecting beams, support only the gravity loads. In general, the lateral strength and stiffness of this structural type are low, and the high level experience and knowledge are required for their proper seismic design. However, flat plate structures without proper seismic load path (missing of exterior column-beam frames, etc.) have been often found in countries like Bangladesh. In Japan, DaidoU and OsakaU conducted tests on flat plate joints in FY2017 and FY2018, and confirmed that the lateral strength was extremely low, as shown in Fig.10. In addition, UAP has conducted loading tests on flat plate joints (Pic. 15). From the results of these experiments, three failure patterns of the flat plate joints, column failure; floor slab bending failure; and floor slab punching shear failure, were confirmed, and the lateral strength to each failure pattern and the seismic evaluation method were proposed by WG3 (Fig.11).

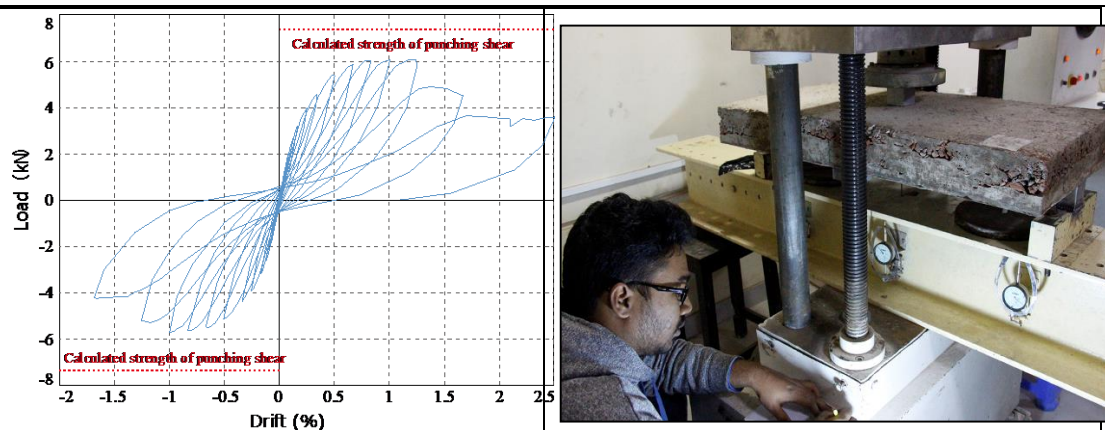


Fig.10 Load-deflection curve of a flat plate specimen

Pic.15 Flat plate test in UAP

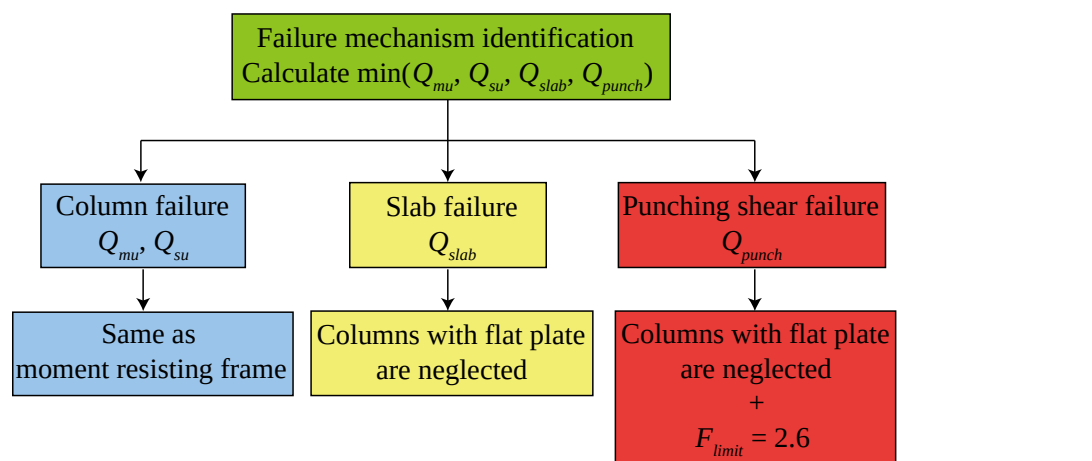


Fig.11 Proposed seismic evaluation procedure

Investigation of non-destructive testing methods to estimate concrete strength (TohokuU and BUET)

TohokuU and BUET has been seeking the most suitable nondestructive testing methods for estimating concrete strength of buildings in Bangladesh. Estimation of concrete strength is very important because it directly affects the performance of all the structural members mentioned above. In general building owners are not, however, willing to conduct destructive testing on their buildings. A nondestructive method for accurate strength estimation is therefore strongly needed. TohokuU and BUET has compared the compressive strength of various samples (concrete cores taken from HBRI building, a public building in Dhaka (Pic. 16), private hospital in Dhaka, BUET column specimen, low strength concrete in Sri Lanka, etc.) with the estimated values obtained by various nondestructive testing methods. As a result, it was found that concrete

strength can be classified into four levels by the combined use of L-type rebound hammer and scratching test method (Fig. 12).



Pic.16 Application of a NDT method to a building in Dhaka

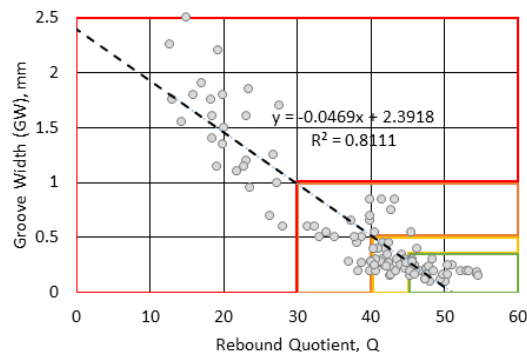


Fig.12 Proposal of strength estimation method with L-type rebound hammer and scratching test method

Planned

Activity 2-4 Determining required performance standard

Actual

In WG2, the method of setting the required performance (I_s) value was examined by comparing the data of earthquake damage in other countries. Fig. 13 shows a relationship between estimated damage and seismic performance of buildings in Dhaka, based on the data from Taiwan Chi-Chi earthquake. As a result, assuming the same level of seismic input as that of the Taiwan Chi-Chi earthquake, 62% of the buildings are estimated to be severely damaged. In addition, WG2 attempted to set the required performance (I_s) value for the second level seismic evaluation by computer analysis. In the analysis, the response level was examined using single-degree of freedom system and the design response spectrum assumed for Dhaka based on BNBC. As a result, I_s value of 0.4 was found as the required performance level for a building with up to six stories, where the ratio of Capacity/Demand is about 1.0 (I_s2 in Fig. 14, and it was confirmed consistent with the required performance level of 0.36 for soil type SD in the CNCRP manual). Based on these results and discussions in the WG meetings, finally it was determined to adopt the target (required) values as equal as CNCRP and BSPP.

Furthermore, based on the correlation between the I_s value in the second level (detailed) seismic evaluation and the I_s value by the VR method, the boundary

values for classifying buildings into the five levels to prioritize the necessity of detailed seismic evaluation, A to E, was determined (Fig. 15). The VR method can practically identify buildings that require detailed seismic evaluation, and therefore it can efficiently identify them out of a huge number of building stock.

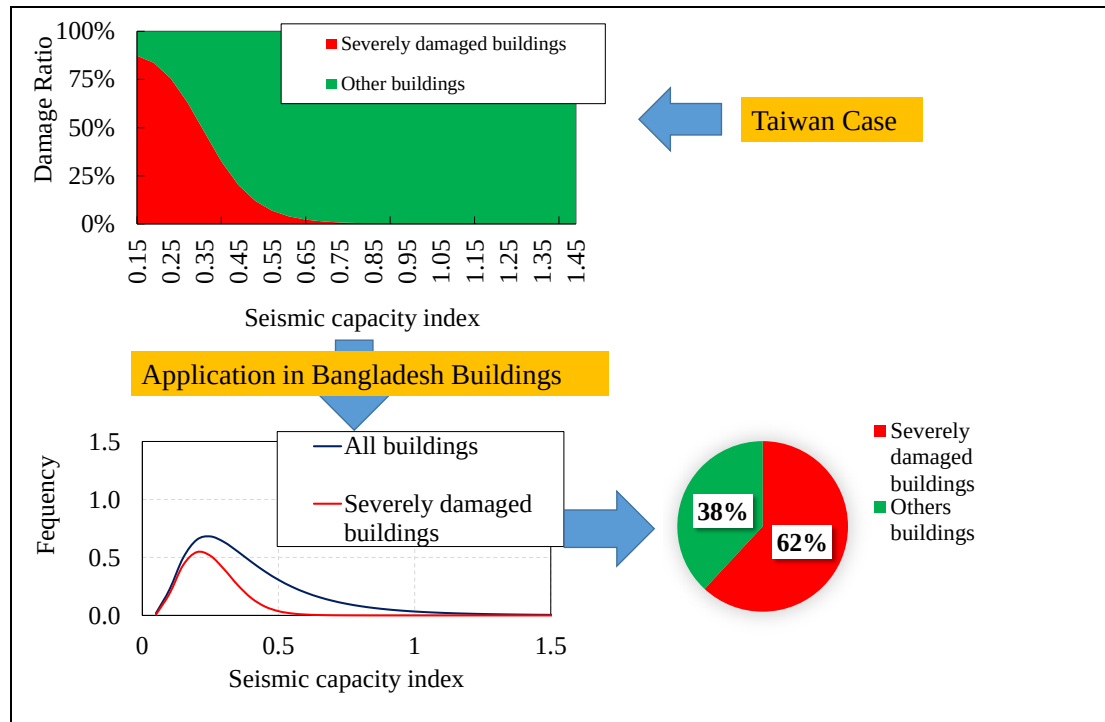


Fig.13 Probability of damage rate severer than "Severe" in Dhaka based on survey results of Taiwan Chi-Chi earthquake

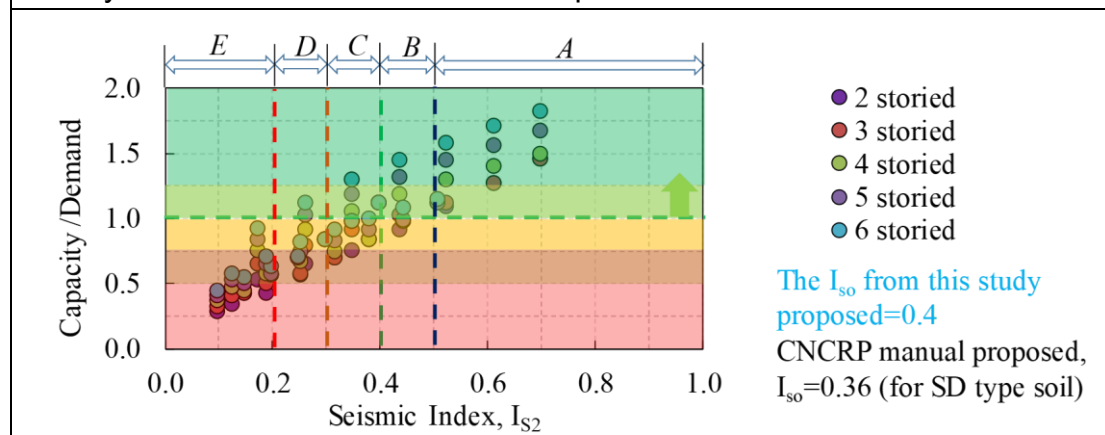


Fig.14 Boundary value of performance level A-E and required p erformance in second level seismic evaluation

Range	Categories	Priority of detailed evaluation
$0.25 \leq I_{VR}$	A	Least
$0.20 \leq I_{VR} < 0.25$	B	Less
$0.15 \leq I_{VR} < 0.20$	C	Moderate
$0.10 \leq I_{VR} < 0.15$	D	High
$I_{VR} < 0.10$	E	Highest

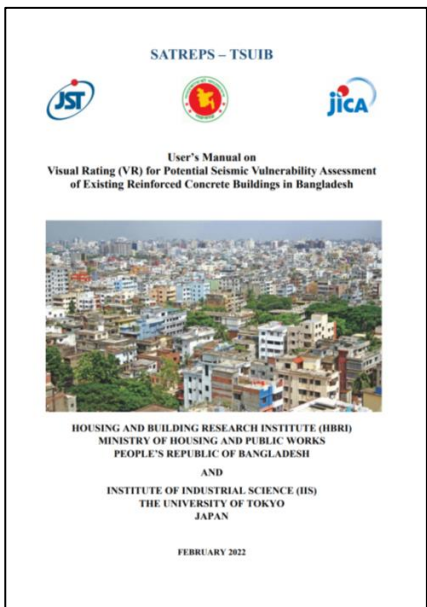
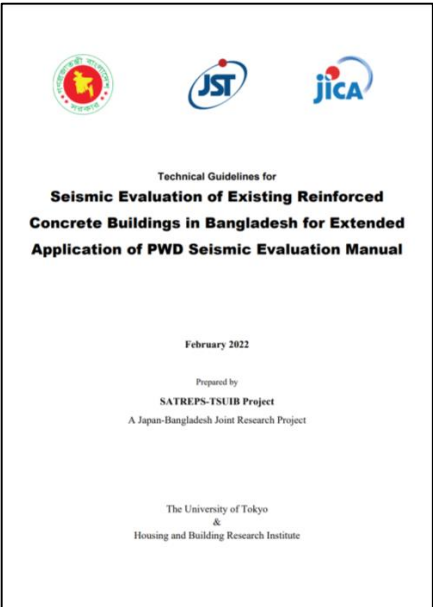
Fig.15 Boundary value of A-E and required performance in VR method

Planned

Activity 2-5 Developing technical manuals of the performance evaluation methodologies

Actual

Based on the results of the above studies, VR method manual and the seismic evaluation guidelines are published (Figs. 16 and 17). These PDF files and the videos of the seminar described below are available on the project website.

	
Fig.16 Developed VR manual	Fig.17 Developed seismic evaluation guidelines

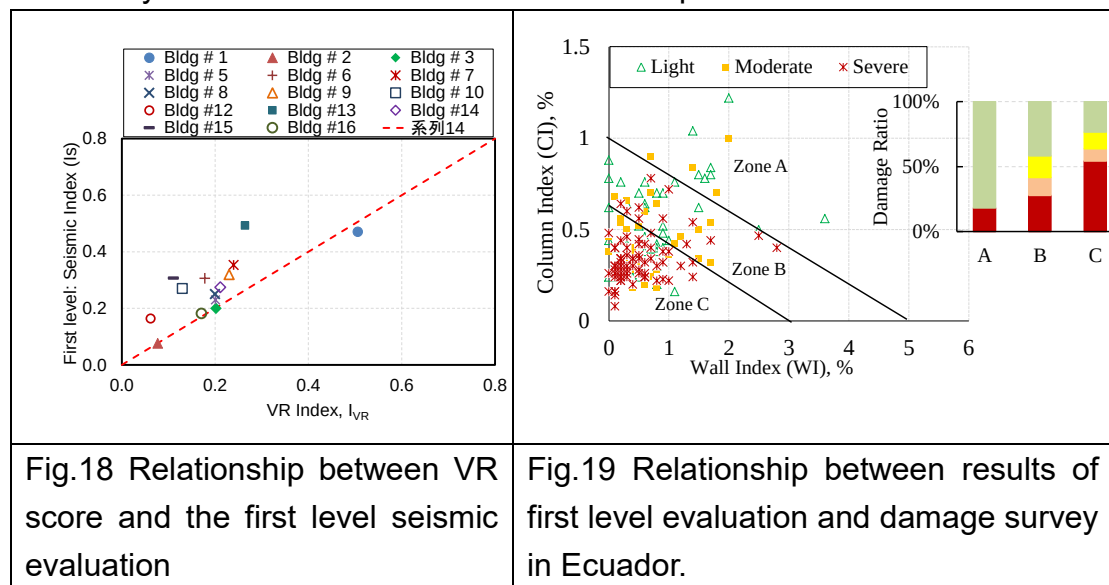
Planned

Activity 2-6 Applying developed methodologies to pilot buildings

Actual

WG2 applied the VR method to 23 buildings in Dhaka city and the developed method for the first level seismic evaluation method to 583 buildings for which structural drawings were obtained from the CDMP1 database, and calculated their I_s values. The results of the former show a strong correlation with the results of the first level seismic evaluation (Fig. 18), and the results of the first level seismic evaluation agreed well with the results of past overseas seismic damage statistics (Fig. 19) in areas where RC frames and masonry infill walls are used, such as Nepal, Ecuador, and Turkey. Therefore, the developed VR method shows great promise as a simple and quick sorting method. The latter result was used to calculate the spatial distribution of buildings with I_s values in Dhaka (Fig. 20).

WG2 and WG4 had planned to conduct a field survey to increase the number of buildings for the application in/after FY2019, however as mentioned above, the survey was cancelled due to the worldwide pandemic of COVID-19.



