Appropriate building technology for Bangladesh

How prepared are we for a major earthquake?

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Bangladesh, too, is within a very active seismic zone. Lying along the Burma-Assam tectonic plate extending from the foothills of the Himalayas to the Bay of Bengal, the country is extremely vulnerable to a moderate to severe earthquake. Dr Kerry E. Sieh, a renowned seismologist at the California Institute of Technology, maintains that the real question is not if but when, where and how big. About earthquake this is probably the right thing to know. During the last 150 years at least seven major earthquakes (7 or above on the Richter scale) jolted Bangladesh and its adjoining area. Population was small then, brick-built houses were rare, and as such death toll was small...The last major earthquake that caused extensive devastation in the region now Bangladesh was the Great Earthquake of 1897. A major earthquake is only an awaited reality in Bangladesh.

BANGLADESH, with a large number of unplanned and unspecified tall and medium-height buildings in urban areas, is apprehensive of a disaster, should an earthquake hit. As we all know, earthquake is a natural phenomenon caused by sudden slippage of rock on a fault line or transgression of two fault lines. About 20,000 earthquakes take place in the United States every year of which about 99.9 per cent is not perceivable.

Gujarat in India experienced a severe earthquake on January 26 this year and since then has experienced a number of smaller jolts. It is not even weeks that El Salvador has experienced a number of big and small earthquakes having thousands of casualties. In recent past we have seen the spine-chilling devastation of Taiwan, Turkey, Greece, Los Angeles, Kobe, which claimed thousands of lives and billions of dollars of property.

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Who knows when such a disaster will strike Bangladesh? Are we going to react only then? Is it that we will act after hundreds of thousands of people will perish in a major earthquake?

After every disaster we discuss, hold workshops and seminars. We undertake threadbare discussions on the origin of the problem and try and find out possible solutions and plans for action. Unfortunately, we do not act. Since the Gujarat tragedy we had a number of seminars and symposia but failed again to come up with some concrete action plan to minimise earthquake damage and earnestly work towards it.

If Bangladesh were the only country that experiences earthquake, such analysis and analytical dissection towards finding a solution would have been appropriate. To be honest, there is not much to analyse to find out a solution. Earthquake-prone developed countries have already devised engineering ways, construction methods and materials to safeguard their own population and billions of dollars of properties and infrastructure. It will be futile on our part to reinvent the already known.

The best thing that we can do is to remain prepared for the disaster brought about by a major earthquake. The preparation has two distinct elements, requiring a two-way action plan. The first and obvious is the preparedness by the government agencies concerned supported by voluntary organisations for post-disaster rescue and sustenance of victims and rehabilitation of essential services. A rigorous and co-ordinated training of various agencies and periodic monitoring of the preparedness are essential. The other preparatory action needed is adoption of a safe building practice that will minimise the severity of damage due to earthquake.

This second aspect of preparedness, i.e. adoption of a safer building practice, is the subject matter of this discourse. It should be realised by all that most fatalities in an earthquake are caused by collapse of buildings, more particularly by falling of debris. "Earthquakes do not kill people, but seismically deficient constructions do. Californian earthquake of January 1992 measured 8 on the Richter scale and it destroyed $30 billion worth of property. Yet only 54 people died when the earthquake struck in the early hours of the morning. That was because most of the population there was sleeping indoors in housing that adhered to seismic parameters. In Latur, India, by contrast, the damage to property was far less, but 10,000 people died because they happened to be sleeping in housing that was devoid on any seismic consideration," said Dr Harsh K Gupta, director of the National Geological Research Institute, Hydrabad. It is an established fact that brittle buildings and those built with brittle materials like non-reinforced brick masonry fall in a heap and cause most deaths when the ground shakes. Buildings should, therefore, be made ductile so that they can accommodate a good deal of ground motion without collapse. Even when ductile buildings collapse, they give adequate warning by swaying and yielding and they do not fall down in a heap. As a result, fatality is minimised by the fact that people either have time to escape or are trapped in cavities of the collapsed structure.

