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# Research Findings on Strengthening Structural Members beyond Bangladesh National Building Code (BNBC) for Protection against Earthquakes

Recently University of Asia Pacific and The Daily Star, with the support of Building Technology and Ideas (BTI), organised a roundtable on "Research Findings on Strengthening Structural Members beyond Bangladesh National Building Code (BNBC) for Protection against Earthquakes". Here we publish a summary of the discussions -- Editor

**Mahfuz Anam, Editor & Publisher, The Daily Star**

It will be suicidal to ignore the threat of earthquake. It requires long term preparation to avoid such disasters. We need to ensure that all our buildings and infrastructures are earthquake resistant. Building codes should be strictly followed in the construction of new buildings. At the same time we need to find effective solutions to protect our existing structures.

**Prof. Jamilur Reza Choudhury, Eminent Civil Engineer and currently, Vice Chancellor, University of Asia Pacific**

When we were students, earthquake was not considered as a factor in building design. There was a prevailing belief that in Bangladesh we had nothing to be worried about earthquake. Now, we know the threat is real. So we need to seriously think about it. Today's discussion will focus on the issue of finding effective solutions to make our buildings earthquake resistant.

In our apartment buildings we see the common design of ground floor parking with all sides open. There are no concrete walls or infill between the columns. It is known as soft-story. It creates hinges during lateral force in the building that makes it vulnerable to earthquake. We have conducted a research to find engineering solutions to avoid hinges in columns. There are various methods. Here we have used steel plate jacket which BTI also tried as sample in their prototype building.

**F.R Khan, Managing Director, BTI**

We have commissioned this research as a part of our corporate responsibility. We tried to find the engineering solution that will help improve our existing building techniques so that we can significantly reduce the risk of earthquake related disasters. The concept of this research is not to panic for earthquake, rather face it by engineering solutions.

**Iftekhar Anam, Professor, University of Asia Pacific**

The prototype building we used for research was a residential building over 5 kathas of land with gross construction area around 20,000 sq. ft. The floor area was 1937 sq.ft. It was a 102 ft (10 storied) building on typical Dhaka soil. Its concrete strength and steel strength were 3~3.5 ksi and 40~72 ksi, respectively. We considered earthquakes of intensity level 7 for testing the building. BNBC also suggests the same for Dhaka region.

Our research shows that the structure survives only up to 7 intensity level for the more conservative modeling scheme having 5% damping and Infill Struts. This almost matches to the real life design for Dhaka as per BNBC 1993.

The most significant observation from these results is the highly underestimated values from the Linear Static Analysis (LSA). Since this method is widely used, these results are quite significant and somewhat alarming. Among the other methods, results from the Pushover Analysis and Non-Linear Response Spectra Analysis are the closest to reality.

The ground floors of buildings with mere columns (without brick works), known as soft-story, remain particularly vulnerable. This is susceptible to enormous active loads of an earthquake effect. But it can still survive with a simple jacketing of steel plate. Its earthquake resistance capacity grows with the designed use of jacketing. It is our observation that after jacketing the prototype building can survive earthquake of 8 intensity level. BTI has already made some practical implementation of this technique.

**F.R Khan**

Jacketing is a significant addition to our effort to make the buildings earthquake resistant. After jacketing, we cast a model. During construction of the tie of a column we will weld the plate with the tie so that it becomes a part of the column. Here we use a plate after a gap of six inch. We do it from both side and cover the column with jacket. Then we do casting over this structure. The finished surface looks like any other column with some stripes. Architects can decorate these stripes. In BTI, we will visualize these stripes with black duco paint so that people can notice this building is earthquake resistant.



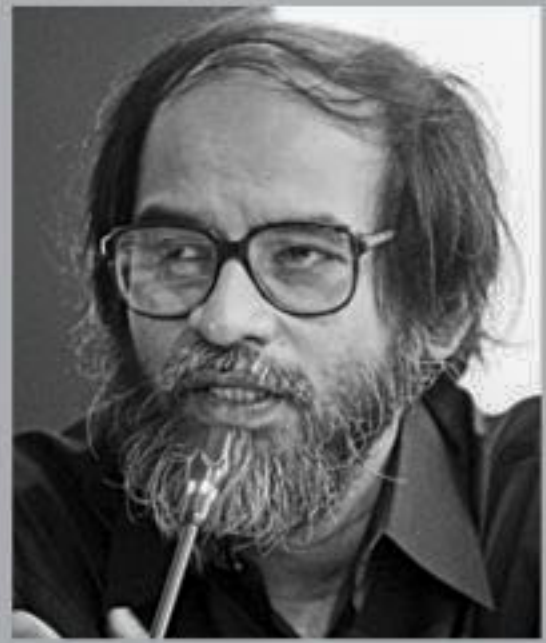
## PARTICIPANTS



Jamilur Reza Choudhury



F.R Khan



Iftekhar Anam



Ali Akbar Mollick



Md Kabir Ahmed Bhuiyan



Saiful Amin



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Abu Sayeed M Ahmed



Rudba Choudhury

**Dr Ali Akbar Mollick, Freelance Consultant**

Globally, weak beam-strong column mechanism is considered to be an effective earth-quake solution. I did not see any mention of this technique in this research. It needs to be incorporated.

The ground floor with bare columns, known as "soft-story", would probably be the foremost reason for building collapse. We can easily solve the soft-story problem by strengthening the structure of ground floor or car parking floor with jacketing. Alongside in-built steel jacketing of columns, wing-walls on both sides of columns would be the most effective measure to prevent the ground floor collapse. It is also a cost effective solution.