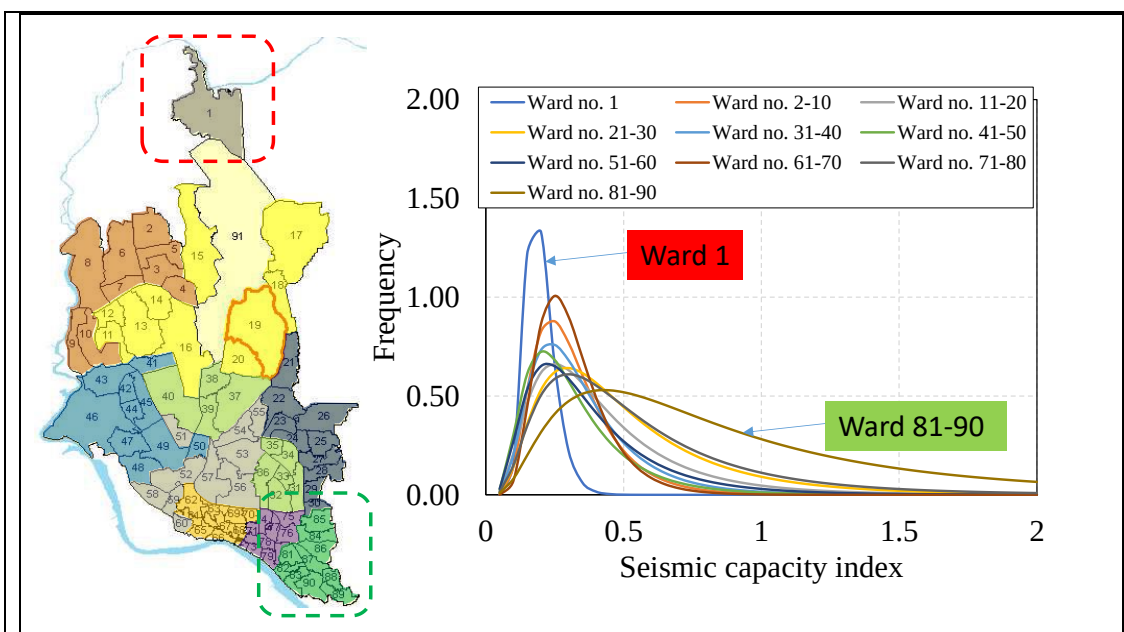


Fig.20 Spatial distribution of buildings with Is index in Dhaka

HBRI has applied the VR method and seismic evaluation method on existing RC buildings by their own research project, as follows:

i) Application on existing RC buildings in Sylhet City by SUST

A total 12 Masonry infilled RC buildings were surveyed by SUST researchers at Sylhet city corporation area as shown in Fig. 21. SATREPS-TSUIB WG2 members supported through technical assistance. The VR method was applied on these buildings (Fig. 22). The results show (Fig. 23 and Fig. 24) that the seismic capacity is little bit higher than Dhaka buildings but not sufficient to resist the local seismic demand as per BNBC 2020. SATREPS-TSUIB acknowledges to SUST researchers for successful the application the outcome of this project.

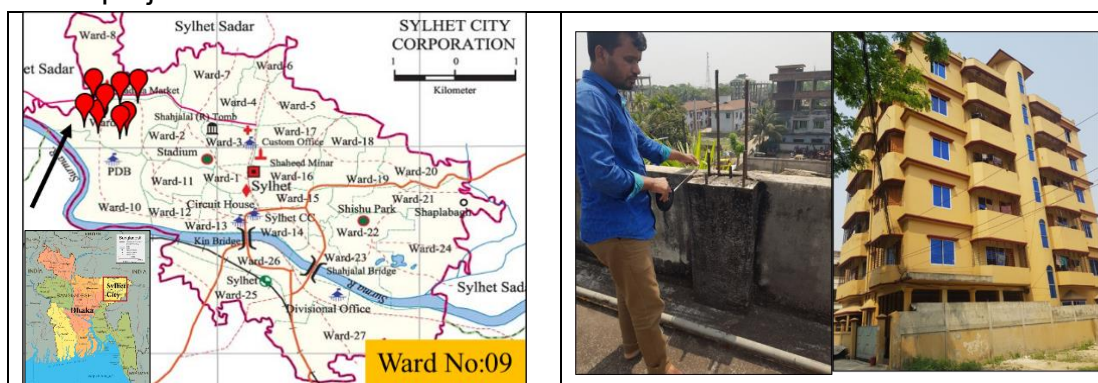
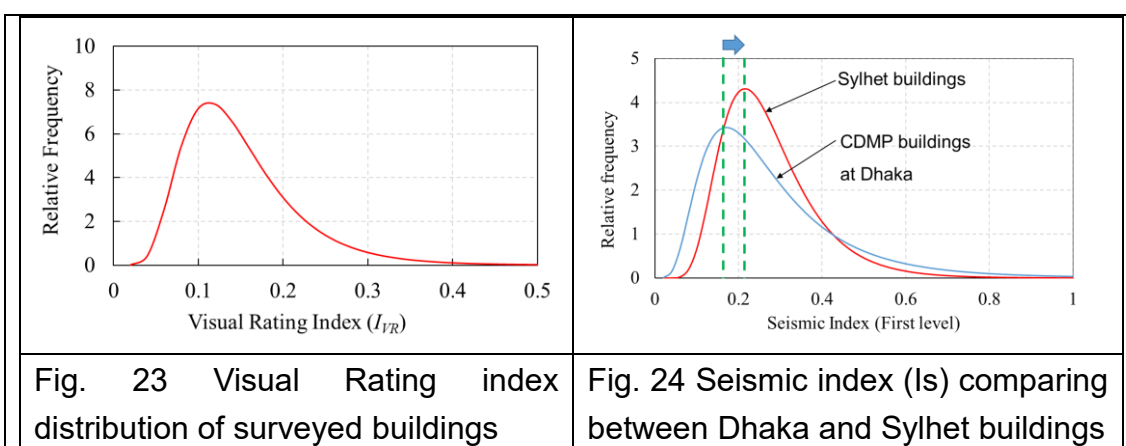


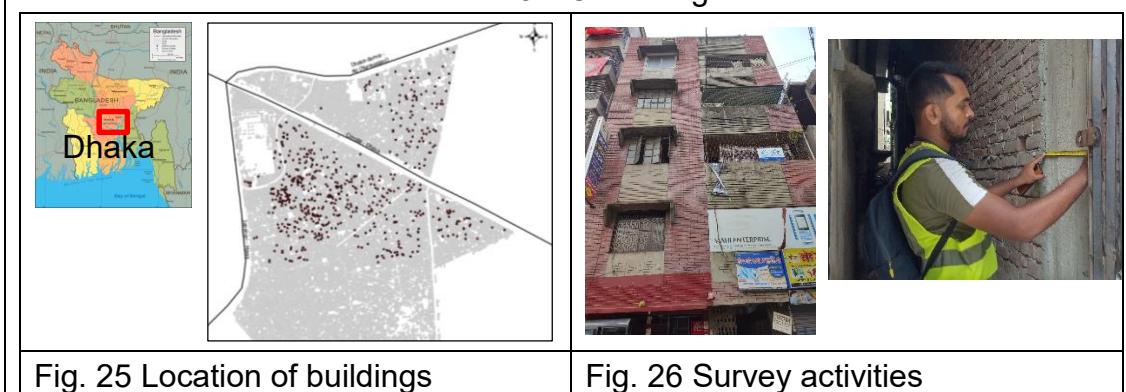
Fig. 21 Location of buildings

Fig. 22 Survey activities



ii) Application on existing RC buildings in Dhaka city.

A total 1000 RC buildings have been investigated at Jatrabari area in Dhaka city as shown in Fig. 25. There are three survey activities (Fig. 26) has been going on such as VR method application, social survey of 1000 buildings and detailed seismic evaluation about 25 RC buildings.



Planned

Activity 2-7 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders

Actual

A VR method open forum for local engineers and researchers was held in August 2018, with 43 attendees (Pic. 17). In the open forum, the methodology was introduced in the morning, while a practical training of its application to existing buildings was conducted in the afternoon (Pic. 18). As a result, we succeeded not only to appeal the effectiveness of the VR method to researchers and engineers in Bangladesh, but also to collect data on the variation of the VR results among investigators (Fig. 27). In FY2021, a seminar on the seismic evaluation guidelines described in Activity 2-5 (Pic. 19) was held

on 13th April, 2021. The second seminar is held on 12th, March, 2022 (Pic. 20). The seminars were held for experts and engineers in Bangladesh, and we received very positive comments from the participants. Those seminars were recorded and posted on the project website to widely collect comments from academic experts and engineers for the finalization of the guidelines.

These seminars above were mainly for the academicians in Bangladesh, but dissemination seminars for the general engineers are also important and were held in May and June 2022 in five cities, namely Dhaka (6/26), Rajshahi (5/14), Khulna (5/21), Sylhet (5/28) and Chattogram (6/4).



Pic.17 VR open forum



Pic.18 Training of VR method

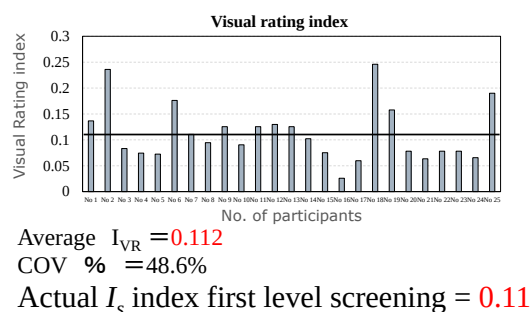


Fig. 27 Scattering of VR score among inspectors



Pic. 19 Online seminar for seismic evaluation guidelines

Planned

Activity 3-1 Developing retrofit policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects

Actual

The flow diagram for the seismic retrofitting was developed as shown in Fig. 28.

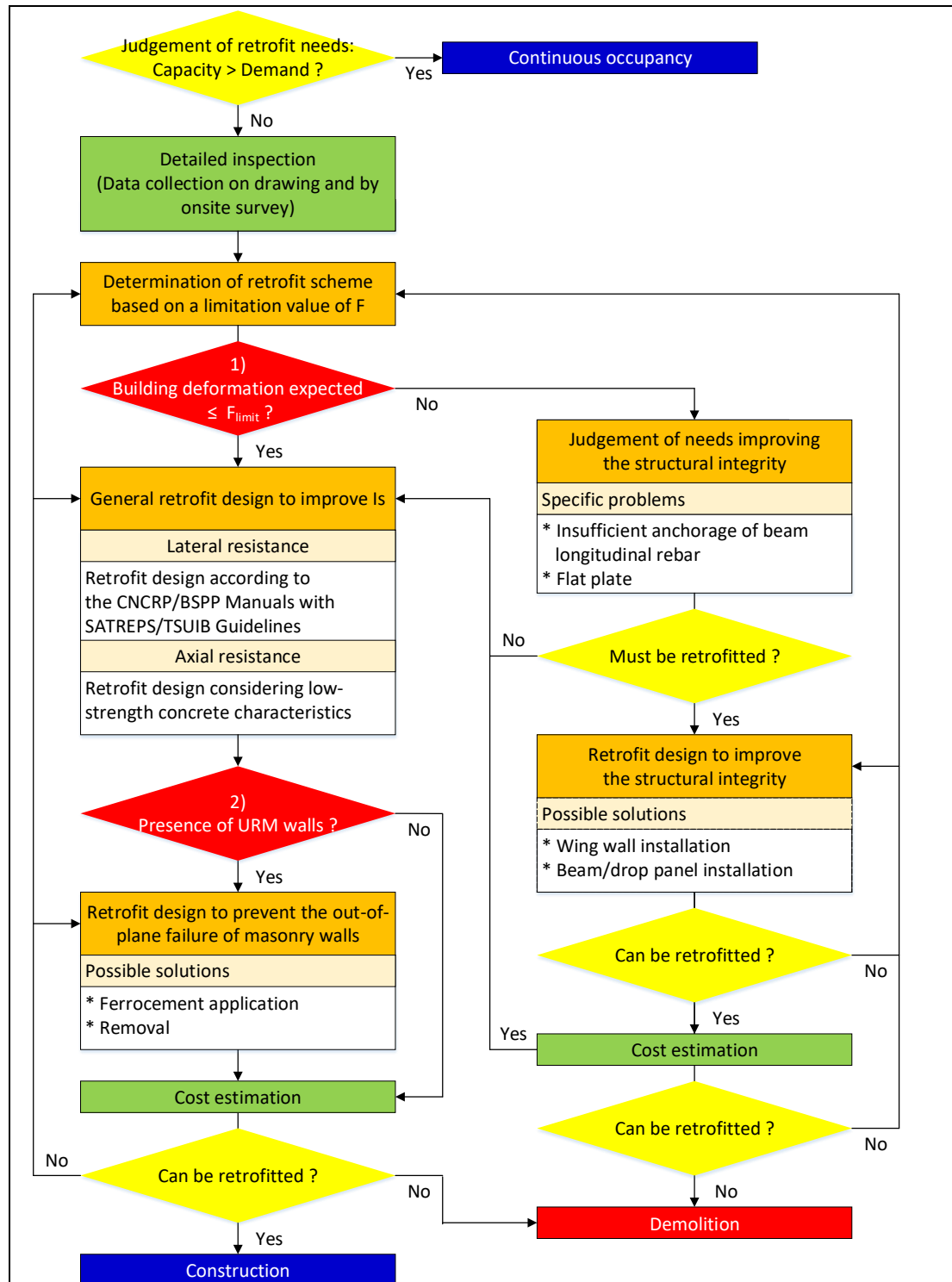


Fig. 28 A flow diagram of seismic retrofit

Planned

Activity 3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structures

Actual

This activity is to develop the seismic retrofit scheme based on the structural experiments and analyses. All the necessary experiments for the development of seismic retrofit schemes were completed.

Ferrocement lamination for masonry infill wall (TohokuU, AUST and HBRI)

Two specimens were tested at Tohoku University in December 2018 (Pic. 21). Both specimens were retrofitted with ferrocement, a method of fixing wire mesh to masonry walls with mortar (Fig. 29). Ferrocement is expected not only to improve the in-plane resistance of the masonry walls, but also to prevent out-of-plane overturning. HBRI has experiences in developing a similar method. In the experiment, the amount of reinforcing (wire mesh) was a parameter, and the strength of the specimen was about twice as high of the specimen without ferrocement retrofit.

Due to the travel restrictions due to COVID-19, the joint experiment in Dhaka was conducted mainly by AUST and HBRI, and Tohoku University supported (via webcast, instructions and advice from Japan, Pic. 22). Three specimens were tested: one without masonry walls, one with masonry walls, and one retrofitted with ferrocement. As a result, the strength of the ferrocement-retrofitted specimens was 1.5 to 2.0 times higher than that of the specimens with masonry walls, and the effectiveness of ferrocement retrofit was confirmed (Fig. 30). The developed ferrocement retrofit scheme is included in the seismic retrofit guidelines, as will be mentioned later.



Pic. 21 Failure of a specimen with ferrocement retrofit

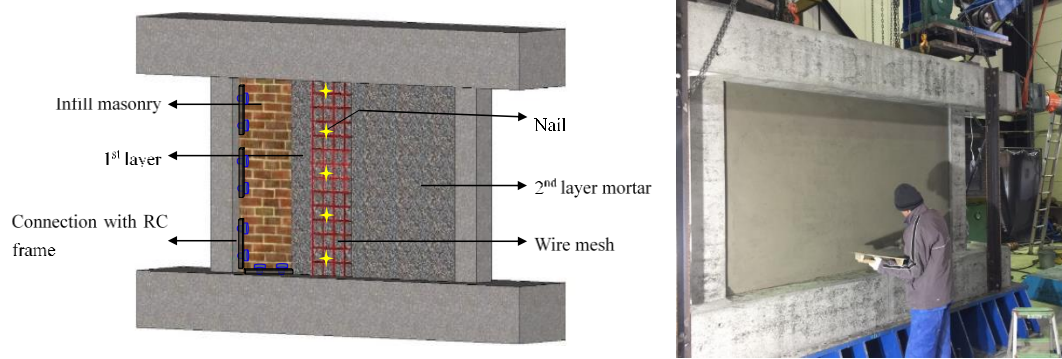
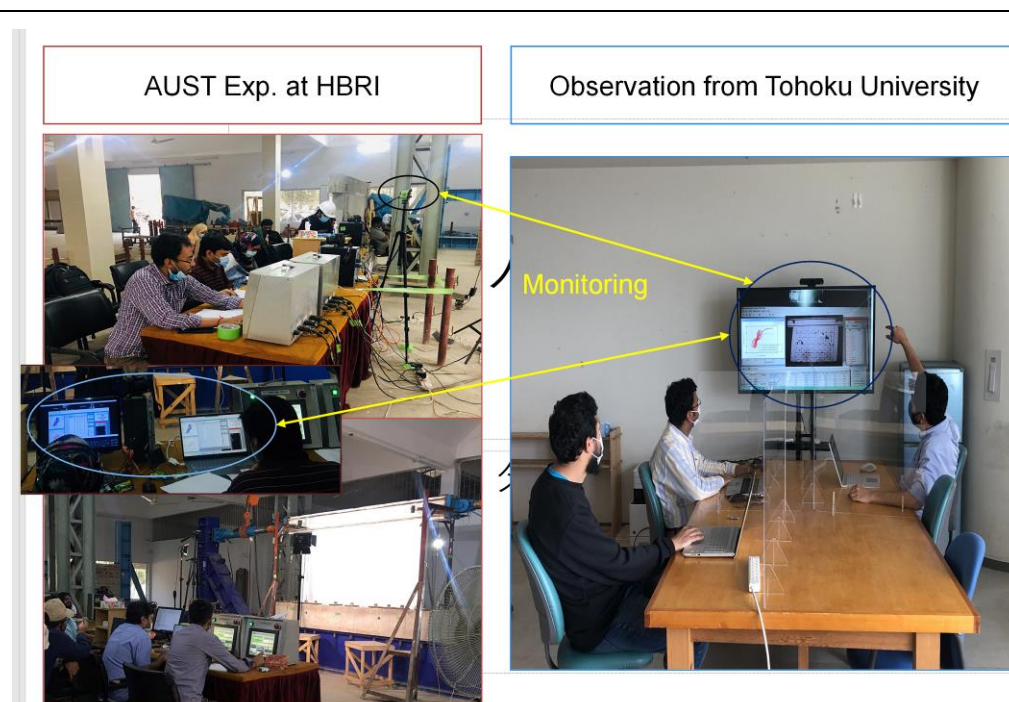