Severe and frequent earthquake prone country Japan copes regularly with earthquake. They have developed design method that allows construction of hundred or so storey buildings. In quake-prone California appropriate design and construction method allowed them to build high-rise to medium-height residential, commercial and other utility buildings. What we should do is to investigate, analyse all these methods of design and construction materials and adopt those that are appropriate to our socio-economic setting. We may tailor such designs and materials to suit our needs to make our structures safer against earthquake.

In Bangladesh we engineers, architects, academics, government departments responsible for building safety etc. have not yet taken much of action to come out with a solution towards a safer building construction. Most buildings are built here with non-reinforced solid burnt clay bricks as either load-bearing element or cladding in a concrete framework. If (God forbid) a major earthquake strikes Bangladesh today, experts say more than 80 per cent tall and medium-height buildings will collapse. Because bricks cannot withstand lateral thrust of earthquake, people get buried or brutalised by falling bricks and get killed.

Engineers are aware of the possibility of earthquake in the country and usually consider earthquake load in their design undertakings. The Bangladesh National Building Code 1993 divides Bangladesh into three zones depending on three different intensities of earthquake possibility. It stipulates, with clear elaboration, design methods showing reinforcement with grouting through vertical holes across hollow blocks/bricks. To develop appropriate methods following our Building Code and practices in earthquake prone developed countries we, at Concord, tried to acquire knowledge and broaden our horizon of technical know-how. To do that our engineers went to California, Australia, Thailand, Singapore, and Indonesia. Experts from these countries also came to train our technical staff. Bangladeshi experts living abroad came on invitation to exchange ideas, had meetings, and held workshops with local experts. We have acquired membership of many professional bodies in US and regularly receive their publications. All such activities have helped us equip ourselves to serve the nation better, to offer houses safer against earthquake disaster.

This we did for the reason that we consider ourselves responsible builders/constructors. We collected, collated, and evaluated solutions available in earthquake prone countries like Japan, West Coast of USA, Indonesia, and Australia etc. For the last four to five years we evaluated such solutions for their effectiveness, relative cost and appropriateness under Bangladesh setting.

Towards reducing or eliminating death and destruction as an aftermath of a severe earthquake we have analysed and compared various construction methods and materials used in other earthquake prone countries and have adopted those that are most appropriate for our socio-economic setting. We have analysed systems used in Japan and concluded that those are inappropriate and costly for us. The same is the case with methods used in California. Fortunately, methods and materials used in Florida, Las Vegas and Brazil are very appropriate and within our economic reach. A comparative analysis of performance will clarify our assertion.

Effect of an earthquake on a building basically depends on distance of structure from the epicentre of earthquake; soil type; total weight of structure; and structural type and configuration.

We cannot choose where an earthquake might hit, so this factor is beyond our control. It is practically not possible or cost-effective to try and change soil type. But designers and builders can control to a great extent the other two factors namely weight and structure configuration.

Our continued effort has brought us to a stage when we can offer the nation materials and design method that will make structures safer in the event of an earthquake at an affordable cost (cheaper when compared with conventional construction). Our proposal is that conventional frame structures should incorporate hollow concrete blocks in place of solid bricks. Such hollow blocks may be reinforced with grouting and integrated with the frame to take lateral thrust due to an earthquake. Such walls will also aid the frame elements in taking vertical loads. In a modern apartment complex, it is the open ground floor car park area mostly where the columns get twisted in case of an earthquake. It is possible to keep parking intact and at the same time provide enough block walls with reinforcement and grouting so that adequate shear walls become available to withstand horizontal thrust. Such modification should be taken up soon in all such buildings already built or is in the process of building.

It is almost three years now that we have made available hollow concrete blocks and technical know how for the people of this country because this is the best available material in the face of an earthquake.

In Bangladesh we use solid bricks as in-fill materials between columns. It exerts unnecessary load on the frame without contributing to its strength making it vulnerable during an earthquake. The Bangladesh National Building Code 1993 advocates the use of hollow bricks/hollow concrete blocks so that reinforcements can be used for making structures safer against seismic thrust. Unfortunately nobody paid any attention and buildings made in bricks continue to be built unabated. At a recent workshop at the Institution of Engineers experts categorically said "no" to solid brick in use in Bangladesh. They advised use of lightweight hollow bricks/blocks so that total load of the structure could be reduced and reinforcement with grouting could be conveniently used. However, holes in the hollow bricks available in Bangladesh make it impossible to place all required reinforcing steel and grouting to resist earthquake forces. Moreover, clay bricks being inherently brittle, structures built in such hollow bricks are not ductile enough to withstand earthquake tremor.

