Outline of Retrofitting

“Project for Capacity Development on Natural Disaster-Resistant Techniques of Construction and Retrofitting for Public Buildings in the People’s Republic of Bangladesh” (CNCRP), and
“Project on Promoting Building Safety for Disaster Risk Reduction” (BSPP)
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Buildings in developing countries are likely to be vulnerable against earthquakes. Once large earthquake occurs, tremendous damage to buildings and human casualties have been often are provided. Bangladesh cannot be outside. In Bangladesh, vast amount of vulnerable buildings have been built and now continuing construction. In order to reduce this situation even though a little bit, the technical cooperation project namely CNCRP started 2011. This leaflet is drafted intending to inform this effort of promotion of technical improvement to Bangladesh citizens as far as possible.

January 2017, PWD-JICA Project Team
1. Purpose of Retrofitting

“Earthquakes don’t kill people, buildings do.” It is the famous saying. Unfortunately, this situation can apply for the buildings in Bangladesh as well. The buildings should supply the sense of the security to nation. However, Rana plaza disaster occurred in April in 2013 without any Earthquake. And it was happened by the fact of not compliant with rules of Bangladesh.

After Rana Plaza accident, CNCRP and BSPP have been supporting the safety for Public and Garment factory buildings. Through the experiences, we can say around 2/3 of the existing buildings might need retrofitting or rebuilding in compliant with BNBC which became effective since 2008.
Earthquake Hazard & Risk Assessment was carried by CDMP, which means the Government of Bangladesh had started the preparation for future earthquakes. And the Hazards in Dhaka caused by a moderate earthquake with seismic intensity VIII were estimated as the following;

<table>
<thead>
<tr>
<th>Damage in Dhaka</th>
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<tbody>
<tr>
<td><strong>Building collapse</strong>: 72,000 buildings</td>
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<tr>
<td><strong>Building damage</strong>: 158,000 buildings</td>
</tr>
<tr>
<td><strong>Estimated dead peoples</strong>: 88,000</td>
</tr>
<tr>
<td><strong>Financial loss</strong>: 12.7 Billion US dollars, 1.0 Trillion Taka (13.4% per GDP of Bangladesh 2009)</td>
</tr>
</tbody>
</table>

Don’t you think is it correct? “We don't do anything, although huge damage appears when an earthquake occurs.” Again to say that Buildings should provide sense of security.

Kathmandu earthquake in April 2015

CNCRP, “Project for Capacity Development on Natural Disaster-Resistant Techniques of Construction and Retrofitting for Public Buildings in the People’s Republic of Bangladesh” was commenced in 2011 to assist the technique dissemination in Bangladesh that the buildings should supply the sense of the security.

Methods for measures for existing buildings are demolish, relocate, rebuild and retrofit, and for new buildings compliant with BNBC. And CNCRP and BSPP have focused retrofitting including Assessment of existing building, Retrofitting Design and Construction Supervision for following appropriate design.
2. Retrofitting Procedure for Existing Buildings.

Seismic retrofitting is different from new building construction fundamentally targeting existing building. Therefore its process in the following figure mainly investigation and assessment of target building are the key processes. And the other highlight is construction supervision, because even design is excellent construction does not follow it is the fundamental trigger for vulnerable buildings in Bangladesh. Systemize the improvement is one of the keys for improvement. Of course seismic design should be disseminate in Bangladesh for seismic resistant structure.

Retrofitting flow is the following, assessment portion is enlarged the later figure;
<Retrofitting Construction Works>
Assessment portions in the Retrofitting Works are carried out the following flow:

1. **Selection Building with Drawings, Geographical distribution**
   - Simplified Evaluation (SE) by Design drawings
     - On site visual observation
     - Weight (column size, concrete strength)
   - BNBC load investigation
   - Deviation Survey
     - On site observation (setback, stairs, etc.)
   - Bearable to Own weight
   - Unbearable to Own weight
   - Demolish & Rebuild/Relocate Or Reduce live load

2. **First Level Inspection**
   - Sufficient earthquake proof (BNBC)
   - Advanced Simplified Evaluation (ASE)
     - On site observation (rebar arrangement, rebound tests), Base shear
   - Demolish & Rebuild/Relocate Or Change occupancy
   - All right, as it is

3. **Second Level Inspection (DEA)**
   - Sufficient earthquake proof (BNBC)
   - As-built drawings
     - On site observation & test (Core sampling & compression test)
   - Demolish & Rebuild/Relocate Or Reduce live load
   - Low earthquake proof
   - Unbearable to Own weight
   - Low earthquake proof
   - Bearable to Own weight
   - As - built drawings
     - On site observation & test (Core sampling & compression test)
   - Reinforcement Arrangement & Strength
     - On site observation & Detailed Inspection calculation
   - Demolish & Rebuild/Relocate Or Reduce live load
   - All right, as it is