Fig. 29 Concept of ferrocement retrofit and construction in Japan



Pic. 22 Remote joint experiment between HBRI and TohokuU

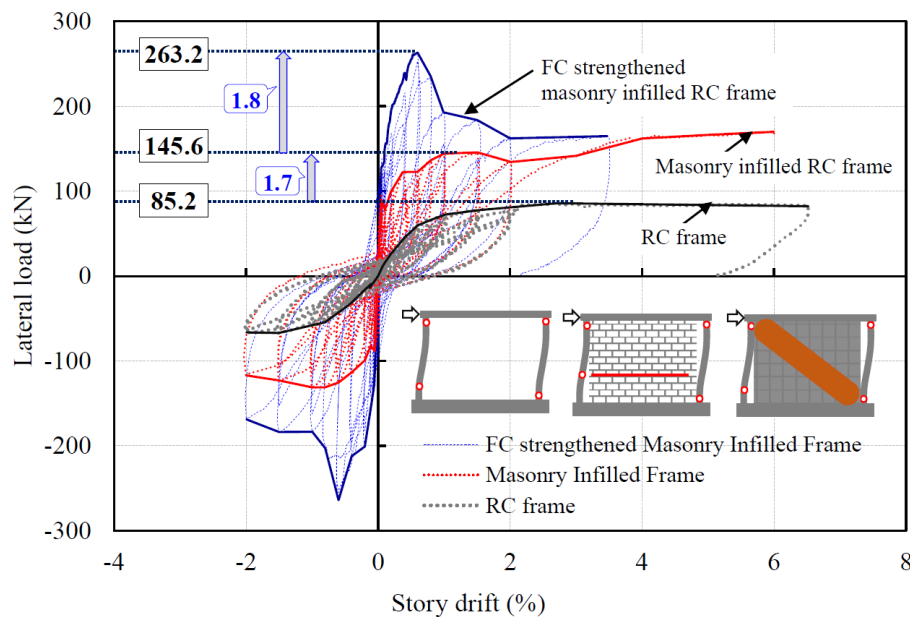


Fig.30 Load-deflection curve of ferrocement-retrofitted specimen in comparison with specimens without retrofit

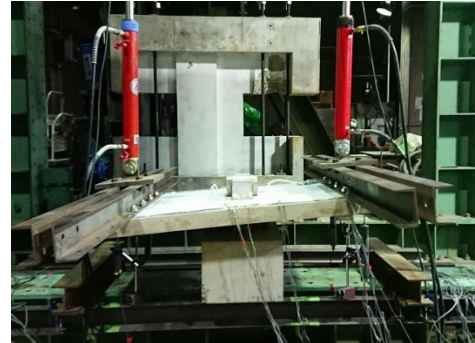
Tests on flat plate structures (DaidoU, OsakaU and UAP)

DaidoU and OsakaU performed a series of experiments on retrofitting flat plate structures in Japan (retrofitted with wing walls) in December 2018 (Pic. 23 and 24). A test specimen retrofitted with drop panel was fabricated at HBRI in FY 2019, and the loading test was performed in FY 2019-20. From the results of this experiment, it was found that the yielding of slab reinforcement preceded the punching shear failure even when the drop panel size was smaller than the minimum size required by ACI 318 (Fig. 31). The test was performed under the pandemic of COVID-19. Due to the travel restrictions, the Japanese researchers of DaidoU and OsakaU participated and supported the experiment remotely via the Internet during this period (Pic. 25).

It was found that the test specimens retrofitted with a drop panel had more than three times the strength of the unretrofitted specimens, and also had higher deformation capacity.



Pic. 23 Flat plate specimen with wing wall tested in DaidoU



Pic. 24 Failure pattern

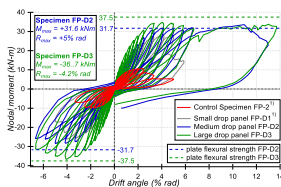


Fig. 31 A flat plate specimen retrofitted with smaller drop panel and its load-deflection curve tested in HBRI.



This slide shows only the system image



Online communication between the general operator @Osaka U. and the loading operator @HBRI



Pic. 25 Joint experiment connecting between HBRI and OsakaU

Tests on beam-column joint retrofit (OsakaU and BUET)

In FY2017, an experiment of beam-column joint specimens retrofitted with wing walls was conducted by OsakaU in Japan. The results showed that without the wing wall, the yield strength of the beam could not be observed due to the pull-out failure, on the other hand, with the wing wall, the beam could yield (Pic. 26),

and a significant increase in the yield strength was confirmed (Fig. 32). Considering the fact that the structural integrity is greatly lost when the beam reinforcement pulls out, and that the same type of failure is likely to occur due to insufficient rebar arrangement of the beam reinforcement in buildings in Bangladesh, retrofit with the wing wall can be an effective retrofit solution. In addition, pull-out and shear tests of post-installed anchors were conducted at BUET in October-November 2018 to confirm the applicability of post-installed anchors to low-strength concrete, which is an important element of the method of reinforcing the wing wall at the beam-column joint. As a result, the equations to evaluate the strength of post-installed anchors generally applied in Japan are found applicable to low strength concrete.

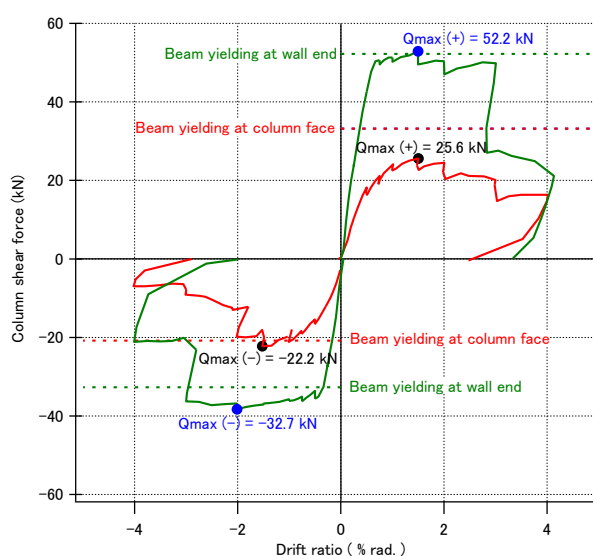
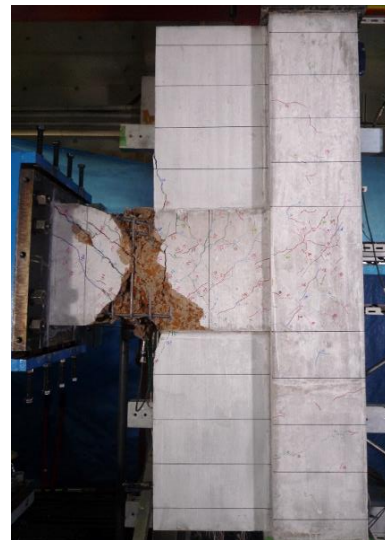


Fig. 32 Comparison of load-deflection curve



Pic. 26 Failure pattern of specimen retrofitted with wing wall

Tests on Carbon fiber reinforced plastics on column (BUET)

Initially, this topic is out of the scope of TSUIB project. As BUET's ability of structural test significantly improves through various on-site trainings provided by TSUIB project, BUET caught an opportunity to start experiments on low strength concrete columns retrofitted with carbon fiber reinforced plastics in collaboration with Japanese private companies. BUET feeds back the outcomes to seismic retrofit guidelines of TSUIB project.

Planned

Activity 3-3 Developing technical manuals of retrofit schemes

Actual

Guidelines of the seismic retrofit design is published as shown in Fig. 33. Since it is especially important to ensure that the retrofit construction work is carried out properly, the guidelines provide visual instructions (Fig. 34) on the details of the retrofit schemes (including explanation and description of the construction procedure). This is of great importance and help especially for local structural designers and construction workers who do not have been well experienced in seismic retrofitting.

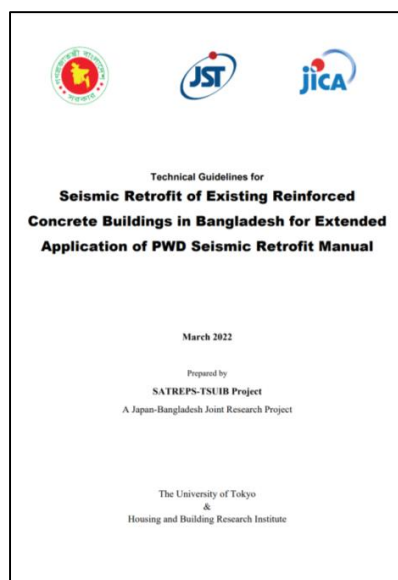
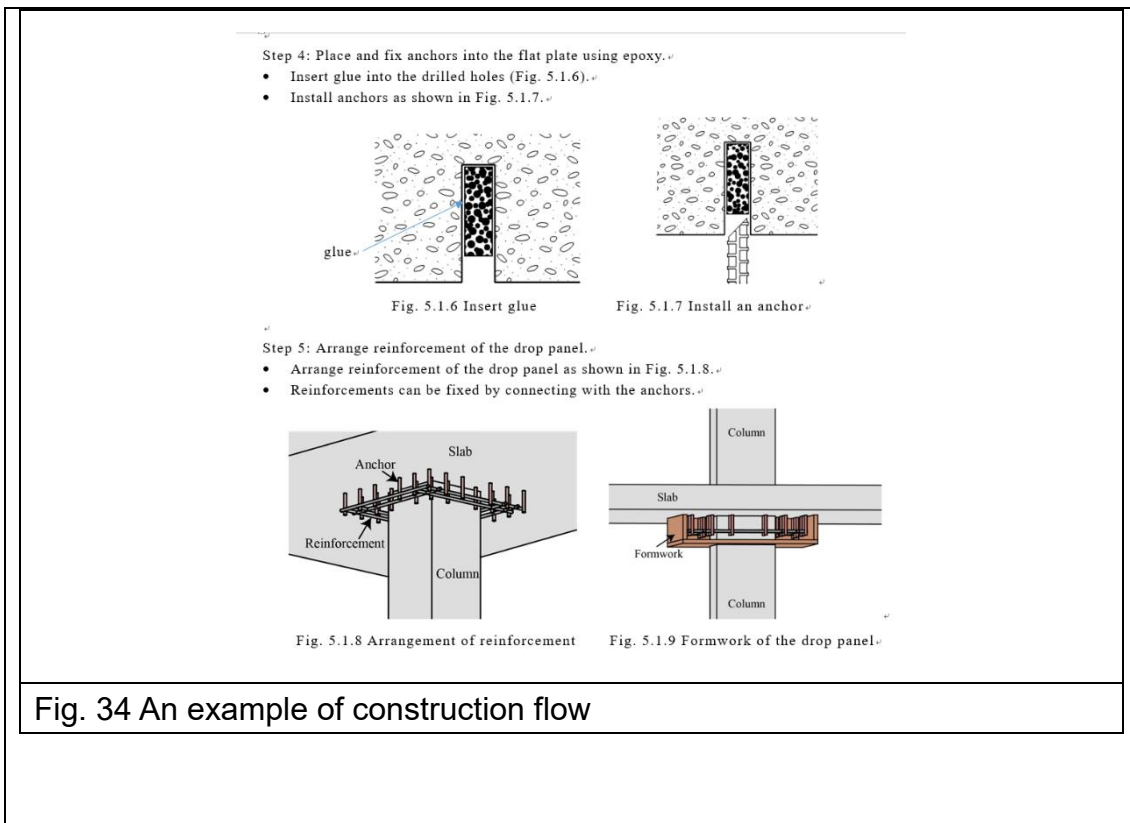


Fig. 33 Developed seismic retrofit guidelines



Planned

Activity 3-4 Sharing developed retrofit technologies with CNCRP, BSPP and other relevant projects

Actual

The above mentioned ferrocement reinforcement method was applied to the PWD HQ building on the coordination with the BSPP, as shown in [Pic. 27](#). In addition, the retrofit plan using developed wing wall to an existing flat plate building in Dhaka was made, as shown in [Fig.35](#).



Pic. 27 Walls of PWD HQ buildings retrofitted with ferrocement

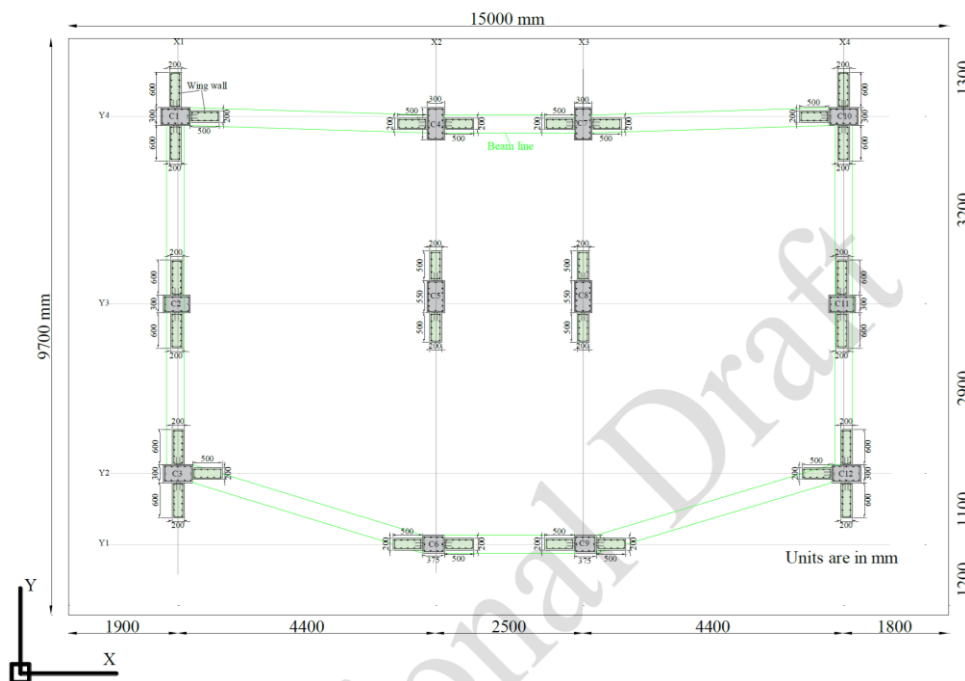


Fig. 35 Wing wall retrofit application plan to an existing flat plate structure in Dhaka

Plan

Activity 3-5 Holding technical seminars, workshops and trainings for

researchers, practitioners and other relevant stakeholders

Actual

The first seminar of seismic retrofit guidelines was held on October 30, 2021. More than 50 participants joined and learned the developed seismic retrofit schemes. The second seminar was held on 12th, March, 2022.

The first seminar was recorded and posted on the project website to widely collect comments from academic experts and engineers for the finalization of the guidelines.

These seminars above were mainly for the academicians in Bangladesh, but dissemination seminars for the general engineers are also important and were held in May and June 2022 in five cities, namely Dhaka (6/26), Rajshahi (5/14), Khulna (5/21), Sylhet (5/28, see [Pic. 28](#)) and Chattogram (6/4).



Pic. 28 Dissemination seminar in Sylhet

Plan

Activity 4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability

Plan

4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1

4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2

4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics

Actual

Since we obtained the latest (as of 2017) RAJUK and CDMP1 databases in FY2017, WG4 has been working on the disaster vulnerability assessment using the database and the research activity results from WGs1-3. The retrofit scenario construction method proposed by WG4 is to prioritize the buildings through hierarchical evaluation method (AHP) using various data such as vulnerability of buildings, cost to improve the vulnerability (seismic retrofit), possibility of road blockage when the building collapses, existence of evacuation space, use of the building, population staying in the building, ground conditions, etc. The data used in this study were obtained from RAJUK and CDMP1 and the outputs made by WG 1-4. Data for individual buildings are, for example, number of floors, use, earthquake resistance, etc. Data for urban area are, for example, road width, open space, ground conditions, etc. These different types of data were organized into the four elements described in (1) through (4) below and buildings are ranked their priority.

(1) Cost-effectiveness of seismic retrofit

WG3 proposed a method for calculating the cost-effectiveness of seismic retrofitting of individual buildings. The cost-effectiveness is calculated for each building by dividing the damage reduction rate by the cost of seismic retrofitting. The damage reduction rate by seismic retrofitting is calculated from the I_s value before retrofitting and the I_s value after retrofitting, using the relationship between the I_s value and the damage rate in the 1999 Taiwan Chi-Chi earthquake. The cost of seismic retrofitting was determined by referring to the actual cost results of seismic retrofitting of actual buildings in CNCRP and BSPP.

(2) Location

The second element "location" is calculated for each Ward. The sub-elements to be considered are accessibility for rescue and evacuation, capacity for

temporary shelters, rescue capacity, accessibility to medical facilities, capacity for shelters, and density of vulnerable RC buildings, which are the outputs from the study of WG 4. After assessing the vulnerability of these sub-elements, the location for each ward were organized in three levels: Lowly Vulnerable, Moderately Vulnerable, and Highly Vulnerable. The results of the vulnerability assessment were compared with the results of a questionnaire survey of university professors and other experts to confirm the reliability of the results (Fig.36, left and right comparisons, the left is the analysis results and the right is the results of the survey of experts). This process has the potential to be widely applied in developing countries because such countries tend to have lack of quantity and/or quality in such data. WG4 also studied the possibility of road blockage (Fig.37) by combining the vulnerability assessment of buildings along the road, debris flow assessment, and the width of the road in front (This is not incorporated into the “location” above.).

