Design and remediation for fire safety of ready-made garment factories in Bangladesh

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INTRODUCTION
The pressures that led to the proliferation of dangerous industrial buildings in Bangladesh are present in developing countries around the world. A fact highlighted by the death of 72 workers in a fire in a shoe factory on the 14th of May 2015 in Manila, Philippines, where local press have attributed the disaster to unenforced safety legislation. This concern can also be seen in the news of many developing countries around the world in other building sectors where rapid urbanization is happening.

During the past three years, Arup Fire has worked with a number of different clients to address fire safety issues from different perspectives, assisting different clients and action groups at surveying factories for Fire safety within a government initiative in Bangladesh.

This paper describes the evolution of four different projects starting from a fire safety survey exercise to an all-encompassing endeavour to find a way to address an industry wide problem in Bangladesh in a way that would be sustainable in the future.

The paper describes how processes of this scale and complexity require private sector expertise to ensure that assessments are rigorous in the context of the first steps towards 'building back better'. It is argued that for a process such as this to be sustainable, the private sector must act by taking an approach to build capacity by transferring knowledge and practical expertise to both the public and private sector. It is hoped that the approach taken and the lessons learnt within will be applicable to future assessment processes and to design for prevention rather than after damaging events.

BACKGROUND
Bangladesh is a young country with a turbulent history. Formed in 1971 in a war of independence from West Pakistan and prior to that from the violent partition of British India in 1947 it has since undergone famine, flooding and a succession of military coups with a hopeful democracy reinstated in 1991. This turmoil has starved Bangladesh of the stability required to develop robust and independent institutions.

With a population of about 160 million, 31% of whom live below the poverty line it is one of the most densely populated and poorest countries in the world. Development of the Ready Made Garment (RMG) industry begun in the 1980’s and has since expanded rapidly to the point where it is the second largest producer in the world, with exports of almost $20 Billion, representing 80% of national exports. The industry provides a vital source of employment to 4 million people, 80% of which are women. This industry has also improved the economic level of many Bangladeshi people and Bangladeshi companies in recent years.

Construction demand generated by rapid and combined urbanisation and industrialisation exceeded the capacity of the construction industry and quality suffered as a result. There are
weaknesses in planning, design and construction. Reinforced concrete buildings dominate the industry allowing ever taller construction in a city where space is scarce. The city authority responsible for enforcing planning laws and design regulations is notoriously anaemic whilst pressure on land has seen unapproved building additions. Site supervision is limited with contractors known to swap specified materials for cheaper alternatives whilst making unilateral design changes as they build. To compound these vulnerabilities appropriate structural, architectural and of course fire safety design is often omitted or simply evaded due to lack of understanding and lack of professional knowledge.

As an example to show the magnitude of the building industry issue, on April 2013 a multistory factory building known as Rana Plaza made international headlines when it collapsed killing 1,200 people and injuring another 2,500. From a fire safety filed of focus, just months before on November 2012, a large fire at another factory building named ‘Tazreen Fashions’ killed 112 workers and injured 200 others.

The scale of these two disasters and the international spot light they drew had the potential to cripple the industry and Bangladesh’s economy in turn. Instead, in an example of supply chain pressure that could be traced back to media coverage and customer outcry at home, manufacturing brands in Europe and subsequently North-America came together to take collective action to avoid new disasters.

On May 15th 2013 a group of mainly European garment brands and trade unions signed a five year legally binding agreement known as the ‘Accord’ to address building safety. This was followed in July by the creation of the ‘Alliance’ by a group of North American apparel companies, retailers and brands. The Accord and Alliance committed to assessing the 1800 and 800 factories from which their members sourced from. The remaining 1800 were to be the responsibility of the ‘National Initiative’, with the International Labour Organisation (ILO), a United Nations agency that deals with labour issues, acting on their behalf. This followed on from a high level ILO mission to Dhaka in early May to agree a response with the National Tripartite. The National Tripartite consisting of the Government of Bangladesh, factory employers and workers organisations. In early July 2013 a plan of action was issued that would later be developed into RMG building safety assessment guidelines.