Our media often confuses intensity with magnitude. We should avoid this mistake. Magnitude measures the amount of seismic energy released by an earthquake while the severity of earthquake shaking is assessed by intensity.

**Md Kabir Ahmed Bhuiyan, President, Institution of Engineers, Bangladesh**

I think jacketing with steel plate is an effective solution to strengthen soft-story. It will significantly reduce the risk of building collapse. We should widely disseminate this finding of the research.

We completed the retrofitting project of PWD in 2015. Many old buildings were retrofitted to make them earthquake resilient. We have also prepared five guidebooks on retrofitting. We will be able to implement these techniques in our new buildings.

**F. R Khan**

In our building there is also an open car parking floor. We have retrofitted the columns using jacketing method. Here you need to tie up a steel cage with the existing column. It does not cost much. If you do it during construction of the

buildings. It costs roughly 600Tk/sq feet for the whole retrofitting process.

In this research we have seen detailing of square shaped building. We should also study on L-shaped buildings. During retrofitting we need to consider improvement of the soil. It is missing in this research.

**Md Nazmul Islam, Professor, Civil Engineering Department, North South University**

Architectural and structural features of a building should be carefully chosen to reduce the avoidable casualties. The research has considered non-structural (Brick Fill) elements which is very important for structural analysis. I think there are some other non-structural elements such as furniture, utility pipes and so on that need to be considered seriously. These non-structural elements create extra pressure during an earthquake.

**Md Sohel Rahman, Executive Engineer (Design), Public Works Department**

In the CNCRP project (Capacity Development on Natural Disaster Resistant Techniques of Construction and Retrofitting for Public Buildings) we systematically retrofitted various construction works. We have also prepared a guideline on retrofitting. In our next project (CNCRP-2) we will emphasise on improving these manuals and disseminate the knowledge to general people.

**Abu Sayeed M Ahmed, President, Institute of Architects Bangladesh**

I appreciate this joint effort of BTI and University of Asia Pacific. We need more such researches where professional problems will be solved with the skills of academicians.

I want to limit my discussion within BNBC. It requires structural designer and geo-technical engineer for construction of a building. There is a severe dearth of practicing structural and foundation engineers. In our country we see three types of buildings: professional building, non-professional building and a mix of professional and non-professional building. The first type of building is quite safe. In Bangladesh, there are less than 5 percent buildings that are designed by professionals. The second one is the most vulnerable type. And the third type of building is also risky because here one or two floors are designed by professional designers. Later the owner adds more floors without consulting with a professional designer. Of the 4,500 building plans that Rajuk approve every year in the capital, only 1,000 are designed by recognised architects. There is no mechanism to ensure the quality of materials and compliance with the approved design during construction. We need to ensure that all the buildings are designed by professionals. Enforcement of building laws and BNBC is also a must to ensure buildings' safety.

**Rudba Choudhury, Architect, BTI**

I think the 2008's guideline of constructing fire exits such as staircase, lift, lobby is not adequate. It needs to be formulated in a way so that in case of an earthquake or fire, residents can easily get out of the building. In Japan, there is a corridor around every building so that people do not need to come all the way to the main lobby for emergency exit. We should incorporate such provision of alternative exit in our buildings.

**Jamilur Reza Choudhury**

Sometimes we see the design is OK but developers do not follow the design during construction of the building. This is a dangerous practice. We should strictly follow the design. There is a big gap in our regulation process. We do not have any authority that can ensure that a building is built as per the design. There is a proposal to divide the city in different zones and appoint a consulting firm for each area. It is yet to be finalized.

We need a separate discussion on how we can properly implement BNBC. There is also a court order which asks for a separate body to regulate proper implementation of BNBC. In practice we have no such body.

A sense of complacency about earthquake prevails in our society. We are busy with everyday issues. We need to come out of it and think seriously about constructing earthquake resilient buildings. This is a beginning of a new era in our country for research by Industry-Academia interaction, which is practiced in the developed world.

building it will cost 20tk/sq.feet for a ten story building with 2000 sq. feet area per floor. That means total 3-4 lakh taka. In case of an existing building it will cost 30-35Tk/sq.feet. I think it is quite affordable.

**Saiful Amin, Professor, Civil Engineering Department, BUET**

After retrofitting a building we reanalyze the structure. The load path follows the order of slab, beam, column and finally the foundation of the building. So if we strengthen a particular section, logically the load hits the weaker spot and makes it vulnerable. So we need to ensure that during retrofitting, stiffness of all the parts of the building should be optimized equally.

Retrofitting requires higher skill than simple designing. That's why we need to think about whether there should be a separate certification system for retrofitting.

**Sk. Sekender Ali, Professor, Civil Engineering Department, BUET**

I appreciate this research effort. It has included infill action. Without infill we cannot get a correct joint detailing. We have to do more studies on it. I would request the researchers to conduct study on the technique of infill with openings that means with the provision of windows and doors. The distance between grade beam and foundation sometimes creates problem. We also need to look into this issue seriously.

**Mehedi Ahmed Ansary, Professor, Civil Engineering Department, BUET**

One lakh out of four-lakh housing units and a thousand of 3,500 factory buildings in the capital are vulnerable as per preliminary assessment. In the last one year we have retrofitted 50 factory buildings. Now we are reviewing details of these