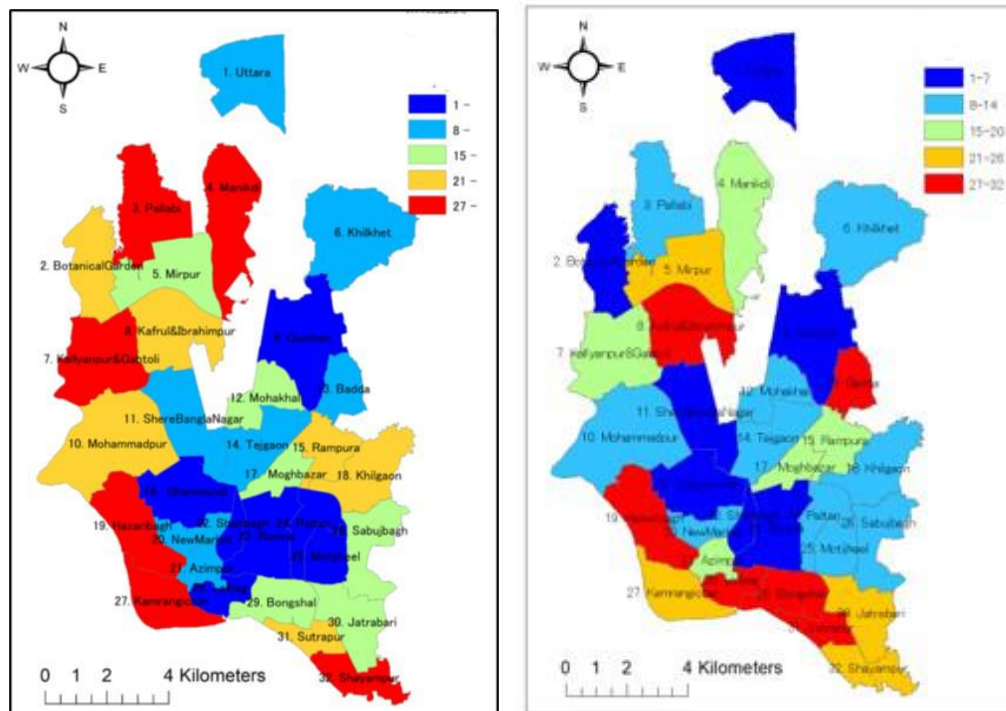


Fig.36 Risk map for seismic hazard (left) and results of questionnaire survey to experts (right).

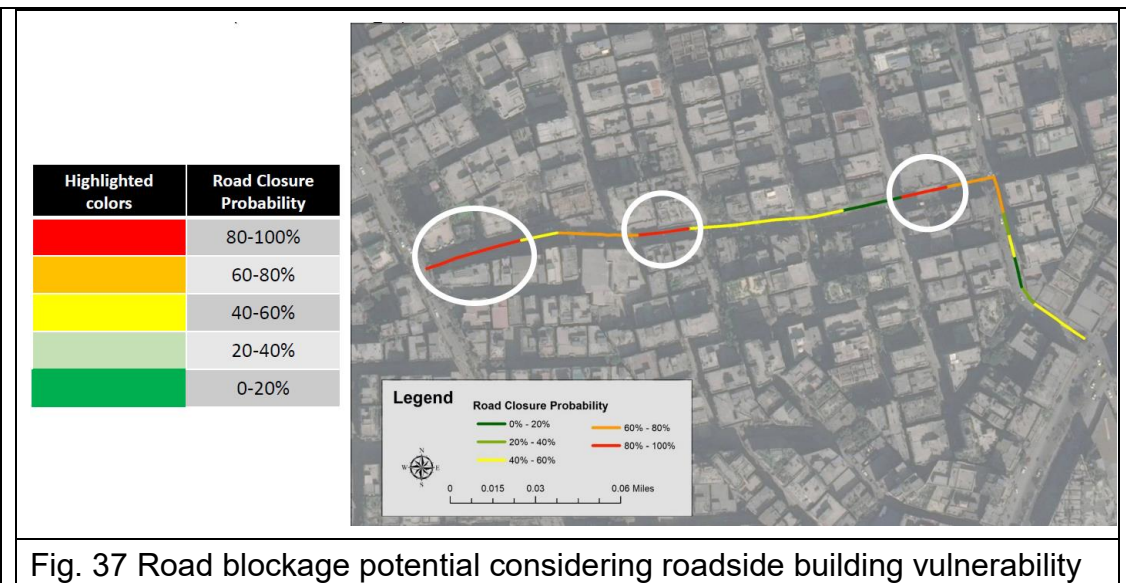


Fig. 37 Road blockage potential considering roadside building vulnerability

(3) Building occupancy

The importance of each building is scored according to its occupancy. The uses were categorized into seven categories: residential, commercial, community, health, education, industrial, and institution, referring to the BNBC definition. For the scoring, WG4 integrated the results of the questionnaire to the experts and AHP, which used the type of building users (general public/children) and the importance of the building functions as criteria. The AHP structure is shown in Fig. 38. The results show that “health” have the highest priority, followed by “industrial”, “community”.

(4) User density

The user density was calculated by dividing the 24-hour population of each building by the floor area.

The above (1) to (4) were weighted by AHP to determine the retrofit priority. As an example, Fig.39 shows the 15 buildings and their retrofit priority evaluation results. In Fig.38, the building that ranked first in the overall ranking (Pic.28) is Building L, which scored high in all elements. Building A, which ranked third, was rated low in terms of cost-effectiveness, but was rated high priority in other aspects, resulting in a high retrofit priority overall. Thus, by determining the retrofit priority based not only on the cost effectiveness of individual buildings based on their seismic performance (engineering aspect), but also on social aspects such as location, building occupancy and user density. We can expect to realize a rational and socially acceptable disaster resilience plan from this method.

The results obtained in this study complement the results of the World Bank and CDMP1, which were limited to vulnerability assessment and did not provide concrete solutions.

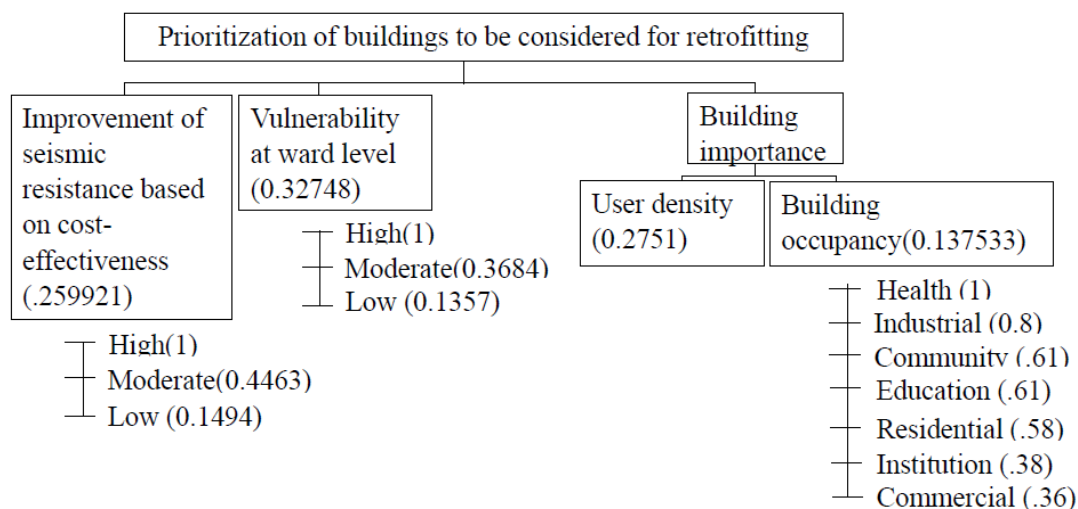


Fig. 38 AHP structure

Building ID	Ward no.	Cost-effectiveness (0.26)	Location (0.33)	Building occupancy (0.14)	User density (0.28)	Priorities	Rank
Building A	DNCC 1	Low	High	Residential	0.0012	0.098	3
Building B	DNCC 31	Low	Moderate	Residential	0.0020	0.053	11
Building C	DNCC 24	Low	Low	Commercial	0.0007	0.029	15
Building D	DNCC 4	Moderate	Low	Residential	0.0019	0.053	7
Building E	DSCC 13	Low	Moderate	Residential	0.0014	0.053	13
Building F	DNCC 7	Moderate	Moderate	Residential	0.0011	0.070	4
Building G	DNCC 13	Moderate	Moderate	Industrial	0.0081	0.058	5
Building H	DSCC9	Low	Low	Residential	0.0013	0.036	14
Building I	DNCC 9	Low	Moderate	Residential	0.0023	0.053	10
Building J	DNCC 10	Moderate	Low	Residential	0.0024	0.053	6
Building K	DNCC 11	Low	Moderate	Residential	0.0026	0.053	9
Building L	DNCC 16	High	High	Residential	0.0046	0.147	1
Building M	DSCC 03	High	High	Institutional	0.0043	0.141	2
Building N	DSCC 26	Low	Moderate	Residential	0.0047	0.053	8
Building O	DSCC 15	Low	Moderate	Residential	0.0017	0.053	12

Fig. 39 A list of prioritized 15 buildings



Pic. 28: Buildings calculated as the first priority for reinforcement in a group of buildings

Generally, it seems people (or government) has little interest to spend some cost for retrofit in Bangladesh. In order to effectively raise awareness of seismic retrofitting among individual building owners and to investigate the Willingness to Pay (WTP), a questionnaire survey on seismic retrofitting were conducted in collaboration with Dhaka city authorities and SEEDs Asia, a non-profit organization working in the city. The results of the WTP survey (Fig.40) show that among the building owners, If the current probability of collapse during an earthquake is 100%, there is average WTP of 192 Tak/m² (1 Tak $\approx$ 1.5 yen) to reduce by 80%. However, it increases to 577 Tak/m² if the probability is reduced by 20%. These increased to 208 Tak/m² and 992 Tak/m², respectively, after the implementation of SEEDs Asia's "Disaster Mitigation Town Tour Program".

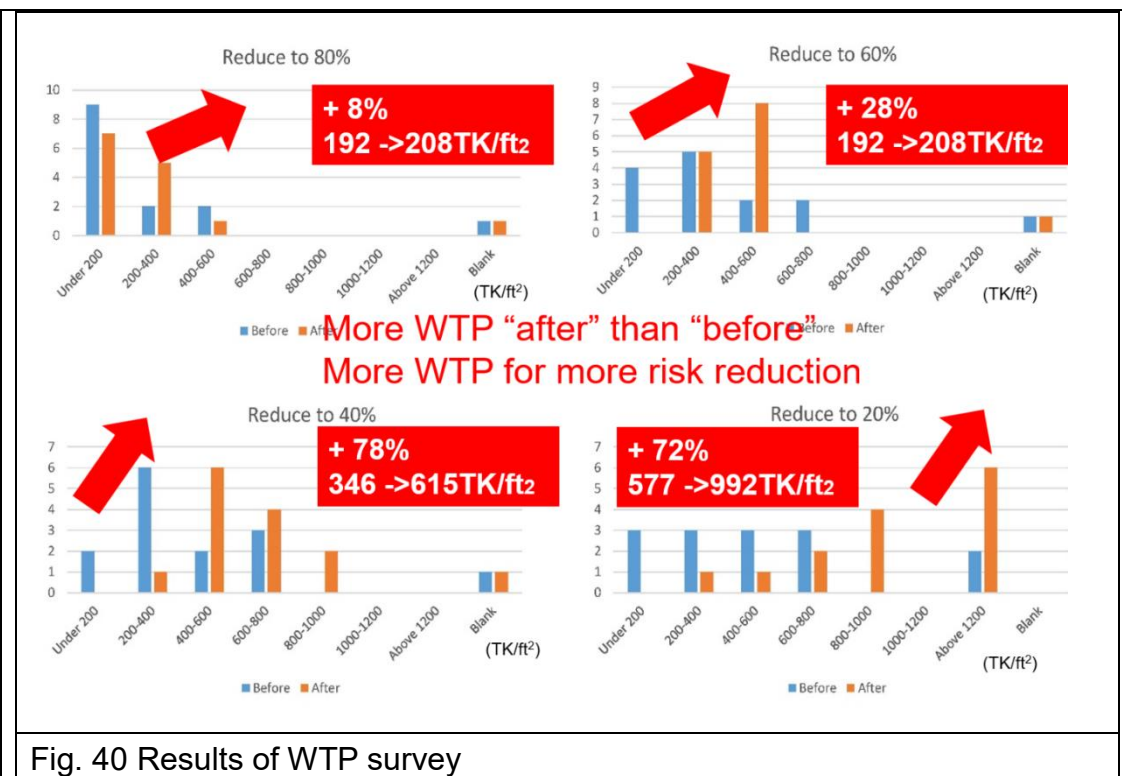


Fig. 40 Results of WTP survey

Finally, WG4 described the method for retrofit prioritization in a guidebook for the future continuous update of the scenarios, as shown in Fig. 41.

In these way, WG4 has developed retrofit scenarios, the guidebook, schemes to increase the WTP for seismic retrofit and method to raise people's awareness, which will directly lead to the achievement of the overall goal.

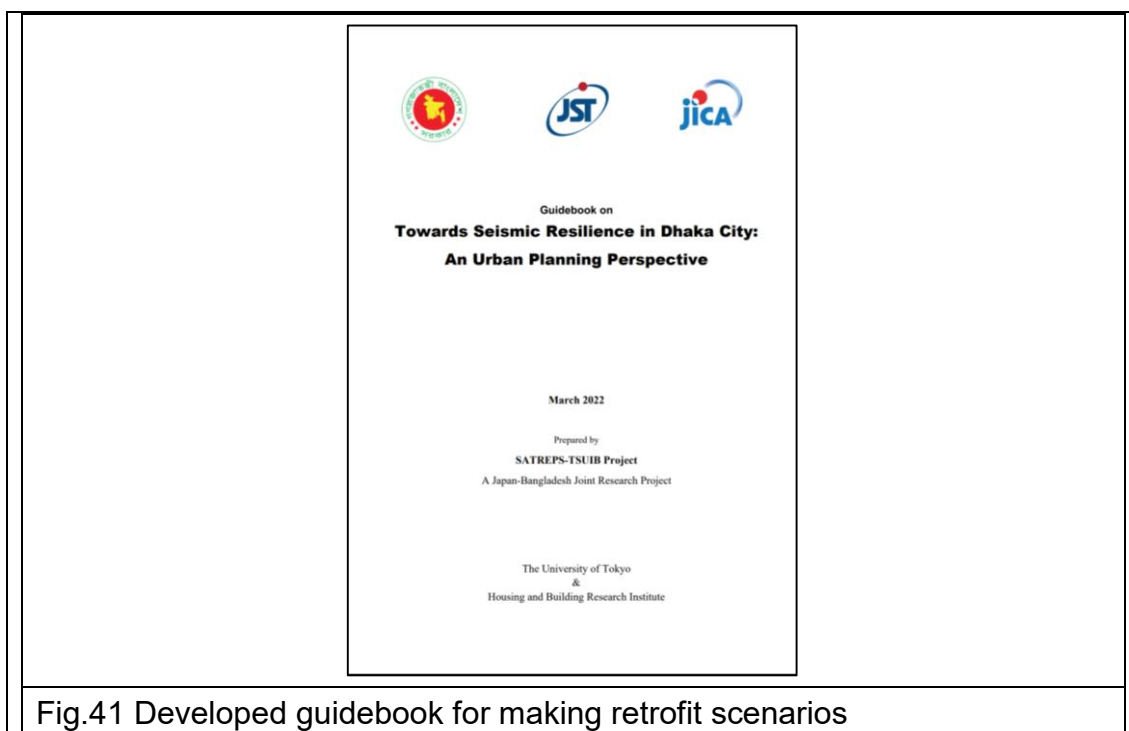


Fig.41 Developed guidebook for making retrofit scenarios

Plan

Activity 4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction

Actual

In the final dissemination seminar held on 26th June, 2022 in Dhaka, the Minister of the Disaster Management and Relief and the secretary of the Ministry of Housing and Public Works were invited. We have informed the importance of seismic evaluation, retrofit and urban planning for seismic resilient cities, as well as output of this project (Pic. 29).