INITIAL PROJECT – GETTING TO KNOW BANGLADESH
In response to a number of fatal garment factory fires in Bangladesh in 2012 – including the Tazreen fire – a major Spanish garment manufacturer approached Arup in early 2013 to assess fire safety in factories that are part of their supply chain and to propose ways to develop specific improvements in general and for particular buildings. This Spanish manufacturer with a strong corporate social responsibility division were the first to take concrete steps in response. In this way, a private sector organisation took the lead in taking actions and stepping into a void of uncertainties not only for fire safety but for the general construction safety of many factories in Bangladesh.

The project
The project involved three main tasks or phases. The first phase resided in understanding the fire safety level of the factories in Bangladesh, providing technical advice and building capacity for local engineers. The engineers were not fire engineers and had little background about the topic, but had the task of surveying and collecting information of about 250 garment factories for specific fire safety topics, mainly means of evacuation and protection against major fire risks.
The second phase consisted in assessing and giving guidance to the local engineers surveying for fire safety improvement of the factories. It was important that the surveyors could produce practical and complete survey checklists so that other professional fire engineers were able to understand the fire safety status of each factory. The survey content and design was developed based on a qualitative decision process involving different variables – not only fire safety ones – such as means of evacuation, active protection measures, fire and smoke containment, remedial processes and costs, surveying time scales, surveyors knowledge, etc. The main challenge was to design a simple data collection sheet that could be practical, that could involve key safety aspects and that could help produce fire safety reports for taking decisions on remedial actions for each individual factory and in general.

The third phase consisted in gathering data from all surveys, organizing it and producing fire safety reports for further decision making. Each factory had an independent report showing the key findings. A benchmark criteria had to be developed based on the Bangladesh building code and further technical and practical criteria. These criteria helped us categorize the problems, understand the overall status of many factories and recommend remedial actions. This exercise helped understand the overall fire safety level of the factories, the most common problems and to point out the factories that had the largest immediate fire risks.

**Relevant findings**

The first visit to Bangladesh and to a few garment factories in June 2013 was a remarkable and emotional experience for the fire engineers adventuring into a land known to have a low level of fire safety but without understanding the extent, the reasons behind and the complexity of the problem that was causing much damage to the society. In order to comprehend the question and propose solutions we had to understand not only the type of construction and designs of existing buildings but also a culture, an industry, the idiosyncrasy of the people and of the factory workers, the social economy, the building design knowledge, the fire safety approvals process and the entire supply and buy trade chain of garments in Bangladesh.

Why is this thinking framework important to be remarked? It is important to be mentioned because every fire safety design or project – no matter if it is small or comprehensive and no matter its location in the globe – requires a similar exercise. Some projects do not require a big amount of analysis (as this first project in Bangladesh) but the simpler a project may look, the easier it is to omit some or most of these factors. The role of the fire safety specialists is complex and requires the fire practitioner to step aside from points of focus to be able to see a larger picture often missed. These issues are very evident in Bangladesh, but they all exist in many other countries.

Soon after initiating this project, we realised that fundamental fire safety design flaws existed in the vast majority of factories, which would not be quickly addressed with rapid remedial measures to specific factories. The problem had to be tackled on an industry wide basis, which meant getting involved in doing factory inspections, sharing fire engineering experience regarding design good practice, helping to build the capacity of the enforcing authorities and local engineers, and identifying a roadmap to a more sustainable situation.

From a larger sociological perspective, it was also noticed that the overall problematic was also caused by global influences and that required external international institutions to step in and support Bangladesh.
SECOND PROJECT – TRAINING FIRE-FIGHTERS

After the first initial and insightful project and after the international and national institutions mentioned above started getting involved for fire safety and structural safety improvements, different action projects since 2013 have taken place, one of these being the improvement of fire safety knowledge of Bangladeshi fire fighters who are also partly responsible of checking that fire safety measures are implemented in existing buildings.