4. **< Basic Assessment >**
   - Deformation Survey
     - On site observation (setback, stairs, etc.)
   - Insufficient earthquake proof
   - Sufficient earthquake proof (BNBC)

5. **< Detail Assessment >**
   - Demolish & Rebuild/Relocate Or Reduce live load
   - Low earthquake proof
   - Bearable to Own weight
   - Unbearable to Own weight
   - Sufficient earthquake proof (BNBC)

6. **< Design & Construction >**

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- **BNBC (Building with Occupancy Based on National Consensus)**
- **DEA (Deformation Evaluation Assessment)**
- **ASE (Advanced Simplified Evaluation)**
- **SE (Simplified Evaluation)**
2-1. Assessment
2-1-1. Basic Assessment

CNCRP established building inventory of Dhaka was prepared to know the conditions of existing buildings in Dhaka. According to this building inventory data, we can easily understand the numbers of the building per construction ages, the building structures such as RC frame, number of stories etc. These are the base data to perform the Basic Assessment in the retrofitting for the existing buildings.

Sample of inventory
**Deviation Survey:**

Deviation is difference between Permitted drawing and as-built situation. Deviation Survey is implemented by visual and measured by ruler.

If surveyed Deviation violates BNBC, Building Rules and regulations, it becomes illegal. Therefore, without renovation to satisfy the regulations, the building cannot be passed the building construction permission.
2-1-2. Simplified Evaluation (SE)

The design of existing building can be evaluated by Simplified Evaluation (SE) method whether it is satisfied BNBC requirement or not most simply. This evaluation needs architectural and structure drawings. In other words, SE is suitable for simple design checking based on BNBC.

2-1-3. Advance Simplified Evaluation (ASE)

Advance Simplified Evaluation (ASE) method needs not only architectural and structure drawings but also site characteristics by non-destructive methods such as rebar arrangement, estimated concrete strength by rebound test. ASE estimates whether it has BNBC functionalities or not. In other words, this evaluation is suitable for design and construction quality as simplified checking based on BNBC.
2-1-4. Building Survey

Detail Assessment is performed based on Building Survey results. It is including As-Built drawing, concrete core sample and compression test. Rebar strength test etc. For getting actual Bangladesh building characteristics, structural test and concrete test are performed.

Concrete test results show lower values comparing with BNBC requirement

Structural test to know the building behavior during the BNBC load
2-1-5. Detail Assessment

To know the actual conditions of the target buildings, Detail Assessment of existing buildings is performed for more accurate Retrofit Design based on Building Survey.

"Is" is the index to show the strength / vulnerability of buildings. If “Is” is larger, the building has an enough resistance against earthquake. In Japan, “0.6” is adopted as index “Is”. Comparing the seismic situation between Japan and Bangladesh, “0.3” can be used in Bangladesh. It means the buildings strength of Bangladesh is required almost half of the Japanese ones. The above graph is a sample of the survey in Dhaka, the situation of this building has a half of Bangladesh standard, and a quarter of Japanese standard. “Is” method is based on Bangladesh characteristics.

Concrete core sampling (left) and rebar detection (right)
2-1-6. Retrofitting Design

Retrofitting Design starts from forming the total plan (Basic Design) considering owner’s and others requirements. Then, to get enough strength as a building, seismic assessment results are applied. As a solution, retrofitting methods and their effectiveness, cost and materials procurement condition etc. are investigated (Detail Design).

Finally, a design drawing of retrofitting based on the seismic assessment shall be prepared, and Cost Estimation will assist decision of retrofitting and budget allocation.

Sample of retrofitting

During Design stage, construction cost is also estimated for retrofitting. Through the experience of CNCRP, retrofitting cost is usually 30-40% comparing with new building construction. For retrofitting existing building, it is important to take the current building situation and working activities of people into consideration before and during construction. It is recommended to conduct the building assessment at least as soon as possible.
2-1-7. Construction

To realize sufficient strength as a building, compliant with BNBC, we shall perform the construction works based on Retrofitting Design. To keep quality of construction, CNCRP and BSPP developed the quality control method for Bangladesh. Daily Report and inspection are typical ones.
<table>
<thead>
<tr>
<th>Safety Drills</th>
<th>Site Instruction</th>
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<tbody>
<tr>
<td>Foundation work</td>
<td>Column Jacketing</td>
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<tr>
<td>Column Jacketing</td>
<td>Steel Bracing</td>
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<tr>
<td>Steel Bracing</td>
<td>Steel Bracing</td>
</tr>
<tr>
<td>Shear wall</td>
<td>Shear wall</td>
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</table>
3. Retrofitting Supporting Manuals by CNCRP/BSPP

Retrofitting is a new technology for Bangladesh and written in BNBC only a little. CNCRP prepared Retrofitting supporting manuals.

