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Let's learn a lesson or two

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ONE the evening the Phoenix factory building fell in a heap at its Tejgaon premises, it was 25th February 2006, a private television channel hastily scooped me to the place of occurrence for an on-site comment. While rescuers searched frantically for survivors and demolishing equipment brought down what remained of the buckled building behind me, standing on a pile of rubble I looked at the flickering red light of the video camera and remarked (a) that there could possibly be several more such buildings awaiting a similar fate in that very vicinity and beyond, (b) that all building owners factory, office, school, hospital, residence, hostel, entertainment should immediately inspect their respective buildings to determine any possible risk due to ageing, structural indiscipline, misuse and lack of maintenance, (c) that efforts should be undertaken to rectify any error that could be hazardous to life and property. Amidst the eerie din I remember having to shout no one heard my voice.

It is our inherent national character to make hue and cry when a catastrophe strikes, drown the situation with all our emotions for the following couple of days, commit some financial compensation (as if life can be compensated) to the family of victims, some building/factory owners pay only a fraction of it, and then forget about the whole thing, loss of life and all. No lesson is ever learnt.

In many ways, we always await a disaster, little knowing that many of them can be avoided by careful planning and methodical attack. We are that shabbily aware. Every accident, each collapse demands a thorough inquiry and a follow-up such that there is no repetition by intent or inadvertence. There should be wide publicity of the causes leading to a mishap, so that lessons can be learnt.

The recurring failure of buildings in the recent past Sakhari Bazaar (June 9, 2004; 19 dead), Spectrum factory, Phoenix factory calls for building up a specialised force of emergency medical technicians (EMT) as well as services (EMS) to tackle future catastrophes. Clark Staten in the second part, of his article today on building collapse rescue continues to explain how.

This week we also feature the second and concluding part of the investigation report on the Savar Spectrum sweater factory failure prepared by an Institute of Engineers Bangladesh (IEB) expert team led by BUET Vice Chancellor Prof. Dr. A.M.M. Safiullah.

Let every fallen building be a source of learning for every owner, architect, engineer, builder and authorising officer. For when a building fails, when lives are lost, when property is reduced to dust, none involved in the building, can rest in peace ever after.

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BUET

The boiler

Savar Spectrum sweater factory failure

Institute of Engineers Bangladesh (IEB) investigation report: Part II

(Part I appeared last Friday, 5 October 2007)

Different phases of collapse: Different phases of the collapse sequence caused by the removal of the northeast corner column were studied by simulation. The analysis showed that due to this support removal, hinges start to form at the slab-column connections in a gradual fashion starting from the top storey. However, formation of such hinges up to Phase 4 were found to be mostly concentrated in the topmost four stories, except the north-east bays where hinges were found to be developed in all storey levels. This largely matched with the Observation Bases formulated during the Investigation, indicating the closeness of the simulation results with the real phenomena that took place at those sad hours.

Committee's remarks about the failure: Based on these findings, the investigation team was able to derive the following conclusions:

- The failure of the northeast corner column is responsible for triggering the collapse of the structure at that fateful night.
- Upon the triggering, the hinges started to form at slab-column connections at top storey levels pushing the upper floors to fall in a sway motion towards east and northeast direction. A mild sway of the southern side columns to southward direction also took place.
- The collapse of the upper floors caused a tremendous vertical impact on the lower stories, which action caused the lower stories to come down vertically. Falling of the lift core added the final blow.
- Northeast corner bays of the structure collapsed vertically at all floor levels.

Construction supervision

North-East Corner Column showed very poor concreting: The push over analysis suggested that the failure is related to the movement of the northeast corner column of the building and also it was apparent from the cleared area of the building that this corner has gone down by about 11 feet from rest of the slab. With the help of the construction firm M/s. Development Constructions Limited this corner was further exposed by manual excavation.