For low to medium rise new construction, Reinforced Concrete Block Masonry (RCBM) is the ideal material to withstand earthquake tremor. A recent design development, this material has been successfully applied in the USA and Brazil and has a satisfactory record of performance. The entire structure without column and beam are made in load bearing blocks reinforced and grouted at designated areas so that adequate shear walls become available, giving the structure the much-desired ductility. Excalibur Hotel in Las Vegas, a 28-storey structure constructed in load bearing concrete blocks, withstood very successfully a violent earthquake when most other buildings around collapsed. Use of 200 to 300mm hollow concrete load-bearing blocks used in Las Vegas or Florida appeared rather costly to the Brazilians. With a weak economy Brazil eventually developed an appropriate method of design using RCBM, which enabled them to construct a 21-storey building in Sao Paolo with 150mm hollow blocks but in a configuration that protects individual building elements against earthquake force coming from any of the four directions. This is known as cellular construction. Advantage of this design system is derived from use of smaller hollow blocks and configuration of tall buildings. This is probably the best and most appropriate building system for Bangladesh - safer against earthquake, cheaper when compared with conventional system of construction.

Masonry construction has a well-documented history of successful performance against the test of time. Its beauty, versatility and economy are its main attractions. It is also intermingled with our architectural tradition and construction culture. However, conventional non-reinforced masonry is a brittle form of construction. It has been recorded that no brick masonry building escaped unhurt during the 1897 Great Earthquake in a region that totally engulfs the territory now Bangladesh. We should take lesson from history and improve our construction method to make this beautiful, versatile and durable masonry construction more ductile and safer in earthquake. Through a century of experience, research and development we have the technology today to build masonry structures safer than those our knowledge permitted us to build one hundred years ago. We strongly believe that RCBM with proper hollow concrete blocks used in a judiciously planned structural system holds the answer to a safer and earthquake resistant construction culture and building practice.

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The Excalibur Hotel in Las Vegas, Nevada at 28 stories high, is the tallest load-bearing masonry structure in the United States. The building is designed to resist the dynamic loads imposed by seismic activity and severe winds. The hotel is actually two L-shaped buildings, each consisting of two wings at right angles to each other.
The structure is supported by interior load bearing concrete masonry walls. A typical interior party wall is 12 inches (290mm) thick for the first five floors. Above that level, the wall thickness eight inches (180mm). The interior corridor walls are the same thickness. Some walls are eight inches (190mm) thick for the entire height of the building. The party walls are typically about 13 feet (4.1 metres) apart. The floors are "lift slabs" that were cast on the ground and placed with a crane. Party wall length is 27 (8.3 metres) to 34 feet (10.4 metres). The six inches (140mm) exterior walls are not load-bearing. The walls are, however, lightly reinforced to comply with the seismic design requirements.

Many of the load-bearing masonry buildings currently being built in the Sao Paulo, Brazil area are a result of the load-bearing structures constructed in the San Diego, California area in the 1960s, 70s and 80s. Although the structural design procedures used in the United States were adopted, they are continuously updated. Structural requirements and differences in the relationship between labour and material costs make the resulting buildings in Brazil somewhat different from those in the United States.
A typical load-bearing apartment building in Sao Paulo is 12 to 21 stories tall. This is the most common type of housing for city residents. It is encouraging that many buildings are load-bearing masonry, and the numbers are increasing annually.
The structure of the buildings is very cellular, with both the interior and exterior walls carrying the load. The load-bearing walls on these buildings up to 21 stories are six inches (140mm) thick to reduce weight and cost. The non-load-bearing walls are also six inches thick, but some of the concrete masonry units have 5/8 inch (16mm) thick face shells and webs. The combination of relatively light masonry structure and many load-bearing walls permit the bearing walls to be six inches (140mm) thick.
The most common floor system is a two-way cast-in-place concrete slab bearing on all four walls. The floor is cast continuously with the bond beam at the top of the wall and measures four and a half (115mm) to six inches (150mm) thick.

