BSRM KNOWLEDGE HUB

Are we safe from building collapse?

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A devastating tragic failure took place in Savar when a nine storied factory building(Spectra Sweaters Ltd.) completely collapse on April 12, 2005at night when workers were working inside. Sixty persons died and about 100 were seriously injured. The whole incidence shocked the nation and the civic society were vibrant about more stringent regulatory laws and implementation of quality assurance process for all civil engineering structures.

Rana Plaza, located at Dhaka–Aricha highway near Savar bus stand, collapsed on 24April 2013 at around 8:30 am, resulting in 1134 deaths and more than 2500 injuries. Rana Plaza housed five garment factories employing around 5000 people, 300 shops, and a bank. From newspaper sources it is learned that it was a 9-storied industrial building with a single basement. Local Municipality (Savar) gave permission to the owner of Rana Plaza to construct a five storey commercial building with one basement in 2005. Later the owner was allowed to extend it up to nine storey, without considering the structural design, though the foundation of the building was for 5 storey. Moreover, the building was converted from commercial to industrial use, and power generators were placed at the higher floors. As a result of such violation in building construction,

cracks developed on some pillars and on few floors of the building following a jolt on 23April 2013, a day prior to the fateful day. After inspection, industrial police requested the building authorities to close the building and to suspend operations of the factories on that day. However, the building owner and top management of the garment factories ignored the warning and forced the workers to work in the next morning on 24April, 2013 .As a consequence, the collapse resulted in the high death toll of 1134 and more than 2500 people were badly injured at the end of the rescue operation on14May 2013. This tragic accident received global attention, and brought forward diverse issues concerning workplace safety and working environment for workers. The employers, brands and consumers – the entire supply chain in the RMG sector was alerted for an acceptable code of construction and design practice for factory buildings.

We have read about a lot of building failure stories that have taken place in the capital city of Dhaka.

Two decades back a building located in a newly filled land and built on the slope of the fill in Sabujbag area of Dhaka failed when the second story was under construction. The rear columns on foundation footings settled and the whole building rotated. The front columns snapped from the footing resulting in collapse of the building. In Kalabagan a five storied building constructed over a pond filled with earth collapsed when the fifth storey was under construction. Column reinforcements snapped from the footing foundation and the whole building rotated and tilted. A seven storied building in Kathalbagan tilted resulting in collapse of ground floor (soft storey) damaging columns at supports. It is learned that the building was built over a ditch filled with rubbish and foundation consisted of micro-piles of inadequate length. In Mirpur an eight storied building tilted to one side after about one year of construction. From available soil report it appeared that the building was founded on wooden piles driven in soft and organic soil. It was apparent that the designer did not take into consideration the possibility of deterioration of wooden piles with time and changes in properties of organic soils with time.

In some low lying areas of Dhaka there have been reports of tilting of four to five storied buildings during construction. Tilting results in reduction of gap between adjacent buildings and adjacent buildings may almost touched each other at the top level. In some cases buildings have completely overturned and fell on adjacent houses resulting in loss of life and property.

With Dhaka becoming a mega city with one of the highest population density we have been constructing high-rise buildings with basement excavations for car park. Most of these excavations are close to existing structures. There have been cases of improper construction practice that have resulted in unwanted ground movements causing collapse of adjacent buildings.

A photograph of one of the recent shore pile failure adjacent to Hotel Sonargaon road intersection is shown.

Are we safe? What is required to prevent the failure incidences mentioned above? A case study of some of the above failures point at several factors predominant being the quality control process followed in construction and noncompliance with National Building Code requirements in building and designing these structures. There has been much discussion on how to implement regulatory controls.

One of the most important part of construction to prevent collapse is the ground stability and control during construction. The ground condition at a site is interpreted from the soil report from a soil exploration firm. It is unfortunate that although National building Code (BNBC) codifies foundation design procedure, it does not specify the competency requirements of a soil investigation firm. As a result anyone who can drill a hole is allowed to make soil investigation and interpret soil condition. Many of the firms engaged in soil boring and sampling do not have technicians trained in field testing and soil sampling. Interpretation of soil test results require qualified geotechnical engineers. In many cases geotechnical works are interpreted and done by structural designers who may not have the requisite background knowledge for geotechnical interpretation. For a safe building it would be mandatory that all soil exploration works should be supervised and interpreted by a qualified geotechnical engineer and the foundation design should be checked and certified by a geotechnical specialist.

Quality materials for quality building construction

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HOUSING is one of the basic needs of human life. Buildings are part and parcel of human activities including living, entertainment, shopping, office, factories and so on. Therefore, buildings should be safe against natural and man-made disasters, comfortable, user friendly and durable. To ensure these requirements, building construction should be done as per following steps:

1. Preparation of architectural design.
2. Preparation of structural design.
3. Preparation of plumbing, electrical and fire safety design.
4. Building construction as per the designs mentioned above.