Some serious construction problems were observed in the northeast corner column of the building, which made it clear how the collapse of the whole building was initiated. It was clear form the excavated portion of the pile cap that the position of the cap was intact. For about 2 feet of the column above pile cap, the column reinforcement buckled and twisted. The concrete at this portion was very weak and contained clay and other deleterious particles. The concrete was so soft that aggregates would easily be pulled out with bare finger. This suggests that although sufficient care was taken in casting the pile cap, the column at this portion was perhaps cast under water that contained significant mud and other loose materials and remained weak. There were twelve 25 mm diameter high yield reinforcement bars that perhaps carried the load of the building but due to sustained creeping these ultimately buckled that lead to the collapse of the whole building.

It's evident from the circumstances that the standard civil engineering procedure has not been followed in this building. Although there had been some flaw in the design consideration of the building, but it is the careless supervision of the construction at column base level that had initiated the catastrophic failure.

Rescue operation

The failure incidence trapped people who were working inside the collapsed building at that fateful hour. In order to rescue the trapped people it was necessary to remove one slab after another from top. But because of heavy weight and bulk and their reinforcement connections it was not easy to separate the slabs and pull them out. Therefore the rescue team cut open hole into the slab and removed it to get people out. But it was a time consuming process as these openings were made by drilling into the slab to form smaller pieces capable of being lifted by three cranes brought for the purpose. Capacities of these cranes varied between 120 and 60 tons. All these removal process took about eight days. Perhaps many lives could have been saved if there were demolition chemicals or rapid concrete disintegrators available at the time of rescue.

Who are responsible for the Polashbari failure incidence?

If one traces the whole process leading to the catastrophic failure, a list of inappropriate actions or inactions can be listed, each having a direct or indirect consequence that has contributed to the failure. A few are listed below:

The Owner

- Did not obtain permission for constructing 9-storied building from appropriate authority.
- Did not have the knowledge of selecting an adequately qualified engineer to design the structure.as unaware of implication of not appointing a qualified/experienced contractor for execution of the job.
- Was unaware of the necessity of quality assurance system for such a critical structure.

The Designer

- Made faulty design considerations such as live load, superstructure system, inadequate consideration for lateral loads, etc.
- Did not provide detailed drawings for all connections
- Did not get his designs checked by another qualified engineer or advise the owner in this regard.

Construction Supervisors

- Failed to ensure materials specifications, structural dimensions and details, and monitoring of the quality of the work.
- Did not seem to have been aware of the consequence of inadequate supervision.

Building Approving Authority: RAJUK/Cantonment Board

- Unaware and indifferent to construction of a dangerously unsafe high-rise factory building built within its jurisdiction.
- Failed to stop unauthorized construction.

The Building Construction Act 1952

- Does not recognize construction and occupational safety as an important aspect of building construction. Main emphasis is given to planning and land use only.

Building Construction Regulations, 1996

- Failed to include BNBC 1993 recommendations for supervision of building design and construction.
- Vested design responsibility only to the architect for any structure and for residential buildings higher than four stories. An architect does not have the educational background and design capability to handle such responsibility.

Others

- Engineering bodies, for failing to make the civil society aware of the danger that lies in the present construction practice.
- Corrupt and dishonest building officials, for allowing malpractice to continue.
- Construction supervisors/inspectors failure to sincerely supervise due to intimidation by mastans and influential mal-practitioners.
- Law enforcing agencies fail to safeguard honest officials.

Table-1 shows the list of actions, inactions and non-compliance issues with quality assurance and quality control requirements/principles which led to the failure of the Spectrum sweater factory.

The Committee feels that the aspects stated in the table point to a number of issues that should be debated nationally to develop an appropriate policy to implement and regulate Building Code Requirements for a safe and functional building.

Q.A. scheme

All concerned organizations/Agencies should install appropriate Quality Assurance (QA) scheme within their set up to prevent similar failures as in Spectrum Sweater Factory. The parliament has enacted "Dhaka Metropolis Building Construction Rules; 2006" (DMBCR, 2006) on April 16, 2006. In the light of experience gained through Palashbari failure, it would be pertinent to examine, if such regulation can prevent such crisis. It had not been possible for the Committee to fully review the DMBCR, 2006 in light of the Palashbari incident.