The project

This project succeeded based on the technical and financial support of ILO. The main goal was to build capacity and provide technical knowledge to key personnel of ‘Bangladesh Fire Service and Civil Defense’ (FSCD). The training was developed by European fire engineers for two 1-week modules at the end of 2014.

The main objectives and desired outcomes can be summarised as follows:

- To provide FSCD with a better understanding of the basic design principles behind fire safety engineering practice as envisaged by the Bangladesh National Building Code (BNBC 2006).
- To enable FSCD to assess fire safety issues on garment factories and understand remedial actions being proposed by reports of Fire & Electrical safety inspections of RMG factories in Bangladesh.
- Specifically to provide FSCD with an understanding of the design principles behind the requirements for means of escape from buildings in the event of fire.
- To provide FSCD with a better understanding of what an Emergency Action Plan (EAP) should consist of and how responsibilities for its implementation in garment factories should be assigned.
- To enable FSCD to assess the effectiveness of EAPs on site and assess whether they can be simply implemented to achieve a safe, quick and orderly evacuation of the building.

Relevant findings

The first days of the course consisted of lecture based learning, at which there were about 55 fire-fighters from different parts of the country, mainly Dhaka. A lot of technical material that was presented – even though was very basic – was new to the attendees. At times, this seemed to be an overload of information to some participants.

For the subsequent sessions a more hands-on practical approach was used looking at case studies using layout plans and projected images. This engaged the FSCD attendees much more directly and they responded by participating a lot more actively. We noticed a clear advancement in their understanding of the issues being dealt with, such as means of evacuation, propagation of fire and smoke between floors, compartmentation of risky areas, alarm and detection systems, etc.

Perhaps the trainers expected too much of the FSCD personnel after observing their progress during the case studies sessions, but during the site visit we noticed that they hadn’t picked up on many of the deficiencies in fire safety measures and provisions covered in class. Once we focused their attention on the issues they could relate them to what had been covered in the course and comment sensibly on possible remedial measures.
Overall it was felt that the training sessions were successful and that the objectives identified for presenting the Training Course were fully met. The FSCD personnel significantly increased their knowledge and awareness of fire safety design issues.

An area identified for further development and where more training was felt to be needed is to develop their capacity to recognise what’s missing in the package of fire safety design measures that they observe on the factory inspections.

Clearly, fire safety principles shall be taught and learned within a longer educational process. It was also noted that some fundamental safety issues were completely foreign in the country and that inspections and design techniques have developed so through the years with a gap in these fundamental topics. The most remarkable example is the ‘no-protection’ of stairs in multistory buildings, an entire culture of leaving stairs open in factories has started to change, but it will require a couple more years to become understood by all stakeholders and building designers including owners, architects and engineers.

THIRD PROJECT – ANALYSING FACTORIES FOR OVERALL FIRE SAFETY
As mentioned before, the UN Agency ILO agreed with the National Tripartite to assess building safety improvements for factories during a five year period, the other factories were to be assessed by The Accord and The Alliance. This project was part of the first phase of these assessments which consisted in the inspection, reporting and categorization of the safety standings of the factories. During 2.5 years, a total of 3500 factories were surveyed, with ILO having made the largest contribution with 40% of the factories, approximately 1375 factories.

The project
This third project was part of this initiative requiring Arup to assist ILO with quality assessments of surveyors from Bangladesh University of Engineering and Technology (BUET) and from private contractors surveying factories not only for Fire Safety, but also for Structural and Electrical safety within the framework of a governmental initiative involving different key stakeholders related to the RMG industry in Bangladesh. The main objective has been to carry out assessments in order to identify factories that are unsafe or require remedial action.

This international economic and educational support was assisted by Arup. It involved a first stage for promoting and help sharing fire engineering and safety knowledge to local engineers, fire safety personnel and private local initiatives. Training and technical guidance was also given throughout the surveying process in order to improve the quality of the reports.

