

SCOSS TOPIC PAPER

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Elliot Mall Inquiry

Introduction

In May 2012 part of the roof of a thirty two year old Mall in Quebec, Canada collapsed killing two people and injuring nineteen. There was a subsequent Public Commission of Inquiry and the conclusions make uncomfortable reading but offer food for thought to all involved in the design, inspection and maintenance of publically used buildings – particularly those with roof top car parking. The role of the Commission was not to castigate but to seek to prevent recurrence.

The Elliot Lake Commission of Inquiry ⁽¹⁾ report published in October 2014 gives various reasons for the collapse at the Algo Mall. It recounts a saga of inappropriate initial construction, neglect over many years by three different owners, reports from engineers that were ignored, and reports that inadequately addressed the issues. During almost all of its thirty two year history the roof had leaked and the ultimate cause of collapse was corrosion of a weld after long term exposure to water and chlorides.

The Commission's findings

The Commission found that the collapse was due to human failure. To quote part of the summary:

Many of those whose calling or occupation touched the Mall displayed failings – its designers and builders, its owners, some architects and engineers, as well as municipal and provincial officials charged with the duty of protecting the public. Some of these failings were minor; some were not. They ranged from apathy, neglect, and indifference through mediocrity, ineptitude, and incompetence to outright greed, obfuscation, and duplicity. Occasional voices of alarm blew by deaf and callous ears.

Some engineers forgot the moral and ethical foundation of their vocation and profession – to hold paramount the safety, health, and welfare of the public.

The Algo Mall was a centre in the retirement-living community of Elliot Lake as a shopping centre and social destination. It was built in 1979-80 with 15,000 m² (165,000 ft²) of retail space, 1,200 m² (12,500 ft²) of offices. The structure was a three storey steel frame with pre-stressed precast hollow core slabs for both floors and roof. It complied with the then current 1975 Ontario Building Code. There was no code specifically for parking structures but the roof was a car park with 334 spaces.

Roof structure

Hollow core pre-stressed units were 203 mm (8 in) deep, 1.2m (4 ft) wide and typically spanned 9.1 m (30 ft). There was insulation beneath the units and an insitu topping above. The decision to use hollow core units for parking deck was unusual as the norm was for long span double-T units. Even more unusually, the Commission concluded it was not thought necessary to provide a full waterproofing system or wearing course.



The collapsed roof structure

Press Association Images

Weather in the region is severe in winter with low temperatures and snow - the design snow load was 1.3 kN/m^2 (27.5 lb / ft^2). Insulation was provided beneath the units so the top surface of the concrete was exposed to freeze/thaw conditions and traffic including snow ploughs. The slabs were also susceptible to movement due to temperature changes. There was no air-entrainment in either the precast slabs or the topping although this was found not to have contributed to the failure. The waterproofing was designed and installed by a specialist company with considerable experience and a track record of successful projects. In this case they adopted the method usually used for long span double-Ts although it had not been used

before with hollow core units (which were less than half the span of a typical double-T).

Longitudinal V-shaped edges between the units were grouted but spaces at the ends were left un-grouted to allow for movement. The Commission found there was no mention of continuity reinforcement over the supports and indeed there seems to have been a view that cracks would form at these joints anyway so this should be encouraged. A composite insitu fabric reinforced topping 75-100 mm (3-4 in) thick or more was used to aid load bearing capacity and help with drainage falls. Three complete structural expansion joints were provided through the building and finished at roof slab level with sealant. Crack control joints were created in the longitudinal direction of the slabs at every third joint (i.e. 3.7 m or 12 ft) where there were strips of waterproof material between the units and the topping. The Commission found the design intent was to preform V shaped recesses in the topping at these positions whilst the concrete was still plastic and subsequently fill these with sealant. At the butt joints over the steel beams, generally every 9.1 m (30 ft), the intent seems to have been for the same technique but there may, in practice, have been complete separation though the topping. There was a membrane strip over the joint between the ends of the units, a filling strip in the joint, and a sealant at the surface. There were therefore many joints in both directions and many potential points for leakage should these not be waterproof.