(a) A speech from the Minister of Disaster Management and Relief



(b) A speech from the secretary of Ministry of Housing and Public Works



(c) A group photo after the final dissemination seminar

Pic. 29 The final dissemination seminar with the Minister of Disaster Management and Relief, and the secretary of the Ministry of Housing and Public Works (26th June, 2022)

Plan

Activity 4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios

Actual

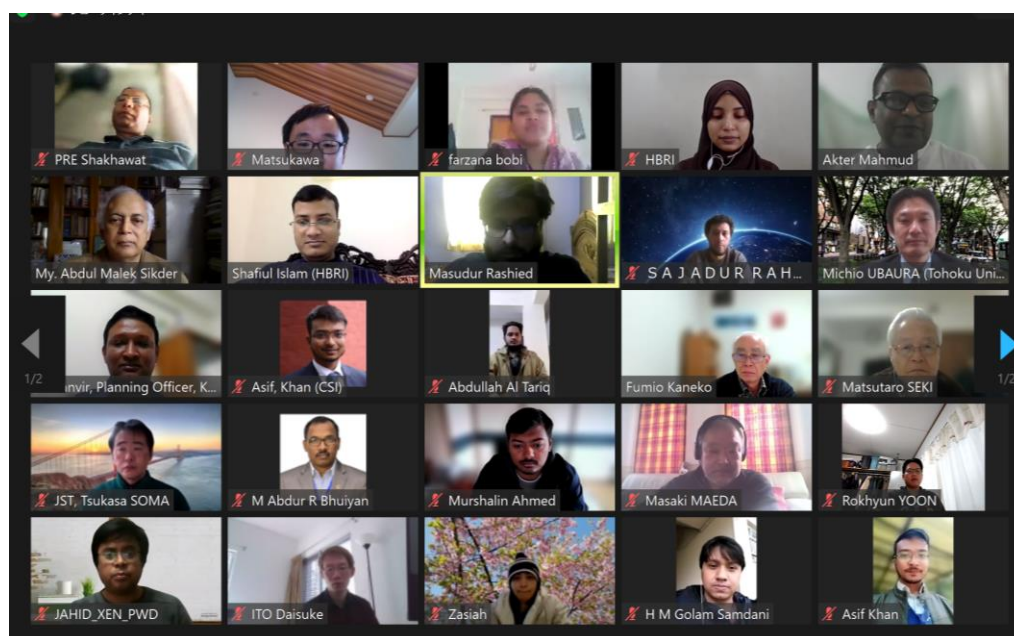
In WG4, a seminar on urban disaster vulnerability assessment was held in BUET for researchers, students, and others during the first half of the project (March 8, 2018), which was attended by 15 people from the Bangladesh.

For topics related to WG4, it is desirable to update the scenarios whenever the available data (e.g., from RAJUK) is updated. Therefore, WG4 has developed a guidebook that summarizes the methodology which helps make a retrofit scenario. A seminar on this guidebook was held on 19th February 2022, and 50 participants attended and learned the methodology. (Pic. 30).

The latter seminar was recorded and posted on the project website to widely collect comments from academic experts and planner for the finalization of the guidebook.

These seminars above were mainly for the academicians in Bangladesh, but

dissemination seminars for the general planners are also important and were held in May and June 2022 in five cities, namely Dhaka (6/26), Rajshahi (5/14), Khulna (5/21), Sylhet (5/28) and Chattogram (6/4).



Pic. 30 WG4 seminar (Group photo)

2. Achievements of the Project

2-1 Outputs and indicators

(Target values and actual values achieved at completion)

Output 1

Building characteristics governing its performance are identified, and research target areas and buildings are determined.

Indicators

- 1-1. At least 3 areas and their buildings are surveyed.
- 1-2. A database containing fundamental building properties and seismic performances of at least 100 buildings is established .
- 1-3. Research target areas and building types are identified.

Achievements

- 1-1. The 90 wards in DNCC+DSCC areas and their buildings were surveyed using database of RAJUK and CDMP1 database, as shown in Figs. 5-6, 20, 36.
- 1-2. RAJUK database contains 453,975 buildings. Their seismic

performance was analyzed by this project, as shown in **Fig. 20**.

- 1-3. The research target areas and buildings are determined as **DNCC+DSCC (Dhaka North City Corporation + Dhaka South City Corporation) area and reinforced concrete structures (including those with masonry walls and flat plate structures), respectively** (see Activity 1-2).

From the achievements above, the Output1 “Building characteristics governing its performance are identified, and research target areas and buildings are determined.” was **successfully achieved**.

Means of Verification

- 1-1. Project reports
- 1-2. Project reports
- 1-3. Project reports

Output 2

Performance evaluation methodology against collapse is established and applied to pilot buildings.

Indicators

- 2-1. At least 3 series of structural experiments are carried out.
- 2-2. Rapid, 1st level and 2nd level evaluation methods are proposed.
- 2-3. At least 3 times of technical seminars, workshops and training are held.
- 2-4. At least 100 buildings' performances are evaluated.

Achievements

- 2-1. The **18** series of tests were made (@TohokuU (RC with MIW x 3), @UTokyo (column x2, 2-bay-2-story x1), @OsakaU (b-c-joint x2), @DaidoU (FlatPlate x1), @BUET (column x2, pullout x1), @UAP(flatplate x1), @ HBRI+AUST(MIW+RCx2), @HBRI+UAP(flatplate x1, @HBRI(2story 2bays), @BUET(b-c-jointx1)), as explained in Activity 2-3.
- 2-2. **The VR (Rapid method), 1st and 2nd level evaluation methods are proposed** and are available from the published guidelines, shown in **Figs.16 and 17**.
- 2-3. The **8** seminars were held (August 2018 (**Pic. 17**) for VR method, April 2021(**Pic. 19**) and Mach 2022 for seismic evaluation + the dissemination seminars in five cities) as shown in Activity 2-7.
- 2-4. The VR method was applied for **23** buildings in Dhaka and the developed seismic evaluation method was applied for **583** buildings, as explained in

Activity 2-5. In addition, HBRI has applied the VR method to 1000 buildings and the seismic evaluation method to 25 buildings in Dhaka, as shown in **Figs. 25-26**.

From the achievements above, the Output2 “Performance evaluation methodology against collapse is established and applied to pilot buildings.” was **successfully achieved**.

Means of Verification

- 2-1. Project reports and published papers
- 2-2. Technical manuals developed through this project
- 2-3. Agenda and photos of technical seminars, workshops and trainings
- 2-4. Project reports

Output 3.

Retrofit schemes for buildings with low performance are established and applied to pilot buildings.

Indicators

- 3-1. At least 2 series of structural experiments are carried out.
- 3-2. At least 3 retrofit technologies are newly developed.
- 3-3. At least 2 buildings are planned to apply the developed retrofit schemes.
- 3-4. At least 2 times of technical seminars, workshops and training are held.

Achievements

- 3-1. The **7** Series of tests were made (@TohokuU(ferrocement x1), @OsakaU(wing wall x1), @DaidoU(wing wall x1), @BUET(pullout x1, CFRP x1)), @HBRI+UAP(drop panel x1), HBRI + AUST(ferrocementx1) as shown in Activity 3-2.
- 3-2. As shown in Activity 2-3, the **5** retrofit schemes (1. Ferrocement retrofit, 2. Drop panel for flat plate. 3. Wing wall for beam-column joint, 4. Wing wall for flat plate, 5. CFRP retrofit) were developed.
- 3-3. As shown in Activity 3-4, the **2** buildings are planned to apply the developed retrofit schemes (**Pic. 27 and Fig.35**).
- 3-4. The **7** seminars (Oct. 2021 and March 2022 + the dissemination seminars in five cities.) were held as shown in Activity 3-5 (**Pic. 28**).

From the achievements above, the Output3 “Retrofit schemes for buildings with low performance are established and applied to pilot buildings.” was **successfully achieved**.

Means of Verification

- 3-1. Project reports and published papers
- 3-2. Technical manuals developed through this project
- 3-3. Project reports and other project reports
- 3-4. Agenda and photos of technical seminars, workshops and trainings

Output 4.

Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.

Indicators

- 4-1. At least 2 scenarios are proposed.
- 4-2. A hi-level seminar is held.
- 4-3. A seminar or workshop is held.

Achievements

- 4-1. **Multiple** (considering not only cost-effectiveness, but also location, building occupancy and user density,) retrofit scenarios were proposed as shown in **Fig.39**.
 - 4-2. In the final dissemination seminar was held on 26th June, 2022 with the Minister Disaster Management and Relief and the secretary of the Ministry of Housing and Public Works. We have informed the importance of seismic evaluation, retrofit and effective urban planning strategy to the ministers, as well as the outcomes of this project.
 - 4-3. **7** seminars (March 2018 and Feb. 2022 + the dissemination seminar in five cities) were held as shown in Activity 4-3.
- From the achievements above, the Output4 “Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.” was **successfully achieved**.

Means of Verification

- 4-1. Project reports and published papers
- 4-2. Record of discussions of hi-level seminars
- 4-3. Agenda and photos of seminars and workshops

2-2 Project Purpose and indicators

(Target values and actual values achieved at completion)

Project Purpose

Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity

and research resources development of relevant institutes.

Indicators

1. Improvement scheme of performance for buildings is proposed.
2. Improvement scenario of safety index for urban areas is proposed.
3. Knowledge and technologies developed through this project are utilized in other projects.
4. **At least 3** documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.

Achievement

1. Both seismic evaluation method and seismic retrofit schemes proposed by TSUIB project is the improvement scheme of performance of buildings.
2. Multiple scenarios to improve urban safety was proposed as shown in **Fig.39**, e.g., only cost-effectiveness, with location, building use, population density.
3. The guidelines and manuals developed by TSUIB are utilized in other project. For example, the ferrocement retrofit technique instructed in the retrofit guidelines was applied through BSPP project (**Pic. 27**). Both seismic evaluation guidelines and seismic retrofit guidelines are developed to be cross-referred with PWD (BSPP) manuals.



Pic. 27 Walls of PWD HQ buildings retrofitted with ferrocement

4. In this project, the four manuals/guidelines/guidebook (**Fig. 42**, VR method, seismic evaluation, seismic retrofit and seismic resilience of Dhaka city) are published. Those manuals/guidelines/guidebook are capable to directly

contribute the updating of BNBC. Bangladeshi side researchers are eager to update using these outcomes. These manuals/guidelines/guidebook are submitted to HBRI, institution in charge of BNBC update.



From the achievement above, the project purpose "Technologies for enhancing structural resilience of buildings and their effective implementation schemes in

Dhaka are proposed through technical capacity and research resources development of relevant institutes.” was **successfully achieved**.

Means of Verification

1. Project reports
2. Project reports
3. Other project reports
4. Submitted documents

3. History of PDM Modification

Version 0 (attached document of the R/D signed on 22th Feb. 2016)

ATTACHMENT II			
Project Design Matrix (PDM ver.0) Project Name: The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities Project site: Dhaka, Bangladesh Duration of Project: 5 years Target Group: Researchers and engineers of governmental authorities and universities in Bangladesh			
Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
Overall goal 上位目標 Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.	1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction.	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government	
Project purpose プロジェクト目標 Technologies for enhancing structural resilience of buildings and their effective implementationschemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.	1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. XX documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents	Policy and social system related to disaster risk reduction in Bangladesh do not change.
Outputs 成果 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.	1-1. At least 3 areas and their buildings are surveyed. 1-2. XX databases are established. 1-3. YY research target areas and buildings are selected. 2-1. At least 3 series of structural experiments are carried out. 2-2. XX formulas are proposed for capacity evaluation. 2-3. XX times of technical seminars, workshops and training are held. 2-4. XX buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. XX retrofit technologies are newly developed. 3-3. XX buildings' performances are upgraded with developed retrofit schemes. 3-4. XX times of technical seminars, workshops and training are held. 4-1. YY scenarios are proposed. 4-2. XX times of hi-level seminars are held. 4-3. XX times of seminars and workshops are held.	1-1. Project reports 1-2. Databases 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Record of discussions of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and ODA project reports 3-4. Record of discussions of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Record of discussions of seminars and workshops	Other ODA projects in Dhaka are successfully carried out.

Activities	Inputs	Important Assumption
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances 1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database 1-1-2 Investigating seismic design code and practice 1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings 1-1-4 Knowledge sharing of results derived from relevant projects 1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database 1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above 2-1 Conducting full-scale structural tests to understand actual performance of typical buildings in Dhaka 2-2 Identifying problems needed to be resolved using results obtained from activity 2-1 2-3 Developing performance evaluation policy using available information and data from 2-1, 2-2, CNCRP and other relevant projects 2-4 Developing formulas for performance evaluation through experiments and analyses of structural components 2-5 Determining required performance standard 2-6 Developing technical manuals of the performance evaluation methodologies 2-7 Applying developed methodologies to pilot buildings 2-8 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 3-1 Developing retrofit policy using available information and data from 2-1, 2-2, CNCRP and other relevant projects 3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structural components 3-3 Developing technical manuals of retrofit schemes 3-4 Sharing developed retrofit technologies with other on-going ODA projects 3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability 4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1 4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2 4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics 4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction 4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios	Bangladeshi side 1. Allocation of budget 2. Allocation of suitable personnel 3. Office space with telephone line, internet connection and office furniture in HBRI 4. Space for Equipment and Machinery 5. Provision of necessary data 6. Taking the necessary procedures Japanese side 1. Dispatch of Japanese researchers as experts in specific fields 2. Dispatch of a Japanese Project Coordinator 3. Counterpart Training in Japan 4. Machinery and Equipment	Building evaluation and retrofiting activities in other ODA project in Dhaka are not considerably delayed

PM Form 4 Project Completion Report

Version 1 (attached document of the amended R/D on 31th July, 2017)

Project Design Matrix (PDM)					1stJCC_No.2
Project Title: The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation					Version 1
Implementing Agency: Housing and Building Research Institute (HBRI)					Dated 2017,03,18
Target Group: Researchers and engineers of governmental authorities and universities in Bangladesh					
Period of Project: 2016 08 01 -2021 07 31					
Project Site: Dhaka, Bangladesh					
Model Site:					
Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.	1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction.	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government	Disaster Risk Reduction is not excluded from development policy and plan of Bangladesh.		
Project Purpose Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.	1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. XX documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents	Authority of revising BNBC is not transferred from government organizations to other organization		
Outputs 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.	1-1. At least 3 areas and their buildings are surveyed. 1-2. XX databases are established. 1-3. YY research target areas and buildings are selected. 2-1. At least 3 series of structural experiments are carried out. 2-2. XX formulas are proposed for capacity evaluation. 2-3. XX times of technical seminars, workshops and training are held. 2-4. XX buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. XX retrofit technologies are newly developed. 3-3. XX buildings' performances are upgraded with developed retrofit schemes. 3-4. XX times of technical seminars, workshops and training are held. 4-1. YY scenarios are proposed. 4-2. XX times of hi-level seminars are held. 4-3. XX times of seminars and workshops are held.	1-1. Project reports 1-2. Databases 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Record of discussions of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and other project reports 3-4. Record of discussions of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Record of discussions of seminars and workshops	Another building code is not established as national standard code		

Activities	Inputs		Important Assumption
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances 1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database 1-1-2 Investigating seismic design code and practice 1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings 1-1-4 Knowledge sharing of results derived from relevant projects 1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database 1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above 2-4 Conducting full-scale structural tests to understand actual performance of typical buildings in Dhaka 2-1 Identifying problems needed to be resolved using results obtained from activity 2-1-1 and 1-2 2-2 Developing performance evaluation policy using available information and data from 2-1-2, CNCRP, BSPP and other relevant projects 2-3 Developing formulas for performance evaluation through experiments and analyses of structural-components structures 2-4 Determining required performance standard 2-5 Developing technical manuals of the performance evaluation methodologies 2-6 Applying developed methodologies to pilot buildings 2-7 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 3-1 Developing retrofit policy using available information and data from 2-1-2, CNCRP, BSPP and other relevant projects 3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structural-components structures 3-3 Developing technical manuals of retrofit schemes 3-4 Sharing developed retrofit technologies with other on-going BDA-projects-CNCRP, BSPP and other relevant projects 3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability 4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1 4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2 4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics 4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction 4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios	The Japanese Side 1. Dispatch of Japanese researchers as experts in specific fields 2. Dispatch of a Japanese Project Coordinator 3. Counterpart Training in Japan 4. Machinery and Equipment	Bangladesh side 1. Allocation of budget 2. Allocation of suitable personnel 3. Office space with telephone line, internet connection and office furniture in HBRI 4. Space for Equipment and Machinery 5. Provision of necessary data 6. Taking the necessary procedures	Other projects targeting building evaluation and retrofitting are not cancelled Pre-Conditions Events which restrict activities of Japan side staffs in Dhaka do not repeatedly happen. <Issues and countermeasures>

PM Form 4 Project Completion Report

Version 2 (Amended on 6th JCC meeting, on 3rd August, 2019)

Project Design Matrix (PDM)		
Project Title: The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities		
Implementing Agency: Housing and Building Research Institute (HBRI)		
Target Group: Researchers and engineers of governmental authorities and universities in Bangladesh		
Period of Project: 2016 08 01 -2021 07 31		Ver. 2
Project Site: Dhaka, Bangladesh	Model Site:	
Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.	1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction. (変更なし)	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government
Project Purpose Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.	1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. At least 3 documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents
Outputs 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.	1-1. At least 3 areas and their buildings are surveyed. 1-2. A database containing fundamental building properties and seismic performances of at least 100 buildings is established. (データベースの数に意味はなく、必要な情報が含まれていることが重要であるため、修正。) 1-3. Research target areas and building types are identified. (研究対象領域をDCCエリア、研究対象建物をRC+MIW, Flat Plateと特定したことに対応して、研究対象建物ではなく研究対象building typeとした。) 2-1. At least 3 series of structural experiments are carried out. (修正なし。) 2-2. Rapid, 1st level and 2nd level evaluation methods are proposed. (数式の数に意味はなく、それらを整理・統合した診断法が重要であるため、上記のように修正。) 2-3. At least 3 times of technical seminars, workshops and training are held. 2-4. At least 100 buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. At least 3 retrofit technologies are newly developed. 3-3. At least 2 buildings are planned to apply the developed retrofit schemes. 3-4. At least 2 times of technical seminars, workshops and training are held. 4-1. At least 2 scenarios are proposed. 4-2. A hi-level seminar are held. (総選挙がプロジェクト3年目終盤に発生し、複数回の実施は困難になった。) 4-3. A seminar or workshop is held.	1-1. Project reports 1-2. Project reports 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Agenda and photos of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and other project reports 3-4. Agenda and photos of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Agenda and photos of seminars and workshops