We are not yet prepared to face an earthquake

Jamilur Reza Choudhury, Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET) in a recent interview threw light on many aspects of earthquake in Bangladesh. Rahela Rabbani of Ecofile, took the interview. Following are the excerpts:

Risk of earthquake in Bangladesh

Whether the rate of earthquake in Bangladesh has increased or not is difficult to ascertain. But be it noted that the south-east region of the country experienced a series of medium tremors in recent years. The tremor that struck Maheskhali, occurred after an interval of many years. In general the quakes originate from outside of our country Myanmar. The tremor that was felt in Sylhet ten years ago, originated in Meghalaya. I think we are constantly under threat. Certain 'faults' when active may lead to tremors.

To assess the probable risks of quakes a map of seismic zones of a country is prepared. Bangladesh has such maps which were last modified in 1993 when National Building Codes were prepared. A team from BUET is now using new data to update the Zoning Map.

Bangladesh and other quake prone countries

Greater Mymensingh, Sylhet and Rangpur regions have the greatest risk of earthquake. But our experience cannot compare with that in other countries. The worst quake we had in a few centuries is that of June 12, 1857. Originating from Shillong it caused extensive damage. The quakes of 1885 and 1918 measured about 7.0 in the Richter scale. Quakes of such magnitude may strike any time again.

Extent of damage

The major cause of damage in our country is our unpreparedness. Preparedness may be of three types pre-concurrent and post-quake preparedness. The first one is about what we should do to reduce impact of earthquake. Second one refers to imperatives during earthquakes. The third one is on how to meet the aftermath. The first one requires that we include anti-quake measures during construction of houses, roads, bridges, infrastructure. The Bangladesh National Building Code (BNBC) sets down simple guidelines. But our constructions in general are 'non-engineered' no significant inputs from professional engineers. The codes are written in simple language so that laymen also understand and can use them. Following them we can build quake-resistant buildings. The extra cost will not come to more than 2-3 percent. But the future cost it will save is enormous. Mass conscientization is required. Disaster Management Bureau and a few NGOs have started campaigning. During earthquake, shelter within a building or some part of a building is relatively safe. Such knowledge should be disseminated in schools and colleges also.

The third phase of preparedness is about how best to use essential services Civil Defence, Fire Service etc for rescue. This phase requires training and technical support which unfortunately is lacking in Bangladesh now. Adopting appropriate measure may reduce damage to a minimum. Emergency medical care training should also be imparted to hospital personnel.

Awareness

We have least awareness of earthquake. Of late, a few organizations have started thinking that apart from cyclone and flood, earthquake also deserves public attention. But the measures taken are too inadequate.

Social preparedness

Mass media should be harnessed to build awareness on how best to manage earthquake disaster. Be it noted that we have a network of gas-pipe lines. Any tremor here may ignite a fire which would be mighty difficult to control. There should be coordinated management plan involving electric and water supply services. Much research work on the matter is going on globally. Of late the BUET, Geology Deptt. of Dhaka University and Geological Survey of Bangladesh have stated joint survey. Much data is required for Zoning Maps. But we don't have a good observatory. A twenty-year-old recommendation for establishing four observation centres are in cold storage. We have to make do with data procured from Assam. But these are not enough for the local needs.

There are infrastructural differences between the rural and urban places. The amount of destruction depends on the weight of an infrastructure. The mud-houses in the countryside are extremely risk prone. The rich people of Sylhet build what they call Assam-type houses which are not risky. Average houses in the town now are built on 5 to 10 inch walls which crumble in an ordinary earthquake.

In Dhaka city, infrastructural designs are duly made. But engineers have little input after that. Common people are concerned with how to reduce building cost. Rods used are low quality. These cannot resist the least tremors. Houses are constructed on loose soil which are filled low lands. In such soils, entire building will come down. With proper foundation designing we can go for high rise buildings.

Much improvement has happened in quake-engineering now. Buildings can be made as intelligent structure. And these can "sense" imminent earthquake at least a few seconds earlier.

(Ecofile/Shamunnay)