Comfort of living, user friendliness and optimum utilization of space of a building depends on the architectural design. A qualified and experienced architect can design a building, considering user's requirement and climatic condition of the geographical location of the building, so that the building will be user friendly and comfortable for habitation.

Safety and durability of a building depends on the quality of structural design as well as quality of construction. Following steps should be undertaken to ensure the safety and durability of a building:

1. Structural design of the building should be done by a qualified and experienced structural engineer who shall design the building as per provisions of Bangladesh National Building Code (BNBC), considering all the natural disasters like flood, storm, tidal surge and earthquake.
2. Fire safety design aspects including fire detection, protection and evacuation of a building should be done by a team of qualified and experienced architect, electrical engineer and mechanical engineer, complying fire safety provisions of BNBC.
3. Building construction should be executed under supervision of a qualified and experienced engineer who can execute the job as per design and as per BNBC.

Construction quality depends on the following aspects:

1. Use of quality construction materials.
2. Appropriate construction methodology.

In the urban area of our country, Reinforced Concrete (RC) structure is the most popular construction method. In this method the structure of the building is constructed by casting of foundation, columns, beams and slabs with concrete and reinforced with steel reinforcing bars.

In RC construction, the following materials are used:

1. Steel reinforcing bars.
2. Cement.
3. Crushed stone/ brick and sand.

To ensure construction of building which will be safe and durable, the construction materials should be of good quality.

To ensure quality of construction materials and other industrial products, there are National and International Standards organizations, responsible for setting the standards for production, quality control and testing of materials. In our country, the Bangladesh Standards and Testing Institute (BSTI) is in charge of setting the standards for industrial products. Consumers will be confident about the quality of materials if those are manufactured as per BSTI standards. There are many International Standards organizations, a few among those are:

1. ASTM (American Society for Testing and Materials).
2. ISO (International Organization for Standardization).
3. EN (European Norm).

Quality aspects of the materials used to manufacture concrete in our country are briefly described below:

A. Steel Reinforcing Bars.

It is the core material used in RC construction works. It should be of good quality and manufactured as per BSTI standard. Consumers should be aware of the fact that, in some cases the steel reinforcing bars available in the local market are of poor quality and not manufactured as per BSTI standards. From strength consideration, there are three grades of steel reinforcing bars available in our market e.g. 40 grade, 60 grade and 75 grade. Building owners should buy steel reinforcing bars having quality and grade recommended by the structural engineer. Quality of steel reinforcing bars should be tested regularly from a standard testing laboratory.

B. Cement.

Cement acts as the binder in manufacturing concrete. Therefore, it should be of good quality and manufactured as per BSTI standard. In our country, there are many types of cement, produced by the manufacturers. The building owners should consult the structural engineer and the engineer in charge of building construction, before buying a particular type of cement. Routine tests to check the quality of cement should be done regularly from a standard testing laboratory having testing facilities as per BSTI standard.

C. Crushed stone/ Brick and Sand.

Crushed stone or brick and coarse sands are used as aggregates for manufacturing concrete. To get a good quality concrete, the aggregates should be of good quality.

Aggregates produced from crushing good quality boulders are the best as coarse aggregate. On the other hand coarse river sands, free from silts and other impurities are best as fine aggregates of concrete. Crushed stone aggregates are better than crushed brick aggregates. Though a little expensive than crushed brick aggregates, buildings constructed using crushed stone aggregates are more durable than the buildings constructed with crushed brick aggregates. On the other hand, clay bricks are manufactured by destroying the fertile top soils, gradually reducing the precious total arable lands of the country. In firing of clay bricks, woods are used along with coals, eventually eliminating the forest resources and polluting the environment of the surrounding areas. We should, therefore, gradually replace the fired clay bricks with non-fired bricks and concrete blocks. To ensure quality of aggregates, regular testing should be carried out from a standard testing laboratory.

After completion of the Reinforced Concrete (RC) frame of a building, finishing works are done using different construction materials. To ensure durability, those materials should also be of good quality. We should always keep in mind that quality materials and appropriate construction method ensures construction of a safe and durable building. A few finishing construction materials are briefly described below:

Clay bricks/ Concrete blocks.

Fired clay bricks are predominantly used to construct walls in buildings in our country. Quality of bricks depends on the size, shape and degree of burning. As the fired clay bricks are not environ friendly, it should be gradually replaced with concrete blocks and non-fired bricks.

Electrical Cables, Appliances, Safety Devices.

Electrical short circuits are the main reason for fire disasters. And the happenings of short circuits are due to poor quality cables, appliances and safety devices. To avoid fire hazards due to short circuits, the electrical design and construction supervision should be done by a qualified and experienced electrical engineer.

Finally, it may be concluded that, as building construction is an engineering job and the investment is large and for long term, services of qualified and experienced engineers should be taken to construct buildings which will be comfortable, user friendly, safe and durable.