Activities	Inputs	
	The Japanese Side	Bangladesh side
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances	1. Dispatch of Japanese researchers as experts in specific fields	1. Allocation of budget
1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database	2. Dispatch of a Japanese Project Coordinator	2. Allocation of suitable personnel
1-1-2 Investigating seismic design code and practice	3. Counterpart Training in Japan	3. Office space with telephone line, internet connection and office furniture in HBRI
1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings	4. Machinery and Equipment	4. Space for Equipment and Machinery
1-1-4 Knowledge sharing of results derived from relevant projects		5. Provision of necessary data
1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database		6. Taking the necessary procedures
1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above		
2-1 Identifying problems needed to be resolved using results obtained from activity 1-1 and 1-2		
2-2 Developing performance evaluation policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects		
2-3 Developing formulas for performance evaluation through experiments and analyses of structures		
2-4 Determining required performance standard		
2-5 Developing technical manuals of the performance evaluation methodologies		
2-6 Applying developed methodologies to pilot buildings		
2-7 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders		
3-1 Developing retrofit policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects		
3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structures		
3-3 Developing technical manuals of retrofit schemes		
3-4 Sharing developed retrofit technologies with CNCRP, BSPP and other relevant projects		
3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders		
4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability		
4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1		
4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2		
4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics		
4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction		
4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios		

PM Form 4 Project Completion Report

Ver.3 (attached document of the amended R/D on 23th March, 2021)

Project Design Matrix (PDM)						
Project Title: The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities Implementing Agency: Housing and Building Research Institute (HBRI) Target Group: Researchers and engineers of governmental authorities and universities in Bangladesh Period of Project: Until July 2022 Project Site: Dhaka, Bangladesh				Version 3 Dated 2020,09,01		
Narrative Summary		Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.		1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction.	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government	Disaster Risk Reduction is not excluded from development policy and plan of Bangladesh.		
Project Purpose Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.		1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. At least 3 documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents	Authority of revising BNBC is not transferred from government organizations to other organization		
Outputs 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.		1-1. At least 3 areas and their buildings are surveyed. 1-2. A database containing fundamental building properties and seismic performances of at least 100 buildings is established. 1-3. Research target areas and building types are identified. 2-1. At least 3 series of structural experiments are carried out. 2-2. Rapid, 1st level and 2nd level evaluation methods are proposed. 2-3. At least 3 times of technical seminars, workshops and training are held. 2-4. At least 100 buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. At least 3 retrofit technologies are newly developed. 3-3. At least 2 buildings are planned to apply the developed retrofit schemes. 3-4. At least 2 times of technical seminars, workshops and training are held. 4-1. At least 2 scenarios are proposed. 4-2. A hi-level seminar are held. 4-3. A seminar or workshop is held.	1-1. Project reports 1-2. Project reports 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Agenda and photos of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and other project reports 3-4. Agenda and photos of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Agenda and photos of seminars and workshops	Another building code is not established as national standard code		

Activities	Inputs		Important Assumption
	The Japanese Side	Bangladeshi side	
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances	1. Dispatch of Japanese researchers as experts in specific fields	1. Allocation of budget	Other projects targeting building evaluation and retrofitting are not cancelled
1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database	2. Dispatch of a Japanese Project Coordinator	2. Allocation of suitable personnel	
1-1-2 Investigating seismic design code and practice	3. Counterpart Training in Japan	3. Office space with telephone line, internet connection and office furniture in HBRI	
1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings	4. Machinery and Equipment	4. Space for Equipment and Machinery	
1-1-4 Knowledge sharing of results derived from relevant projects		5. Provision of necessary data	
1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database		6. Taking the necessary procedures	
1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above			Pre-Conditions
2-1 Identifying problems needed to be resolved using results obtained from activity 1-1 and 1-2			Events which restrict activities of Japan side staffs in Dhaka do not repeatedly happen.
2-2 Developing performance evaluation policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects			<Issues and countermeasures>
2-3 Developing formulas for performance evaluation through experiments and analyses of structures			
2-4 Determining required performance standard			
2-5 Developing technical manuals of the performance evaluation methodologies			
2-6 Applying developed methodologies to pilot buildings			
2-7 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders			
3-1 Developing retrofit policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects			
3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structures			
3-3 Developing technical manuals of retrofit schemes			
3-4 Sharing developed retrofit technologies with CNCRP, BSPP and other relevant projects			
3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders			
4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability			
4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1			
4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2			
4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics			
4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction			
4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios			

4. Others

4-1 Results of Environmental and Social Considerations (if applicable)

N/A

4-2 Results of Considerations on Gender/Peace Building/Poverty Reduction, Disability, Disease infection, Social System, Human Wellbeing, Human Right, and Gender Equality (if applicable)

N/A

III. Results of Joint Review

*Since the Joint Review could not be conducted during the project period, it was drafted by JICA and Japanese researchers after the project was completed. JICA requested the government of Bangladesh to check the contents and comment, but we were unable to obtain a response because some time had passed since the project end. Therefore, the following are the result of a review only by the Japanese side.

1. Results of Review based on DAC Evaluation Criteria

1) Relevance: High

Consistent with the Development policy and needs of the country, and there are no problems with the appropriateness of the project plan and approach.

[Development policy]

From 2015, when the project started, to 2021, when it will end, Bangladesh's Seventh Five-Year Plan (FY 2015/16 to 2019/20) and Eighth Five-Year Plan (FY 2020/2021 to 2024/25) have set "reduction and adaptation to potential disaster risks" as a goal. The plan stipulates that new construction and retrofitting of earthquake-resistant buildings must be addressed. In addition, one of the four strategic goals of the National Plan for Disaster Management 2010-2015 stipulates that the Ministry of Housing and Public Works will update and enforce the BNBC and promote earthquake-resistant buildings as a measure to strengthen earthquake preparedness. This project is positioned within these Bangladesh policies.

[Development needs]

The country of Bangladesh belongs to a seismically active region, and Dhaka is

more than 100 years past its last damaging earthquake, during which time the city has become densely populated. The building structure is extremely fragile, and although there is BNBC, many of the buildings do not comply with the code. According to studies conducted by the United Nations, World Bank, and other organizations, Dhaka is the most vulnerable city in the world to earthquakes. It is predicted that there would be severe economic and human losses at the event of a major earthquake.

The BNBC itself is largely based on U.S. standards, which do not reflect the structure type and quality of materials in Bangladesh. In addition, there are many buildings that are weaker than their design strength due to inadequate construction techniques and construction supervision, and the application of existing Japanese and Western methods to the diagnosis and reinforcement of earthquake resistance of these buildings is difficult because the structure type and materials are unique to the local conditions.

The earthquake-proofing of buildings has become an issue for Bangladesh, as the public is increasingly concerned about the vulnerability of buildings in the country, especially since the Madhupur Blind fault, which is estimated to have a high probability of occurrence based on recent seismic activity, is located in nearby Dhaka.

Therefore, the project meets the development needs of Bangladesh, including the development of seismic diagnosis and reinforcement methods suitable for local materials and structural types, to promote the earthquake resistance of buildings based on the results of scientific risk analysis.

2) Coherence: High

The project is consistent with the development cooperation policies of the Japanese government and JICA. It is also well-coordinated with other assistance within JICA.

[Consistency with Japanese Development Policy]

Japan's "Country Assistance Policy for the People's Republic of Bangladesh" (February 2018) set "Overcoming Social Vulnerability" as a priority objective and stated that Japan would support disaster risk reduction measures, including earthquake countermeasures. At the time of project completion, disaster risk reduction, including earthquake countermeasures, remained a priority area, and this project is consistent with Japan's assistance policy.

The project also addresses problems identified in the CNCRP (Capacity Development on Natural Disaster Resistant Techniques of Construction and Retrofitting for Public Buildings), which began in 2011, such as extremely low concrete strength and inadequate reinforcement.

[Consistency with global frameworks]

The project is considered to be positioned as Priority 3 "Investment in Disaster Risk Reduction for Resilience" in the Sendai Framework for Disaster Risk Reduction (2015-2030) adopted at the UN World Conference on Disaster Risk Reduction, and is consistent with the international framework.

[Collaboration with other JICA projects]

The reinforcement method developed in this project has been applied to actual buildings through BSPP (Promoting Building Safety for Disaster Risk Reduction in the People's Republic of Bangladesh) and construction has been completed. The participants of four earthquake-related disaster risk reduction projects (SATREPS, BSPP, UBSP, and SEEDs Asia) including this project in Bangladesh gathered to share information like activities, objectives, and current status, and to confirm mutual collaboration for the future social implementation of this project. The participants confirmed that they will collaborate with each other for the future social implementation of this project.

[Consistency with other development partners]

Although there is no direct collaboration, data collected through the CDMP1 project, a comprehensive disaster management program implemented by UNDP, is being utilized. The World Bank and CDMP1 support was limited to vulnerability assessments and did not provide concrete solutions, and the project complements the results of those projects, and there is no policy conflict with other development partners regarding the content of support.

3) Effectiveness: High

Through the implementation of the project, the expected outcomes were achieved as planned.

At the end of the project, the project objectives have been achieved as follows;
Indicator 1: Improvement scheme of performance for buildings is proposed, the

seismic evaluation method and retrofit scheme are described in the guidelines.

Indicator 2: Improvement scenario of safety index for urban area is proposed, Guidebook for resilient city is published.

Indicator 3: Knowledge and technologies developed through this project are utilized in other projects.

Indicator 4: At least 3 documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs. Regarding Guidelines/Guidebook /VR manual were submitted to HBRI for future upgrade of BNBC.

All of these accomplishments would not have been possible without the implementation of this project. It means that this project has been implemented very effectively.

4) Efficiency: High

Project inputs (costs and duration) are generally efficient relative to outputs.

[Cost]

The total budget provided by the Japanese side (approximately 320 million yen) was within the planned amount (approximately 400 million yen) and was used efficiently to produce the expected results. The majority of the Japanese budget was provided by JICA to the University of Tokyo, the project's primary research institution, and the University of Tokyo was responsible for purchasing and shipping equipment, dispatching experts from Japan, and hosting researchers from Bangladesh.

Due to the spread of COVID-19, budget adjustments were necessary for several activities. Since travel between Bangladesh and Japan were restricted, expenditures for the dispatch of Japanese members to Bangladesh after April 2020 were lower than originally planned.

In other expenses directly implemented by JICA, the input of a project coordinator was required for a total of more than five years, and there were additional costs for the dispatch of a long-term expert.

[Period]

The implementation period was extended by one year from the originally planned five years to a total of six years. Following the outbreak of the pandemic and the suspension of many activities in both countries, the project proposed

and agreed to a one-year extension of the implementation period.

[Input-output analysis]

The budget and schedule are considered reasonable, taking into account the extent of the results. The project budget has been appropriately allocated to complete all research activities and no unnecessary costs have been incurred. The extension of the project duration was unavoidable due to the impact of COVID-19, and it can be concluded that high efficiency was achieved.

5) Impact: High

The expected impact of the project was achieved as planned. Considerations and effects have been realized as expected, and the project is expected to have no negative social, environmental, and economic impacts in the long term.

[Prospects to achieve the overall goal]

Regarding the first indicator (Knowledge and technologies developed through this project are included in BNBC.), three documents have been submitted for revision by BNCB. PWD, the implementing agency of this project, has been participating as a project member, and the guidelines of this project have been adopted by PWD in a step ahead manner. In addition, PWD has been holding seminars and promoting the project's guidelines to government engineers. In addition, seminars have been held to gather opinions from a wide range of academic experts outside of the project, and videos of the seminars have been made available for public comment, in order to promote a better understanding of the guidelines. However, it is not clear at this time whether the timing of the revision will be by the time of the ex-post evaluation.

Regarding the second indicator (Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction), it will require further action by the PWD or by the PWD to the MoDMR. In this project, a seminar was held at the end of the project and the Minister of Disaster Management and Relief and the Undersecretary of the MoHPW were invited to explain the results of the project and the importance of earthquake resistance diagnosis and reinforcement.

In addition, there is a possibility that the project will be incorporated into the

policies and plans of RAJUK, which is supervised by the MoHPW, since JICA has provided continuous cooperation to RAJUK in this field (The Project for Improvement of Design and Construction Quality for Resilience of Private Buildings: January 2020 - March 2026) and the said field continues to be an important issue for Bangladesh.

However, since the results of this project are strongly technical based, they are not directly included in the country's plans and policies, but may be included indirectly, for example, in matters related to earthquake reinforcement.

[Other Impact]

No negative impacts outside the project have occurred at this time.

6) Sustainability: High

There are some minor issues regarding related policies and institutions, Structure of the implementing agencies, Skills of the implementing agencies, and Finance of the implementing agencies, but the prospects for improvement and resolution are high. In addition, there are no sustainability risks from an environmental, social, or other perspective.

[Policies and institutions]

As noted above, the project is founded on Bangladeshi national policy and is expected to be sustained in the future.

[Structure of the implementing agencies]

The project has been conducted with the participation of not only the research institute but also the PWD, which is responsible for the practical implementation of the project, and it is expected that the results will continue to be utilized. The RAJUK, which is in charge of building administration for private buildings in the Dhaka metropolitan area, is also involved in the project, and it is expected that the results will be widely utilized.

On the other hand, there are concerns about the continuation of research activities due to the chronic shortage of manpower at HBRI.

[Skills of the implementing agencies]

During the implementation period, the project has promoted knowledge transfer and capacity building to its members in Bangladesh, mainly through the dispatch

of experts and visits of researchers to Japan. In addition, as mentioned above, the project is actually making use of the technology in another project, and it can be judged that the degree of its utilization is high.

Regarding the use of equipment, in the HBRI, the main working group for the project activities is not HBRI staff but JCs (Junior Research Consultants), who are trained by Japanese researchers on how to use the equipment provided and how to conduct the experiments. After the completion of the project, some of the JCs continue to work as Research Fellows at HBRI, which ensures that the equipment is continuously utilized and maintained appropriately. In addition, the universities participating in the project are actively using the equipment, and have made arrangements with HBRI to share equipment, and the universities have secured budgets for equipment installed in university facilities, and have established a system for appropriate operation and maintenance management so that external organizations such as HBRI can also use the equipment.

[Finance of the implementing agencies]

The continuation of the results of this project will not require significant financial resources. In the meanwhile, the continuation of research activities will require other expenses such as personnel costs. Regarding personnel expenses, some JCs continue to work as Research Fellows. In addition, although it is not highly probable, HBRI could generate income from testing fees if it receives orders for performance testing, and could supplement this income if it receives orders for basic inspections of infrastructure projects by other countries and international organizations. However, it should be noted that the income cannot be used solely for the continuation of this project.

Based on the above analysis from the four perspectives, the project is judged to have relatively high sustainability.

2. Key Factors Affecting Implementation and Outcomes

[Impact of the Terrorist Incident]

The terrorist incident that occurred in Dhaka on July 1, 2016, shortly after the start of the project, resulted in restrictions on activities, including a travel ban to the area. In response to the above issues, the following measures were taken to address the above issues from the viewpoint of facilitating research activities even under travel restrictions:

- Inviting Bangladeshi researchers to Japan to conduct experiments in Japan and transferring experimental techniques to them, not only to efficiently conduct the field experiments planned for the mid- to late-term of the project, but also to ensure that the experiments would be carried out even if Japanese researchers' travel was minimized.
- The project team also conducted WS actively and referred to the outputs from preceding projects such as CNCRP and CDMP1 to understand the problems faced by the buildings on the Bangladesh without relying on the full-scale experiments that were originally planned, and to understand the city conditions in Dhaka without conducting field surveys.

[Impact of COVID-19 outbreak]

Due to the impact of the outbreak of COVID-19 infection, some of the flat plate and RC+URM experiments described in 2 and 3 were conducted remotely (via webcast, with instructions and advice provided from Japan). In addition, as travel to and from Japan has become more difficult, the project team has considered and devised various ways to achieve the project purpose without having to travel to Japan, such as holding online meetings and online seminars. In addition, the project coordinator could not be dispatched to Bangladesh between April 2020 and March 2021, which had no small impact on the progress of the project.

[Delays in various procedures]

The following four problems existed for a long period of time from the beginning of the project.

- The TAPP budget was not flexible and the amount was not sufficient to pay the customs duties on the equipment procured in Japan.
- The actual leader of Study Group 4 in Bangladesh had not been confirmed for a long period of time.
- The MoU (Minutes of Understanding) between HBRI and the Department of Urban Planning, BUET, had not been signed in relation to the above.
- Delay in TAPP amendment application and approval

As a result of discussions with the JCC, it was decided that customs payments would be made through a TAPP budget amendment, and the application for this amendment was completed in January 2020 and approved in November 2021. The substantive leader of Study Group 4 was changed from BUET Urban

Planning Department to JU, and the MoU with JU was completed, so the issues related to Study Group 4 were resolved.

3. Evaluation on the results of the Project Risk Management

[Risk management results]

After the project was initiated, the above-mentioned problems were encountered, but by responding flexibly and flexibly, moves were made to resolve the problems.

- Matters related to procedures in Bangladesh were repeatedly taken up and discussed at the JCC.
- Alternative means of information were adapted to the situation where on-site surveys were difficult due to the effects of the terrorist attacks.
- In response to the difficulty of conducting a full-scale experiment, the JCC took a different approach, such as proceeding with a study based on information from hearings and other sources.