This assessment – in contrast to the first initial project presented – involved a larger effort based on a long-run process to assess, guide, improve and refurbish a large amount of factories for clear set out safety improvements. The benchmark for a satisfactory safety level was agreed and developed by many different stakeholders under a governmental framework and initiative.

Relevant findings
For this paper, it seems important to show overall general characteristics of the many factories surveyed.

Four fire safety measures or categories were identified as being a priority in terms of ensuring safe evacuation in the event of fire. These are categories found with typical deficiencies throughout factories in Bangladesh:
1. Effective fire detection systems
2. Automatic fire alarm systems
3. Protected escape routes
4. Fire separation of areas with unusually high fire loads

In general, most factories have deficiencies on the design, implementation and installation of passive and active fire safety systems, but the above four categories are considered the most critical ones for the safety of the workers. Housekeeping is also a common issue where combustibles many times are located along protected evacuation routes, blocking the routes or simply creating a risk area at the wrong locations. Probably the most critical issue is the fact the most – if not all – multistory factories, do not have fire protected staircases.

No meaningful trends were found in the provision or absence of these measures when analysed against age, location or size of building. Deficiencies in these areas appears to be endemic, reflecting a lack of appreciation of their purpose within the industry.

Instead of focusing on the above four fire safety measures and other relevant ones, five key ‘risk factors’ were determined in order to have a reference or ‘rule of thumb’ framework of when a factory could have a higher or lower qualitative fire risk. This was based on an analysis of 75 randomly selected reports reviewed by Arup, an appropriate representative statistical value.

High Rise Buildings – Higher rise buildings have larger potential fire areas, more levels on which fire and smoke can propagate, and longer evacuation times. The benchmarking guidelines define buildings higher than 23m as high rise buildings, most of the times equivalent to more than 6 storeys. Most, if not all factories surveyed had unprotected stairways.

Multi-tenancy – Buildings with multiple tenants generate difficulties in terms of integrating safety systems, and management of those systems. They are also more likely to have inconsistent fire safety measures.

Ground floor mixed use – Buildings where the ground floor is divided due to mixed use are more likely to have unsafe evacuation routes at discharge (ground) level as well difficulties integrating fire safety systems. For example, where the rear area is a factory, and a shop is located facing the road.

Basement – Basements are typically utilised for operations that have higher than average fire risks. If not properly fire separated from the upper floors they create higher risks on the factory floors above. Most, if not all factories surveyed had unprotected stairways, including stairways connecting the basement floors.

Mezzanine – Mezzanines are more likely to lack adequate fire separation from floors below and may also have extended evacuation distances, putting mezzanine occupants at higher risks in the event of fire.

Relatively few factories had basements or mezzanines, but the majority were multi-tenancy and a significant proportion high rise. It is reasonable to assume that where a factory combines one or more of these risk factors, the overall fire risk for occupants in the building will be greater. Buildings with 2 or more risk factors could be considered potentially ‘high risk’ factories,
although the actual level of risk is also influenced by the fire safety measures provided. Based on this approach:

- 31% were considered ‘high risk’; with 12% of these having 3 or more risk factors present;
- 39% present one risk factors;
- 30% present no risk factors therefore can be considered ‘low risk’ in terms of fire safety and safe evacuation.

It is important to note that even if a building presents few, or even zero, typical ‘risk factors’ it does not mean that the fire safety measures required have been implemented; therefore, it could still display many fire safety deficiencies.

ONGOING TRAINING PROJECT
An additional ongoing project is presented here to show how the different national and international initiatives are developing and seem to be leaving a legacy beyond the assessment and remedial tasks for factory improvements.

The Accord is interested in delivering a comprehensive training program to their local engineers in the fields of fire, structural and electrical engineering. The idea is to look ahead and build capacity and skills that the engineers will require in the future to successfully deliver projects in Bangladesh.

The project will consist of four main tasks:

- Identify Training Needs – Diagnosis analysis that has taken place to understand the current knowledge level, needs and career aspirations of the 90 engineers to be trained.
- Developing training materials and implementing the programme – Design
- Delivering three training workshops – Delivery
- Providing post-Course continuous development – Consolidation

Different levels of training will be required within the fire course to suit different roles on projects, e.g. technical or project manager, or co-ordinator.