Let's all seriously learn lessons from the failure of the 9-storied Spectrum sweater factory building. Achieving quality and safe infrastructures require commitment from the top levels of the democratic government, law enforcing Agencies, Owners/Investors first.

The Owner, in case of the important Spectrum factory building, instead of engaging an individual professional should have engaged one qualified registered architectural/structural consulting firm with good track record for planning, designing, preparing drawings, specifications, estimates of quantities & cost and brief tender documents, and for supervision of works; and one competent registered construction firm for constructing the building.

A proper contract defining the responsibilities of the First Party (Owner) and the Second Party (Consulting/Construction Firm) including the compensation package should have been signed and followed. Learned Societies such as IEB, Institute of Architects (IAB) and Institute of Planners Bangladesh (IPB) should provide facilities for prospective owners to choose qualified registered firm(s) with good track record.

The ISO 9001:2000 Quality management systems - Requirements gives the comprehensive steps to be followed for each stage of planning, designing and development. As an example the sample design and development stages activities of similar structures are given below:

Step-1 Planning of the activities: The Consultant's organization shall plan the different stages activities including those of the review, verification and validation of the design and development stages. The Consultant's organization shall manage the interfaces between different groups involved in the design to ensure effective communication and clear assignment of responsibility.

Step-2 Design brief/input: This will contain the Owner's requirements regarding functional and performance requirement, statutory or regulatory requirements for example, mandatory requirement of following the prevalent Building Regulations with Amendments (AMDs) if any, the Bangladesh National Building Code 1993 (BNBC 1993), design loading, material specifications, and other essential requirement for designing the building etc.

Step-3 Design output: The output of the design stage activities will be appropriately computed design and drawings, appropriate information for constructing the structure, acceptance criteria of the different components of works, and the characteristics of the finished structure or its components that are essential for safe and proper construction and use of the facilities. This design output will be in a form that enables review/verification against the design input and shall be approved prior to release.

Step-4 Design review: The review will be done to evaluate the ability of the results of design to meet Owner's requirement, and to identify any problems and propose necessary actions. All records of review should be properly documented and preserved.

Step-5 Design verification: The design & drawings and other documents should be verified whether it meets the requirement of design brief. Records of the results of verification and any necessary actions shall be documented properly and kept in record.

Step-6 Design validation: This stage activities will be performed to check the correctness of the input data, and to ensure that the resulting structure is capable of meeting the requirements for the specified requirement or intended use of the building for which It's designed. This validation will be completed prior to delivery of the design drawings and other documents or implementation. This shall be done by a professional of higher relevant experiences. Records of the results of validation and necessary actions shall be maintained.

Step-7 Control of design changes: The design changes shall be identified and records maintained. The changes shall be reviewed, verified and validated as appropriate, and approved before implementation. The review of design and design changes shall include evaluation of the effect of the changes on the constituent parts and documents already delivered. Records of the changes and any necessary actions shall be maintained.

Similarly, for the construction stages activities the supervision and quality control sampling and test requirements are to be developed and followed.

Conclusion

The lessons learned from the Spectrum sweater factory building failure strongly emphasizes the need for the implementation of Quality Management System in our organizations, and achieve quality assured structures and services for the building industry. This also requires to critically review and evaluate weakness in our present system of building planning, design and construction regulations, the need for training individuals at all levels of work and bringing commitment to it. Of course this needs commitment of all concerned including the top level of governance. Political will of the democratic Government is a must to achieve it.

AMD Amendment
BACE Bangladesh Association of Consulting Engineers
BGMEA Bangladesh Garments Manufacturers and Employers Association
BUET Bangladesh University of Engineering & Technology
DMBCR Dhaka Metropolis Building Construction Regulations
GoB Government of Bangladesh
ISO International Standards Organization
QA Quality Assurance
QMS Quality Management System
RAJUK Rajdhani Unnayan Kartripakhya

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Table - 1: List of action, inactions and non-compliance issues.