As a result, except for the impact of COVID-19, there were no delays that had a significant impact on the project, and it can be concluded that project risk management was correctly implemented to a certain degree.

[Results of the use of lessons learned]

According to the lessons learned from the Terminal Evaluation Report of the SATREPS project "Project for Enhancement of Earthquake and Tsunami Disaster Mitigation Technology in Peru", information and recommendations based on scientific analysis by research institutions need to be processed and edited according to the uses of each user of social implementation, including ministries, local governments, private companies, and communities, and lessons learned that opportunities to create and share those deliverables should be included as an activity.

According to the lessons learned from the Terminal Evaluation Report of the technical cooperation project "Enhancement of Technology for the Construction of Earthquake-Resistant Popular Housing" in El Salvador, the lessons learned are that the earthquake resistance of buildings should be promoted as part of urban and regional development projects, rather than only to strengthen the earthquake resistance of individual buildings. Another lesson learned was that when applying the new technology developed, it is necessary to consider the level of the implementers of the activities in the partner country during the project

planning phase, and ensure that they have sufficient time to learn the technology in the early stages of the project.

Based on these lessons, this project included engineers who will utilize the technology in the future as researchers in the partner country, and included institutions responsible for urban and regional development in the organizations concerned. In disseminating the results of the research, the project also provided opportunities to share information not only with government agencies in charge of building administration, public building construction, and urban development, but also with university professors and other academic experts, in order to ensure that the technology would be authorized as a diagnostic method for public buildings. In addition, issues that arose during the course of this project were identified through close collaboration with related parties, and these issues were taken into consideration and reflected in the actual construction practices in the partner country, leading to the proposal of a realistic method. The results of the building diagnosis were shared with relevant organizations through JCC and seminars so that they could be used as reference for future development plans.

As a result, coupled with the collaboration with other projects, the technology developed in this project could be used in the actual field and resulted in a better understanding by government engineers. The building diagnosis attracted the interest of a very large number of stakeholders.

4. Lessons Learnt

In the case of a research institute under a ministry, there is a possibility that the representative may be replaced during the project period due to personnel changes. In addition, contract staff may be engaged in research and experiments due to a shortage of permanent staff. While reliance on these personnel is unavoidable in the implementation of a project, it is necessary for the implementing agency to consider and take measures to ensure that the employment and contracts of these personnel are as stable as possible, in order to ensure continuity during and after the project period.

IV. For the Achievement of Overall Goals after the Project Completion

1. Prospects to achieve Overall Goal

Overall goal: **Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh**

As approaching the final stage of this project, contributions from Bangladesh side to this project has greatly increased and spontaneous activities for the future development has also increased, as shown below. These activities are independent of this project, however, they complement and develop the results of this project, and strongly support the achievement of the overall goals.

(1) In addition to reinforced concrete buildings (which generally incorporates unreinforced masonry walls (URM walls)) and flat plate buildings, which are the subject of this project, pure masonry buildings are another common type of building structure in Bangladesh. In the beginning of this project, there was a great deal of debate as to whether or not to include pure masonry buildings, which have a high component ratio in Dhaka city. However, since the vulnerability of such buildings cannot be overlooked, it was decided that the Bangladeshi side will treat the pure masonry structures as another project. As experimental and analytical studies on seismic evaluation methods and seismic retrofit schemes were carried out in this project, HBRI was motivated to set up its own research theme and take budgetary measures and proposed a seismic evaluation method for the pure masonry buildings. The proposal is based on the method developed by TSUIB project. Although this proposal is independent of TSUIB project, a workshop for WG2 and WG3 members was held in July 2021 to hear opinions from JICA experts.

(2) Urban earthquake disaster prevention involves a wide range of fields, including elucidation of earthquake generation and propagation mechanisms, performance evaluation of structures, retrofit schemes, post-earthquake evacuation measures, and development of recovery and reconstruction technologies. BUET, which is one of the main counterparts of this project, organized a workshop on Earthquake Disaster Risk Mitigation (EDRM), led by Prof. AFM S. Amin, including early warning system and measures to improve public awareness. At the workshop, participants discussed the establishment and implementation of research topics to be developed through discussions

among relevant stakeholder groups.

(3) As mentioned previously, BUET has greatly improved its ability to conduct seismic tests on components in this project and started carbon fiber reinforcement experiments of low strength concrete columns in collaboration with Japanese private companies.

(4) Research on how to increase the strength of brick-aggregate concrete is in process as a doctoral course research by a Japanese government-sponsored student who studied in Japan under this project.

2. Plan of Operation and Implementation Structure of the Bangladesh side to achieve Overall Goal

Prospects to achieve Overall Goal

To achieve the overall goal of the project, “Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh”, HBRI has undertaken the following research works, independent of the SATREPS-TSUIB Project:

- 1). To develop a methodology for “Seismic Assessment of Unreinforced masonry (URM) Buildings. This is very important for any future initiative of HBRI to take up a large-scale project to assess the Buildings of Dhaka city.
- 2). Research titled “Seismic behaviour of a two bay two story reinforced concrete Building frame” was undertaken by HBRI. This research is planned to supplement a similar test done at UTokyo, under TSUIB project. In this research work, effect of local materials and construction techniques on the seismic behaviour of RC frames will be studied.
- 3). Research titled “Beam-column joint pullout test” has been undertaken by BUET. The objective of this test is to find out the joint pullout behaviour with straight anchorage, which is a common problem in the building construction practice of Bangladesh.
- 4). Research titled “Building survey and investigation of existing RC buildings in Bangladesh” is being undertaken by HBRI. In this research, 1000 buildings of ward no. 33, Jatrabari, Dhaka, will be surveyed and detailed seismic assessment will be carried out. The objective of this study is to develop an effective method for retrofitting prioritization of existing RC buildings.
- 5). Vision beyond SATREPS-TSUIB Project-
 - a) Take up joint research programs with the local universities, in continuation of the SATREPS-TSUIB Project.
 - b) Take up new Japan-Bangladesh joint research project with Japanese and Bangladeshi universities in the sector of Disaster Risk Reduction.
 - c) Take up large projects to conduct seismic assessment of the buildings of Dhaka, Sylhet and Chattogram cities and prepare a prioritization map and strategy for retrofitting of the vulnerable buildings.
 - d) Incorporate a new section on “Assessment and retrofitting of existing Buildings” in the future edition of Bangladesh National Building Code (BNBC).

- e) As a part of mainstreaming of the seismic assessment and retrofitting know-how, gathered from CNCRP, BSPP and TSUIB projects, a proposal will be prepared to be incorporated in the 9th Five Year Plan (2025-2030) of GOB, to retrofit the vulnerable buildings of Dhaka, Sylhet and Chattogram cities.

3. Recommendations for the Bangladesh side

As mentioned above, Bangladeshi side has performed spontaneous activities for the future development. Japanese side strongly recommend to continue such efforts for the safer Bangladesh.

4. Monitoring Plan from the end of the Project to Ex-post Evaluation

N/A.

(If the Project will be continuously monitored by JICA after the completion of the Project, mention the plan of post-monitoring here.)

ANNEX 1: Results of the Project

(List of Dispatched Experts, List of Trainings, etc.)

ANNEX 2: List of Products (Report, Manuals, Handbooks, etc.) Produced by the Project

ANNEX 3: PDM (All versions of PDM)

ANNEX 4: R/D, M/M, Minutes of JCC (copy) (*)

ANNEX 5: Monitoring Sheet (copy) (*)

(Remarks: ANNEX 4 and 5 are internal reference only.)

Separate Volume: Copy of Products Produced by the Project

List of Dispatched Experts

No.1	Period of dispatch		Breakdown	
Name	From	To	Fiscal year	Number of days
Yoshiaki Nakano	16 March 2017	21 March 2017	2016	6
	08 August 2017	17 August 2017	2017	27
	03 December 2017	08 December 2017		
	06 March 2018	16 March 2018		
	25 May 2018	31 May 2018	2018	44
	06 August 2018	15 August 2018		
	05 October 2018	10 October 2018		
	16 November 2018	23 November 2018		
	09 March 2019	21 March 2019	2019	55
	29 July 2019	08 August 2019		
	27 September 2019	06 October 2019		
	12 November 2019	24 November 2019		
	04 December 2019	15 December 2019		
	10 January 2020	18 January 2020		
	01 February 2022	16 February 2022	2021	16
	07 May 2022	26 May 2022	2022	35
	18 June 2022	02 July 2022		
Masaki Maeda	10 August 2017	16 August 2017	2017	19
	20 January 2018	24 January 2018		
	09 March 2018	15 March 2018		
	08 August 2018	16 August 2018	2018	19
	05 October 2018	09 October 2018		
	16 March 2019	20 March 2019		
	31 July 2019	05 August 2019	2019	11
	08 February 2020	12 February 2020		
	20 June 2022	29 June 2022	2022	10
Matsutaro Seki	10 August 2017	16 August 2017	2017	14
	08 March 2018	14 March 2018		
	10 August 2018	10 August 2018	2018	18
	06 October 2018	12 October 2018		
	16 March 2019	20 March 2019		
	01 August 2019	07 August 2019	2019	7
	21 June 2022	30 June 2022	2022	10

Annex 1-1 List of Dispatched Experts

No.2	Period of dispatch		Breakdown	
Name	From	To	Fiscal year	Number of days
Yasushi Sanada	15 March 2017	21 March 2017	2016	7
	11 August 2017	15 August 2017	2017	11
	08 March 2018	13 March 2018		
	19 July 2018	23 July 2018	2018	17
	10 August 2018	15 August 2018		
	15 September 2018	20 September 2018		
	30 October 2019	04 November 2019	2019	15
	30 November 2019	04 December 2019		
	15 February 2020	18 February 2020		
	22 June 2022	27 June 2022	2022	6
Michio Ubaura	19 March 2017	23 March 2017	2016	5
	09 September 2017	15 September 2017	2017	14
	06 March 2018	12 March 2018		
	05 August 2018	12 August 2018	2018	21
	14 September 2018	20 September 2018		
	14 March 2019	19 March 2019		
	02 August 2019	07 August 2019	2019	13
	19 December 2019	25 December 2019		
	21 June 2022	28 June 2022	2022	8
Tomoya Nishiwaki	03 December 2017	08 December 2017	2017	13
	09 March 2018	15 March 2018		
	14 March 2019	19 March 2019	2018	6
Susumu Takahashi	18 March 2017	22 March 2017	2016	5
	09 August 2017	15 August 2017	2017	13
	07 March 2018	13 March 2018		
	27 July 2018	01 August 2018	2018	35
	08 August 2018	17 August 2018		
	15 September 2018	21 September 2018		
	02 November 2018	07 November 2018		
	14 March 2019	19 March 2019		
	30 October 2019	04 November 2019	2019	17
	28 November 2019	02 December 2019		
	20 December 2019	25 December 2019		
	27 January 2020	03 February 2020		
	13 February 2020	19 February 2020		
	22 June 2022	27 June 2022	2022	6

Annex 1-1 List of Dispatched Experts

No.3	Period of dispatch		Breakdown	
Name	From	To	Fiscal year	Number of days
Kazuto Matsukawa	16 March 2017	22 March 2017	2016	7
	08 August 2017	17 August 2017	2017	30
	03 December 2017	08 December 2017		
	10 February 2018	16 February 2018		
	08 March 2018	14 March 2018		
	14 April 2018	19 April 2018	2018	42
	25 May 2018	31 May 2018		
	13 July 2018	18 July 2018		
	09 August 2018	15 August 2018		
	05 October 2018	11 October 2018		
	13 March 2018	21 March 2018		
	30 July 2019	07 August 2019	2019	17
	04 December 2019	11 December 2019		
	1 February 2022	13 February 2022	2021	13
	19 June 2022	28 June 2022	2022	10
DAS Sangita	16 March 2017	21 March 2017	2016	6
	09 September 2017	15 September 2017	2017	16
	06 March 2018	14 March 2018		
	09 May 2018	14 May 2018	2018	16
	06 August 2018	15 August 2018		
Fumihiko Seta	11 September 2017	15 September 2017	2017	5
Kazumasa Hanaoka	06 March 2018	09 March 2018	2017	4
	15 September 2018	19 September 2018	2018	10
	15 March 2019	19 March 2019		
Osamu Murao	11 September 2017	15 September 2017	2017	5
	14 September 2018	20 September 2018	2018	11
	16 March 2019	19 March 2019		
Mihoko Matsuyuki	06 March 2018	09 March 2018	2017	4
Debasish Sen	10 August 2017	16 August 2017	2017	22
	20 January 2018	26 January 2018		
	09 March 2018	16 March 2018		
	09 August 2018	17 August 2018	2018	14
	16 March 2019	20 March 2019		
	31 July 2019	05 August 2019	2019	6
	24 January 2020	31 January 2020		

Annex 1-2 List of Trainings funded by
JICA

List of Trainings funded by JICA

Long-term training program

Name	Organizatoion	Position	Training place	Period of dispatch		Breakdown	
				From	To	Fiscal year	Number of days
Nassif ZUBAYER	Public Works Department	Engineer	The University of Tokyo	28 March 2017	30 September 2019	2016	4
						2017	365
						2018	365
						2019	183
Debasish SEN	Ahsanullah University of Science and Technology	Lecturer	Tohoku University	28 March 2017	16 September 2020	2016	4
						2017	365
						2018	365
						2019	366
						2020	168
Sadia AFROSE	Bangladesh University of Engineering and Technology	Research Assistant	Tohoku University	31 March 2018	16 September 2020	2018	365
						2019	366
						2020	168
S.M. Naheed ADNAN	Bangladesh University of Engineering and Technology	Research Assistant	The University of Tokyo	19 April 2018	16 September 2020	2018	306
						2019	366
						2020	168

Short-term training program

Name	Organization	Position	Training place	Period of dispatch		Breakdown	
				From	To	Fiscal year	Number of days
Golam SAMDANI	University of Asia Pacific	Lecturer	Daido University	15 August 2017	29 August 2017	2017	15

Business trip base

Name	Organization	Position	Training place	Period of dispatch		Breakdown	
				From	To	Fiscal year	Number of days
Mohammad Abu SADEQUE	Housing and Building Research Institute	Director	The University of Tokyo, Tohoku University, BRI, Nagoya Institute of	31 July 2016	08 August 2016	2016	9
				04 November 2016	09 November 2016		6
Iftekhar ANAM	University of Asia Pacific	Professor	The University of Tokyo, Tohoku University, BRI, Nagoya Institute of Technology,	31 July 2016	08 August 2016	2016	9

Annex 1-2 List of Trainings funded by
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			Daido University				
			Daido University	18 December 2018	24 December 2018	2018	7
			Tohoku University	10 October 2019	16 October 2019	2019	7
A.F.M. Saiful AMIN	Bangladesh University of Engineering and Technology	Professor	The University of Tokyo, Tohoku University, Osaka University, BRI, Nagoya Institute of Technology, Daido University	31 July 2016	08 August 2016	2016	9
				04 November 2016	09 November 2016		6
				07 June 2017	11 June 2017	2017	5
				13 September 2017	17 September 2017		5
				21 February 2018	01 March 2018		9
				20 December 2018	28 December 2018	2018	9
				10 October 2019	13 October 2019	2019	4
Mizanur RAHMAN	Bangladesh University of Engineering and Technology	Professor	The University of Tokyo, Tohoku University, Osaka University, Daido University	06 June 2017	12 June 2017	2017	7
				11 September 2017	17 September 2017		7
				21 February 2018	01 March 2018		9
				23 December 2018	28 December 2018	2018	6
Md. Shamim Miah	University of Asia Pacific	Assistant Professor	The University of Tokyo	04 November 2016	09 November 2016	2016	6
Sharmin Reza CHOWDHURY	Ahsanullah University of Science and Technology	Professor	The University of Tokyo, Tohoku University, BRI, Nagoya Institute of Technology, Daido University	31 July 2016	08 August 2016	2016	9
				04 November 2016	09 November 2016		6
				26 July 2017	03 August 2017	2017	9
				09 May 2018	14 May 2018	2018	6
Md. Rafiqul ISLAM	Public Works Department	Executive Engineer	The University of Tokyo, Tohoku University, BRI, Nagoya Institute of Technology, Daido University	31 July 2016	08 August 2016	2016	9
				04 November 2016	09 November 2016		6
				26 July 2017	03 August 2017	2017	9
				09 May 2018	14 May 2018	2018	6
Khurshid zabin hossain TAUFIQUE	Urban Development Directorate	Director	The University of Tokyo	04 November 2016	09 November 2016	2016	6
Mohammad Shakil AKTHER	Bangladesh University of Engineering and Technology	Professor	The University of Tokyo	04 November 2016	09 November 2016	2016	6
Murshalin AHMED	Bangladesh University of Engineering and Technology	Research Assistant	The University of Tokyo, Tohoku University, Osaka University	06 September 2017	21 September 2017	2017	16
				21 February 2018	01 March 2018	2017	9