The training will develop discipline specific knowledge of participants in Structural, Fire and Electrical engineering, but will also aim to give participants a broader multi-disciplinary appreciation of other areas of building design and the regulatory context.

The training will include modules applicable to all 3 disciplines, but most will be specific to a particular discipline. Relevant topics to be covered are:

- Technical surveys
- Design of new buildings
- Retro-fitting and remedial works
- Building Codes and Standards
- Regulatory framework and procedures
CONCLUSIONS
The following conclusions focus on key learnings as a result of the different projects presented. The learnings are relevant to Bangladesh and the ongoing initiative, but are also relevant to the international public and fire safety practitioners taking part in the design of new buildings and in the improvement of existing ones in developing and in developed countries.

The projects described above exemplify that fire safety implementation in buildings requires the involvement of many stakeholder teams, where each one of the teams involved needs to have certain skills and fundamental knowledge. The stakeholders need to understand their roles and have a clear action route to be provided by a framework of governmental procedures and law enforcement. This has proven to be complex in many developing countries and where a long route of administrative reforms and educational developments are still required.

Fire engineering, computational models, modernization of fire protection systems, technological advances, all have improved a lot in the past three decades. Universities are now more and more involved in interesting research projects to test and rationally understand construction materials and building behavior against fire. This is clearly important for the present in fire safety developed countries and for the future in fire safety developing countries, too. We shall not stop this, however, a gap appears to exist in low developed and mid developed countries where this existing knowledge and technical advancements are not being used nor implemented due to different reasons.

One important reason for writing this paper is to question ourselves, if the international fire engineering community can do something else so fill a gap in transferring knowledge to the areas of the world that are more or most vulnerable to fire disasters, e.g. developing countries with a high manufacturing culture. We invite the participants of this international SFPE conference to think about the following questions:

1. Is SFPE having a direct impact in the entire range of countries, from the highest developed ones to the lowest developed ones in terms of fire safety practices, guidelines and codes?

2. Are fire engineered solutions or performance-based approaches practical or relevant in middle income and low income countries that are lacking fundamental fire safety practices?

3. Would international standards such as ISO standards be helpful, if developed towards an international market of developing countries in parallel to their local building codes?

The most remarkable conclusions derived as a result of the projects mentioned above are:

Technical knowledge – At the time of assessing, surveying and refurbishing existing buildings to achieve a high level of design and detailing, it is necessary to involve technically skilled people within the teams of all stakeholders.

Ideally, fundamental technical skills shall be acquired at university level, but practical professional skills are also required. Currently, developing countries requiring fire safety assessments of existing (and also new) buildings, will need to build capacity from international sources such as private companies and educational and governmental institutions.
Currently, a big difference in educational level exists between countries with a tradition in fire safety engineering, and developing countries in general.

**Fire safety is more than design** – Fire safety design is not just about design; to be meaningful, fire safety designs need to be administratively regulated, implemented and commissioned correctly with ongoing management and maintenance procedures in place.

**Regulatory framework** – All fire safety stakeholders need to understand the local jurisdiction and be accountable for their responsibilities.

**Fire risks and costs** – Building projects in developing countries tend to have more financial limitations making fire safety measures to be perceived as unpractical in many cases. Quantitative or qualitative fire risk based analyses could be orientated for cost benefit analyses to figure out if some countries or industries need to focus more on some fire safety measures before other measures.

**Resilience and safety risks** – Some developing countries may undermine fire risks in comparison with other risks, such as seismic risks that usually appear to be – but may not be – higher due to the typical larger event magnitudes.

**Design for safety since the beginning** – International companies should take into consideration this major international and national initiatives happening in Bangladesh to mitigate mistakes from the past, and try to involve local governments, organizations and companies to start designing for safety from the beginning. We are seeing examples of this conscious planning already happening in new projects – being promoted by garment companies – in developing countries with building safety practice deficiencies.