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Use of mild steel rebar in seismic design on RC buildings

Some essential information everybody should know

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MILD steel rebar, commonly known as MS rod or simply rod, is an essential component of building materials. This product is being manufactured in our country for a long time. Construction of reinforced concrete buildings started in this country approximately after the 2nd World War. The first re-rolling mill to manufacture MS rod was established by the H Akberali Group of Industries at the Nasirabad area of Chittagong named Bangladesh Steel Re-Rolling Mills (BSRM) in 1952. Later it was followed by the establishment of Rahim Steel Mills Ltd. in 1958. In the post-liberation period, more steel mills emerged in the market, notably the Kabir Steel Re-Rolling Mills (KSRM) and Ratanpur Steel Re-Rolling Mills (RSRM), both in 1984, AbulKhair Steel Ltd. in 1991 and many others. All these mills can now meet the internal market demand. Some companies are even exporting rebar to neighbouring countries. From the beginning till the '80s decade, all these mills manufactured rebar of grade 275 (275 Mega-Pascal equivalent to American ASTM Grade 40 or yield strength 40 ksi). There was no national standard for manufacturing rebar that time. Also we had no design code to guide the engineers to properly design the buildings considering the geo-environment of Bangladesh. BSTI first published the national standard BDS-1313 for manufacturing MS rebar in 1991. Two years later, the first edition of Bangladesh National Building Code (BNBC) was published in 1993. BNBC provides adequate guideline for engineers to design and construct buildings considering the weather and geological characteristics of Bangladesh. In BNBC, the whole north-eastern side of the Padma-Meghna River including the whole of Chittagong area has been declared as vulnerable to earthquake. Among these areas, Sylhet, Mymensingh and the northern parts of Dhaka fall in severe seismic vulnerable zone. In these areas, the BNBC code dictates to construct special seismic structural systems for the buildings. Since the 80s, with the economic growth of the country, demand for construction of multi-storied high rise building increased. At the same time, the consciousness for construction of seismically safe buildings started increasing. To meet the demand of high-rise construction, production of Grade 420 (equivalent to ASTM Grade 60) started in the 90s which was also pioneered by BSRM. In 2006, BSTI published a new standard BDS ISO 6935 for MS rebar which is also followed internationally in many European countries. In 2008, BSRM started production of Grade 500 rebar and other companies also followed suit. Recently in 2015, BSRM introduced Grade 420 rebar specially fabricated for seismic application and Grade 550 for large/mega structures in accordance with American ASTM A706 standard. Process of the publication of equivalent Bangladeshi standard BDS ISO 6935 – 2016 is also underway. Such development in the grade of rebar can be observed worldwide.

Water, sand, stone chips, cement and MS rebar are the main ingredients of concrete construction. Seismic resistance characteristics of a concrete structure primarily depend on the properties and arrangement of rebar. Properties of other ingredients generally do not have any contribution to the seismic resistance characteristics of a concrete structure. For this reason, it is necessary for everyone to have some idea about the engineering properties of MS rebar. Especially, for the engineers engaged in the design and construction of concrete buildings, this is extremely important.

From seismic design consideration, the important engineering properties of rebar are a) unit weight –the weight of a piece of rod of 1 m length, b) yield strength – generally the tensile stress level up to which the rod elongates proportionally, c) ultimate strength – maximum stress level a rod can sustain before fracture, d) elongation – the amount of extension a rod sample undergoes in tension before fracture which is generally expressed as a percentage of original un-elongated length, e) bend test – how easily a rod can be bent without breaking and f) deformation measurement – appropriateness of the geometric measurement of the surface patterns of the rod.

For seismic resistant design, the yield and ultimate strength and the amount of elongation is very important. The tested yield strength must be equal or greater than the rated strength of the bar but at the same time it shall not exceed the rated strength by 125 MPa. For example, for Grade 420 rebar, the tested yield strength shall be between 420 MPa and 545 MPa (420+125). The ratio of tested ultimate strength and tested yield strength shall be 1.25 or higher. This is a very important and essential characteristic for specially designed seismic resistant structures and must be ensured before construction. After testing, the total elongation of the broken specimen shall be at least 12% to 14% on a 200mm gage length, depending on the diameter of the rod. Only a few of the brands of MS rod available in the market can satisfy all these requirements. It is, therefore, strongly suggested that the required properties of the rod to be used in a building be tested from reputable and reliable laboratory before being used in a construction.

Fatigue characteristic is another property to judge the quality of steel. Generally speaking, good quality steel must possess the required fatigue characteristic as per the standards. Good fatigue properties are essential for the design and construction of steel bridges like the Hardinge Bridge. However, it must be made clear that fatigue property has nothing to do with the seismic design of concrete buildings. Fatigue property is not required or used in the construction of seismic resistant concrete structures. In the highly competitive market, some of the manufacturers show catchy advertisements mixing up fatigue with seismic design and put people in confusion which is undesirable. Readers are requested not to get confused seeing such ads. Instead, they are advised to seek the opinion of experienced engineers or experts and get the rods tested from a reliable laboratory.

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