The Commission found that from day one the roof leaked and numerous attempts were made to fix it throughout the life of the building. Water found its way through joints, in between the slabs and the topping, onto the supporting steelwork, and into the retail units below. In winter the water contained de-icing salts. Over time the topping debonded in parts and there was significant corrosion of the structural steelwork.

Eventually there was a sudden collapse as a steel frame connection between a beam and a column failed and debris fell into the mall.

The lack of continuity and tying of planks to supports meant that when failure did occur there was no alternative mechanism. This issue is now covered in the *Practical guide to structural robustness and disproportionate collapse in buildings (2010)*⁽²⁾.

Responsibilities

The Commission found that no individual, or prime consultant, was responsible for the whole design and construction; the architect prepared architectural drawings, the engineer handled structural design, the developer acted as main contractor, and a specialist firm was in charge of designing and applying the waterproofing system to the roof deck.

One of the criticisms made by the Commission was that all three owners involved in the property had the resources to fix the leakage problem but none did so. Their preferred option, the Commission found, was to continue to patch and seal the roof cracks despite the fact that the repairs were not working. Over its lifetime there were several engineering inspections, either in relation to the leaks or of a more general nature. The Commission says;

Some engineers forgot the moral and ethical foundation of their vocation and profession – to hold paramount the safety, health, and welfare of the public.

It goes on;

Some of the inspections were so cursory and incomplete as to be essentially meaningless. Others were fundamentally flawed because they were based on false assumptions or calculations.

Several reports pointed out the risks of not carrying out proper remedial work but they were ignored. None of the professionals appeared to have anticipated the severity of corrosion caused by years of leakage and the effect of water-entrained chlorides on the steel below. It was found that little attention was paid to connections between beams and columns. Public officials who could have intervened were also criticised for ignoring repeated complaints about leaks and did not enforce, or improperly enforced, their own property standard by-laws. Some public officials were apparently unaware of the contents of their own by-laws.

A sad and damning incitement indeed of the whole process, but a welcome airing of all the facts such a short time after the event. By comparison many years can elapse in the UK before the results of an enquiry are published.

Recommendations

The Commission made a number of recommendations for implementation in the state of Ontario. Those which are most generally relevant are summarised below.

- There should be minimum structural maintenance standards for buildings.
- Owners of buildings should be required to ensure that their buildings are inspected periodically by a properly qualified structural engineer.
- The Engineer's governing body (in Ontario) should have a performance standard for such inspections.
- Inspections should take place when buildings are sold and more frequently if public safety dictates.
- Inspection reports, with recommendations for repairs, should go to the owner and be placed in a publically accessible register.
- If the condition of the structure does not meet minimum standards a copy of the report should go to the local authority who should have the power to issue an order requiring repairs.
- In the case of non-compliance by an owner the local authority should have the powers to prohibit the use of a building or cause it to be repaired or demolished for the protection of the public.
- Information about building condition should be easily accessible and understandable to owners, the public and potential buyers.
- Enforcement of standards should be straightforward and public authorities should be made accountable for their decisions and actions.
- Professional engineers and municipal building officials should be trained and certified, and information about them be accessible to the public.

In some countries such standards already exist, at least in part, whilst in others the implementation of these recommendations would greatly improve public safety. The response to the Commission's report in Ontario is not yet known.

Lessons to be learned

This Topic Paper has been published by Structural-Safety⁽³⁾ so that the lessons to be learned from the Commission's report can be more widely known. In particular:

- Designs incorporating unusual features, in this case an untried waterproofing system, may be vulnerable to unexpected consequences,
- Roof top car parks are safety critical and any weakness in the waterproofing will be serious,
- Continuity and robustness must be included in all such buildings,
- Public buildings should be periodically inspected by professional engineers and properly maintained.
- An engineer's duty is to report objectively and, on occasions, it may be necessary to put the safety of the wider public before any duty to the client.

References

1. Report of the Elliot Lake Commission on Inquiry, <http://www.attorneygeneral.jus.gov.on.ca/inquiries/elliottlake/report/index.html>, accessed 15 December 2014
2. [Practical guide to structural robustness and disproportionate collapse in buildings](#) (2010), The Institution of Structural Engineers, London, accessed 15 December 2014
3. Structural-Safety, <http://www.structural-safety.org/>, Accessed 15 December 2014

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