3 main Retrofitting factors are “Seismic Assessment/Evaluation”, “Seismic Retrofit Design” and “Construction Supervision”. Other than that new building design, quality control and non-seismic issues are covered by 6 manuals and guidelines.

To make strengthen city against natural disaster, we must follow BNBC when we construct new buildings. There are thousands of vulnerable buildings in Bangladesh. And many of them should be demolish, rebuild, relocate or retrofit by Bangladesh building Engineers.

More than 3,000 new buildings have been newly constructed every year in Dhaka (RAJUK) that should be compliant with BNBC, and the above Manuals can support effectively.

We need to take a license to work in society. The buildings also need the license.

These Manuals are uploaded PWD’s web page, and will be revised during BSPP.
4. Plan for the future
4-1. Secure Important Buildings

Even in the disasters, the fire-department must keep the normal functions.
CNCRP conducted the retrofit work for one of the old fire stations as a pilot project.
New JICA project will succeed the activities and will implement demolish/rebuild old fire stations, and retrofit and newly build fire stations in Dhaka.

<table>
<thead>
<tr>
<th>before</th>
<th>after</th>
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<tbody>
<tr>
<td><img src="image1" alt="Before Retrofit" /></td>
<td><img src="image2" alt="After Retrofit" /></td>
</tr>
<tr>
<td><img src="image3" alt="Before Inspection" /></td>
<td><img src="image4" alt="After Inspection" /></td>
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<tr>
<td><img src="image5" alt="Before Training" /></td>
<td><img src="image6" alt="After Training" /></td>
</tr>
<tr>
<td><img src="image7" alt="Before Evacuation" /></td>
<td><img src="image8" alt="After Evacuation" /></td>
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</tbody>
</table>

Activities of FSCD
4-2. Training

The dissemination of the technology regarding to retrofitting works, is important to make a resistant city against the natural disasters in Bangladesh. More than 60 engineers of Bangladesh learn the retrofitting technology in CNCRP project every year. Not only engineers, but people including building owners should raise awareness on disasters, and government officers should get knowledge on retrofitting through trainings and lectures etc.

<Training Material & Conditions of Training>

Text  CD of Seismic Evaluation  Opening ceremony  Closing ceremony

Conditions of Training

<Certificate Awarding Ceremony>
4-3. Future Hypothetical Calculation

Regarding to Public building, a new construction cost depends on the conditions. Then we can't estimate exact price without the detail design. However, considering PWD’s experience, the general cost is approximately TK 2,000 per square feet. It is rough estimation. On the other hand, the cost of retrofitting price is ongoing to estimate. In our few experience, the cost is 30-40% of the new construction building.

Can we consider the following issue?

- **Loss of One trillion Taka caused by CDMP Earthquake**
- **77,700 sft.**
  average of floor area of RCC buildings
- **62,160,000 Taka**
  roughly estimate retrofitting cost
- **16,000**
  damaged buildings

If we have one trillion Taka, we can retrofit 16,000 buildings
4-4. Sustainable to Future

Regarding the role of school, it is very important for save children from disasters. Children will teach parents and will grow to adults and will load the society. Therefore, retrofitting school buildings and conduct evacuation training in the school are also highly required in Bangladesh to secure children, as well as to save the future of Bangladesh.

<Building survey>

Survey location of Coring and so on  Drilling survey in school

Evaluation results compare with BNBC 1993

1. Though stone chips were used in concrete, low concrete strength have been found from core test result.
2. Column size is smaller compared to the long span.
3. Existing columns capacities are inadequate according to BNBC code. Even some of the column doesn’t meet the requirement of minimum reinforcement as per code.
4. Columns are not satisfactory even for vertical load only as per BNBC.

To be an evacuation center, the activities by students have provided an opportunity for the residents to think about DRR (Disaster Risk Reduction). After town watching, the students developed hazard map for evacuation drills. The DDR of school is necessary to promote a relationship between education of disaster management and building safety.
Unfortunately, Rana Plaza collapsed in April 2013 that caused a huge number of victims by the building collapse. The survey after the collapse, experts said, “The building was not compliant with BNBC (Bangladesh National Building Code).”

There are many houses and buildings in Bangladesh. However, many of them are currently vulnerable and not compliant with BNBC, unfortunately.

You can have a chance to live in a building, to construct your house. Surely you will live and construct your house compliant with BNBC, we believe.