Sl.	Action / Inactions / Non-compliance	Responsibility	Result
1.	Application for approval of a nine storied factory building to RAJUK/Cant. Board. / Factory Inspection Office	Owner	No document or information about building available with appropriate authorities
2.	Responsibility for vigilance against unauthorized construction of a 9-storied building in Palashbari area.	RAJUK/Cantt. Board	Unaware and indifferent to construction of a dangerously unsafe high-rise factory building.
3.	Provision for checking structural and foundation design by a competent engineer for any high rise building	Building Construction Rules, 1996	Clause 6 of the Order contradicts requirements of such provision
4.	Provision for appointing a 'Building Official' as proposed in BNBC 1993	GoB	Not implemented by GOB in the spirit of BNBC 1993
5.	Appointment of a Consultant for design through a Diploma Engineer who hired a graduate engineer to do the structural design.	Owner	It is likely that the Owner was not aware of the capability of the person designing the building and the consequences that are likely to develop.
6.	Faulty design considerations made by the Engineer assigned to the job	Designer	Weak columns and stiff slabs resulted in sandwich type collapse trapping people to death.
7.	No Contractor was appointed for construction of the building. Two Diploma Engineers executed the job with labour contractors, the Owner paid for construction materials and labour.	Owner/Supervisor	Supervisors did not stick to the material specifications and failed to adequately supervise construction of critical elements of the building such as foundation column, which lead to the catastrophic failure.
8.	Supervision by the designer	Designer	Designer supervised the work from time to time but did not make any comment on quality of construction.
9.	No quality assurance (QA) system was in place	Owner/Constructor/ Supervisor	No proper and documented check on quality control was in place for the construction work. No QA scheme was followed by any party.

Building collapse rescue

A guide for EMTs (emergency medical technicians) Part II

CLARK STATEN

(Part I appeared last Friday, 5 October 2007)

(7) Great care must be taken when a person is located, either dead or alive, to ensure that additional collapse doesn't occur in the area of their entrapment. Rescuers should use their hands and small tools to remove the remaining debris surrounding a person. The victim's condition may dictate the speed with which rescue efforts progress. Consideration should be given to early application of Military Anti-Shock Trousers for viable persons that have "crushing" injuries. Preparation and the beginning of application of them should take place as soon as the entrapment permits. Several instances of complete hemodynamic (blood related) collapse and death have been noted upon release from confinement. Intravenous solutions can also be administered by qualified EMS (emergency medical service) personnel as extrication continues. Caution should be urged in the use of morphine or other painkillers.

(8) DO be prepared for the emotional and psychological implications of the incident. Prepare early for Critical Incident Stress debriefing sessions for rescuers, victims and families. It is strongly suggested that mental health professionals and crisis intervention be made available to the families of those believed trapped, at the earliest opportunity. The stress of protracted digging, discovery of disfigured remains, odd smells and sights can affect even the most hardened of rescue professionals. Supervisory personnel may want to set aside a special place for families and psychological care near to, but, off of the rescue site. To do otherwise will invite charges of insensitively, and probably prompt the families to attempt to enter or stay in the rescue area.

(9) Relief for both supervisory and field rescue personnel must be forthcoming. Even though most rescuers will insist in continuing their efforts for many hours, they lose a large part of their effectiveness after 18-24 hours or less. Ensure that all rescuers eat and rest at frequent intervals, as circumstances permit. Prepare to (and do) call in off-duty or mutual aid personnel as they are needed. Stage all extraneous units in a planned way and avoid having more personnel on-site than can effectively work at one time.

(10) During long term or at major rescue operations, expect extreme "media" coverage, including the national and international press. Be prepared for analysis and commentary of your every move. It is suggested that this scrutiny can be somewhat averted by appointing a designated Public Information Officer (PIO), and by planning and giving frequent press briefing and updates. Include "front-line" rescuers and technical experts that you may be being utilizing in the effort. During the early stages of the event, give these briefings hourly in an area adjacent to the site and provide as much information as you can actually verify. As the length of the rescue increases, plan a morning and afternoon news conference. It is suggested that someone monitor press activities on a constant basis, in order to be able to anticipate the questions and concerns of the media. Be as forthcoming as possible, without compromising the integrity of the rescue operation, the victims, or the families of the victims.