Annex 1-2 List of Trainings funded by
JICA

S.M. Naheed ADNAN	Bangladesh University of Engineering and Technology	Research Assistant	The University of Tokyo	19 April 2018	16 September 2020	2018	9
Mohammad ShamimAKTHER	Housing and Building Research Institute	Director	Tohoku University, BRI	09 May 2018	14 May 2018	2018	6
				10 October 2019	18 October 2019	2019	9
MD. Jahidul Islam KHAN	Public Works Department	Executive Engineer	Tohoku University	09 May 2018	14 May 2018	2018	6
				10 October 2019	16 October 2019	2019	7
Humaira Binte HASAN	Public Works Department	Assistant Engineer	Tohoku University	09 May 2018	14 May 2018	2018	6
MD. ARIFUJJAMAN	Housing and Building Research Institute	Research Engineer	Daido University	18 December 2018	24 December 2018	2018	7
S.M. Muhaiminul ISLAM	Housing and Building Research Institute	Junior Research Consultant	Daido University	15 December 2018	27 December 2018	2018	13
Abdullah Al Hashib	Ahsanullah University of Science and Technology	Lecturer	Tohoku University	09 December 2018	24 December 2018	2018	16
Jobaer UDDIN	Housing and Building Research Institute	Junior Research Consultant	Tohoku University	09 December 2018	24 December 2018	2018	16
Zasiah TAFHEEM	Ahsanullah University of Science and Technology	Assistant Professor	Tohoku University	09 May 2018	14 May 2018	2018	6
Md. Iftekharul Islam	Public Works Department	Assistant Engineer	Tohoku University	24 January 2019	03 February 2019	2018	11
Md. Raquibul Hassan	Public Works Department	Assistant Engineer	Tohoku University	24 January 2019	03 February 2019	2018	11
Md.Abdul Malek Sikder	Housing and Building Research Institute	Senior Consultant	Tohoku University, BRI	10 October 2019	18 October 2019	2019	9
Muhammad Abdur Rahman Bhuiyan	Housing and Building Research Institute	Senior Consultant	Tohoku University	10 October 2019	16 October 2019	2019	7

Annex 2 List of Products Produced by the Project

Working Group 1

- Seismic Provisions in Bangladesh National Building Code 1993 for RC Buildings and Comparison with Japanese Building Code
- Seismic Provisions in Bangladesh National Building Code 2017 for RC Buildings and Comparison with Japanese Building Code
- Procedure of Official Permit and Inspection System in Construction Works of Public Works Department (PWD)

Working Group 2

- User's Manual on Visual Rating (VR) for Potential Seismic Vulnerability Assessment of Existing Reinforced Concrete Buildings in Bangladesh
- Technical Guidelines for Seismic Evaluation of Existing Reinforced Concrete Buildings in Bangladesh for Extended Application of PWD Seismic Evaluation Manual

Working Group 3

- Technical Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings in Bangladesh for Extended Application of PWD Seismic Retrofit Manual
- Appendix: Pilot Project for Ferrocement retrofit construction in Bangladesh

Working Group 4

- Guidebook on Towards Seismic Resilience in Dhaka City: A Planning Perspective

Annex3 All versions of PDM ATTACHMENT II

Project Design Matrix (PDM ver.0)

Project Name: The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities

Project site: Dhaka, Bangladesh

Duration of Project: 5 years

Target Group: Researchers and engineers of governmental authorities and universities in Bangladesh

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
Overall goal 上位目標 Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.	1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction.	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government	
Project purpose プロジェクト目標 Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.	1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. XX documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents	Policy and social system related to disaster risk reduction in Bangladesh do not change.
Outputs 成果 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.	1-1. At least 3 areas and their buildings are surveyed. 1-2. XX databases are established. 1-3. YY research target areas and buildings are selected. 2-1. At least 3 series of structural experiments are carried out. 2-2. XX formulas are proposed for capacity evaluation. 2-3. XX times of technical seminars, workshops and training are held. 2-4. XX buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. XX retrofit technologies are newly developed. 3-3. XX buildings' performances are upgraded with developed retrofit schemes. 3-4. XX times of technical seminars, workshops and training are held. 4-1. YY scenarios are proposed. 4-2. XX times of hi-level seminars are held. 4-3. XX times of seminars and workshops are held.	1-1. Project reports 1-2. Databases 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Record of discussions of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and ODA project reports 3-4. Record of discussions of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Record of discussions of seminars and workshops	Other ODA projects in Dhaka are successfully carried out.

Activities	Inputs	Important Assumption
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances 1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database 1-1-2 Investigating seismic design code and practice 1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings 1-1-4 Knowledge sharing of results derived from relevant projects 1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database 1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above 2-1 Conducting full-scale structural tests to understand actual performance of typical buildings in Dhaka 2-2 Identifying problems needed to be resolved using results obtained from activity 2-1 2-3 Developing performance evaluation policy using available information and data from 2-1, 2-2, CNCRP and other relevant projects 2-4 Developing formulas for performance evaluation through experiments and analyses of structural components 2-5 Determining required performance standard 2-6 Developing technical manuals of the performance evaluation methodologies 2-7 Applying developed methodologies to pilot buildings 2-8 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 3-1 Developing retrofit policy using available information and data from 2-1, 2-2, CNCRP and other relevant projects 3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structural components 3-3 Developing technical manuals of retrofit schemes 3-4 Sharing developed retrofit technologies with other on-going ODA projects 3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability 4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1 4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2 4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics 4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction 4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios	Bangladeshi side 1. Allocation of budget 2. Allocation of suitable personnel 3. Office space with telephone line, internet connection and office furniture in HBRI 4. Space for Equipment and Machinery 5. Provision of necessary data 6. Taking the necessary procedures Japanese side 1. Dispatch of Japanese researchers as experts in specific fields 2. Dispatch of a Japanese Project Coordinator 3. Counterpart Training in Japan 4. Machinery and Equipment	Building evaluation and retrofitting activities in other ODA project in Dhaka are not considerably delayed

Project Design Matrix (PDM)**Project Title:** The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implemen **Version 1****Implementing Agency:** Housing and Building Research Institute (HBRI)**Dated 2017,03,18****Target Group:** Researchers and engineers of governmental authorities and universities in Bangladesh**Period of Project:** 2016 08 01 -2021 07 31**Project Site:** Dhaka, Bangladesh**Model Site:**

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.	1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction.	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government	Disaster Risk Reduction is not excluded from development policy and plan of Bangladesh.		
Project Purpose Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.	1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. XX documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents	Authority of revising BNBC is not transferred from government organizations to other organization		
Outputs 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.	1-1. At least 3 areas and their buildings are surveyed. 1-2. XX databases are established. 1-3. YY research target areas and buildings are selected. 2-1. At least 3 series of structural experiments are carried out. 2-2. XX formulas are proposed for capacity evaluation. 2-3. XX times of technical seminars, workshops and training are held. 2-4. XX buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. XX retrofit technologies are newly developed. 3-3. XX buildings' performances are upgraded with developed retrofit schemes. 3-4. XX times of technical seminars, workshops and training are held. 4-1. YY scenarios are proposed. 4-2. XX times of hi-level seminars are held. 4-3. XX times of seminars and workshops are held.	1-1. Project reports 1-2. Databases 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Record of discussions of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and other project reports 3-4. Record of discussions of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Record of discussions of seminars and workshops	Another building code is not established as national standard code		

Activities	Inputs		Important Assumption
	The Japanese Side	Bangladeshi side	
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances 1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database 1-1-2 Investigating seismic design code and practice 1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings 1-1-4 Knowledge sharing of results derived from relevant projects 1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database 1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above ~~2-4 Conducting full-scale structural tests to understand actual performance of typical buildings in Dhaka~~ 2-1 Identifying problems needed to be resolved using results obtained from activity ~~2-4-1-1~~ and 1-2 2-2 Developing performance evaluation policy using available information and data from 2-1, ~~2-2~~, CNCRP, ~~BSPP~~ and other relevant projects 2-3 Developing formulas for performance evaluation through experiments and analyses of ~~structural components~~ structures 2-4 Determining required performance standard 2-5 Developing technical manuals of the performance evaluation methodologies 2-6 Applying developed methodologies to pilot buildings 2-7 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 3-1 Developing retrofit policy using available information and data from 2-1, ~~2-2~~, CNCRP, ~~BSPP~~ and other relevant projects 3-2 Developing appropriate retrofit technologies based on experimental results and analyses of ~~structural components~~ structures 3-3 Developing technical manuals of retrofit schemes 3-4 Sharing developed retrofit technologies with ~~other on-going ODA projects~~ CNCRP, BSPP and other relevant projects 3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability 4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1 4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2 4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics 4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction 4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios	1. Dispatch of Japanese researchers as experts in specific fields 2. Dispatch of a Japanese Project Coordinator 3. Counterpart Training in Japan 4. Machinery and Equipment	1. Allocation of budget 2. Allocation of suitable personnel 3. Office space with telephone line, internet connection and office furniture in HBRI 4. Space for Equipment and Machinery 5. Provision of necessary data 6. Taking the necessary procedures	Other projects targeting building evaluation and retrofitting are not cancelled Pre-Conditions Events which restrict activities of Japan side staffs in Dhaka do not repeatedly happen.  <Issues and countermeasures>

Project Design Matrix (PDM)

Project Title: The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities

Implementing Agency: Housing and Building Research Institute (HBRI)

Target Group: Researchers and engineers of governmental authorities and universities in Bangladesh

Period of Project: 2016 08 01 -2021 07 31

Ver. 2

Project Site: Dhaka, Bangladesh

Model Site:

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.	1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction. (変更なし)	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government
Project Purpose Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.	1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. At least 3 documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents
Outputs 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.	1-1. At least 3 areas and their buildings are surveyed. 1-2. A database containing fundamental building properties and seismic performances of at least 100 buildings is established. (データベースの数に意味はなく、必要な情報が含まれていることが重要であるため、修正。) 1-3. Research target areas and building types are identified. (研究対象領域をDCCエリア、研究対象建物をRC+MIW, Flat Plateと特定したことに対応して、研究対象建物ではなく研究対象building typeとした。) 2-1. At least 3 series of structural experiments are carried out. (修正なし。) 2-2. Rapid, 1st level and 2nd level evaluation methods are proposed. (数式の数に意味はなく、それらを整理・統合した診断法が重要であるため、上記のように修正。) 2-3. At least 3 times of technical seminars, workshops and training are held. 2-4. At least 100 buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. At least 3 retrofit technologies are newly developed. 3-3. At least 2 buildings are planned to apply the developed retrofit schemes. 3-4. At least 2 times of technical seminars, workshops and training are held. 4-1. At least 2 scenarios are proposed. 4-2. A hi-level seminar are held. (総選挙がプロジェクト3年目終盤に発生し、複数回の実施は困難になった。) 4-3. A seminar or workshop is held.	1-1. Project reports 1-2. Project reports 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Agenda and photos of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and other project reports 3-4. Agenda and photos of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Agenda and photos of seminars and workshops

Annex3 All versions of PDM

Activities	Inputs	
	The Japanese Side	Bangladeshi side
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances 1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database 1-1-2 Investigating seismic design code and practice 1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings 1-1-4 Knowledge sharing of results derived from relevant projects 1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database 1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above 2-1 Identifying problems needed to be resolved using results obtained from activity 1-1 and 1-2 2-2 Developing performance evaluation policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects 2-3 Developing formulas for performance evaluation through experiments and analyses of structures 2-4 Determining required performance standard 2-5 Developing technical manuals of the performance evaluation methodologies 2-6 Applying developed methodologies to pilot buildings 2-7 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 3-1 Developing retrofit policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects 3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structures 3-3 Developing technical manuals of retrofit schemes 3-4 Sharing developed retrofit technologies with CNCRP, BSPP and other relevant projects 3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability 4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1 4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2 4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics 4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction 4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios	1. Dispatch of Japanese researchers as experts in specific fields 2. Dispatch of a Japanese Project Coordinator 3. Counterpart Training in Japan 4. Machinery and Equipment	1. Allocation of budget 2. Allocation of suitable personnel 3. Office space with telephone line, internet connection and office furniture in HBRI 4. Space for Equipment and Machinery 5. Provision of necessary data 6. Taking the necessary procedures

Project Design Matrix (PDM)

Project Title: The Project for Technical Development to Upgrade Structural Integrity of Buildings in Densely Populated Urban Areas and its Strategic Implementation towards Resilient Cities

Implementing Agency: Housing and Building Research Institute (HBRI)

Target Group: Researchers and engineers of governmental authorities and universities in Bangladesh

Period of Project: Until July 2022

Project Site: Dhaka, Bangladesh

Model Site:

Version 3

Dated 2020,09,01

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal Structural vulnerability for buildings is reduced and urban safety against earthquake is enhanced in Bangladesh.	1. Knowledge and technologies developed through this project are included in BNBC. 2. Knowledge and technologies developed through this project are incorporated with national plan and policy related to disaster risk reduction.	National building code (BNBC) and national plan related to disaster risk reduction of People's Republic of Bangladesh government	Disaster Risk Reduction is not excluded from development policy and plan of Bangladesh.		
Project Purpose Technologies for enhancing structural resilience of buildings and their effective implementation schemes in Dhaka are proposed through technical capacity and research resources development of relevant institutes.	1. Improvement scheme of performance for buildings is proposed. 2. Improvement scenario of safety index for urban areas is proposed. 3. Knowledge and technologies developed through this project are utilized in other projects. 4. At least 3 documents are submitted for updating BNBC as well as for other earthquake disaster risk reduction programs.	1. Project reports 2. Project reports 3. Other project reports 4. Submitted documents	Authority of revising BNBC is not transferred from government organizations to other organization		
Outputs 1. Building characteristics governing its performance are identified, and research target areas and buildings are determined. 2. Performance evaluation methodology against collapse is established and applied to pilot buildings. 3. Retrofit schemes for buildings with low performance are established and applied to pilot buildings. 4. Efficient and effective urban planning strategies for resilient city against disasters are established and promoted.	1-1. At least 3 areas and their buildings are surveyed. 1-2. A database containing fundamental building properties and seismic performances of at least 100 buildings is established. 1-3. Research target areas and building types are identified. 2-1. At least 3 series of structural experiments are carried out. 2-2. Rapid, 1st level and 2nd level evaluation methods are proposed. 2-3. At least 3 times of technical seminars, workshops and training are held. 2-4. At least 100 buildings' performances are evaluated. 3-1. At least 2 series of structural experiments are carried out. 3-2. At least 3 retrofit technologies are newly developed. 3-3. At least 2 buildings are planned to apply the developed retrofit schemes. 3-4. At least 2 times of technical seminars, workshops and training are held. 4-1. At least 2 scenarios are proposed. 4-2. A hi-level seminar are held. 4-3. A seminar or workshop is held.	1-1. Project reports 1-2. Project reports 1-3. Project reports 2-1. Project reports and published papers 2-2. Technical manuals developed through this project 2-3. Agenda and photos of technical seminars, workshops and trainings 2-4. Project reports 3-1. Project reports and published papers 3-2. Technical manuals developed through this project 3-3. Project reports and other project reports 3-4. Agenda and photos of technical seminars, workshops and trainings 4-1. Project reports and published papers 4-2. Record of discussions of hi-level seminars 4-3. Agenda and photos of seminars and workshops	Another building code is not established as national standard code		

Activities	Inputs		Important Assumption
1-1 Establishing database of buildings and urban areas of Dhaka related to seismic risks and performances 1-1-1 Establishing database of individual buildings related to their performances and risks in Dhaka (e.g. building use, number of stories, construction year, drawings, loads, natural period, etc.) through field surveys and existing database 1-1-2 Investigating seismic design code and practice 1-1-3 Investigating official permit and inspection system as well as construction practice for understanding problems in buildings 1-1-4 Knowledge sharing of results derived from relevant projects 1-1-5 Establishing database of fundamental urban statistics through field surveys and existing database 1-2 Selecting research target areas and buildings in Dhaka through analyzing obtained database and information above 2-1 Identifying problems needed to be resolved using results obtained from activity 1-1 and 1-2 2-2 Developing performance evaluation policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects 2-3 Developing formulas for performance evaluation through experiments and analyses of structures 2-4 Determining required performance standard 2-5 Developing technical manuals of the performance evaluation methodologies 2-6 Applying developed methodologies to pilot buildings 2-7 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 3-1 Developing retrofit policy using available information and data from 2-1, CNCRP, BSPP and other relevant projects 3-2 Developing appropriate retrofit technologies based on experimental results and analyses of structures 3-3 Developing technical manuals of retrofit schemes 3-4 Sharing developed retrofit technologies with CNCRP, BSPP and other relevant projects 3-5 Holding technical seminars, workshops and trainings for researchers, practitioners and other relevant stakeholders 4-1 Developing retrofit scenarios through quantitative evaluation of urban vulnerability 4-1-1 Developing safety evaluation policy for urban areas based on activity 1-1 4-1-2 Developing safety index for urban areas through vulnerability analyses of target areas identified in activity 1-2 4-1-3 Scenario making for efficient and effective upgrading of urban safety considering building characteristics 4-2 Holding hi-level seminar(s) for policy makers to advocate retrofit scenarios for mid-to-long term plan of earthquake disaster risk reduction 4-3 Holding seminars and workshops for researchers, practitioners and other relevant stakeholders to share retrofit scenarios	The Japanese Side	Bangladeshi side	
	1. Dispatch of Japanese researchers as experts in specific fields 2. Dispatch of a Japanese Project Coordinator 3. Counterpart Training in Japan 4. Machinery and Equipment	1. Allocation of budget 2. Allocation of suitable personnel 3. Office space with telephone line, internet connection and office furniture in HBRI 4. Space for Equipment and Machinery 5. Provision of necessary data 6. Taking the necessary procedures	Other projects targeting building evaluation and retrofitting are not cancelled
			Pre-Conditions Events which restrict activities of Japan side staffs in Dhaka do not repeatedly happen.
			<Issues and countermeasures>