(11) Anticipate the need for additional resources that you haven't thought of prior to this event. Be prepared to obtain architectural drawings of the building(s) affected. How about gas mains, water pipes, or electrical services that are disrupted? You may want an aerial perspective of the scene...do you know where and how to get overhead photos of the collapse? How are you going to feed "hundreds" of construction workers, rescue workers, families, and others, who may be there for days? Who's going to pay for what? Will you need a city/county purchasing agent on-site to approve the immediate purchase of your needs? Ensure that you have planning and logistics officers who can anticipate these needs and fulfil them within a moments notice. Often the difference between what is perceived as a completely successful rescue and a "disorganized" one is the quality of your planning and the careful execution of your contingency plans.

(12) Particularly in multi-story buildings, be prepared for the possibility and likelihood of underground or cave- type rescue procedures. This type of specialized rescues requires those experienced with climbing (ascending and descending) manoeuvres and the use of technical rappelling methods. Each rescue team (minimum of two rescuers) going "underground" should have a safety rope attached and be in constant communications by radio with the surface. They should also possess a minimum of three viable light sources. Hose rollers and other types of "rope slip devices" must be used, as to avoid the sharp edges of concrete that will abrade normal rescue ropes.

(13) IT AIN"T OVER UNTIL IT'S OVER! Generally speaking, you will be criticized for any early termination of rescue efforts, if there are still people missing or bodies not recovered. A rule of thumb says it's over when everyone is accounted for or the "field is cleared" (of debris). Practical application says that you will probably scale back the aggressiveness and scope of the effort after several days of rescue, but that you should remain aware of the fact that people have been successfully rescued alive after as much as twelve (12) days, buried in the rubble of an earthquake. In the March, 1992 Turkish earthquake, a 22 year old nurse was pulled from beneath a building collapse after eight days. She was also quoted as saying that she had been "talking with her two friends", who were also buried, for several days after the collapse until she "didn't hear them anymore". The thought of someone remaining buried alive for several days should be enough motivation for most rescuers to continue with their efforts until every possible hope has been exhausted.

(14) Establish on-scene (and separate) communications (Radio, Data, telephone) connections and expect problems with being able to coordinate with many differing agencies. It might be suggested that a "common" disaster frequency might be designated in preplanning sessions for the initial response to the incident. Once on-scene, the Incident Command team may need to establish several different "nets" of units or agencies and have a common dispatch centre at the command post. Anticipate the need to constantly communicate with construction workers (crane operators) and their supervisors, and probably a dozen other agencies that you never thought of. Also remember that the need for coordination with local and state police may become necessary for crowd/access control and other purposes. Often police agencies will become involved in securing the remains of fatal victims in a temporary morgue at the scene.

(15) EXPECT THE UNEXPECTED! Regardless of the thoroughness of your contingency planning efforts and the diligence of all of the people involved in the rescue, something will become a problem that no one has anticipated. This is just another opportunity to demonstrate the quality, commitment, and dedication that comprise the makeup of most rescue organizations. Let the improvisational ability of the firefighters, EMTs, paramedics, police officers shine through!

Conclusion

One of the most difficult, emotionally draining, and technically complex types of rescue can be a building collapse incident. The keys to a successful rescue are pre-planning, practice, and perseverance. By learning more about this increasing commonplace event, we can be better prepared to save lives and alleviate the suffering of its victims.

Abridged from a paper published in 'Emergency Medical Services Magazine' 1992. The author is Assistant Chief Paramedic, Chicago Fire Dept. (Retd), former Chairman, National Society of EMS Administrators and former Chairman, Emergency Management Committee, National Association of EMTs.