

# CROSS-SA

## Confidential Reporting on Structural Safety Southern Africa

THE FOLLOWING TWO reports were recently submitted to CROSS and will appear shortly in the on-going quest to keep designers up to date with areas of design wherein the required standards of design and supervision have not been met.

These designer-created problems are a failure of the structural design process and of the understanding of the wider safety issues – from which we all can learn.

### **FAILURE TO CONNECT A BEAM TO A COLUMN IN A STAIRWELL IN A REINFORCED CONCRETE FRAMED BUILDING**

Excessive deflection of a floor slab which incorporates a stairwell was observed following the stripping of shutters of the second floor of a four-storey reinforced concrete frame building during its erection. Cracking was also observed in the corner of a slab in the floor above. Work was stopped in this building for safety reasons, and the affected slab was propped, pending the assessment of the slab and the issuing of instructions for remedial work.

An investigation found that a gross drawing and detailing error had occurred. The modelling of the structure indicated that a column was supposed to support the second floor, whereas the detailing and construction were such that it ran through the void. This occurred following the change in the management of the structural division of the consultant and

a change in the staff member responsible for the structure as a whole.

The safety question that needed to be answered was, was this a gross error, a once-off incident, or a systemic problem, in which case what other issues could surface? The consulting engineer had been contracted to provide services in accordance with the provisions of the Joint Structural Division's *Standard for Structural Engineering Services*. The employer's engineer probed the workings of the consulting engineer, using a checklist based on this standard. This probe revealed that the service had not been discharged in accordance with this standard, as several gaps were detected. The consulting engineer was instructed to certify the structural work in accordance with the provisions of the contract. This was necessary to ensure the safety of the building, not only in use, but also during construction of the outstanding work.

The failure on the part of the consulting engineer to use the skill and care normally used by professionals providing similar services resulted in costs which the employer had to cover and, where possible, recover from the consulting engineer. This included:

- the identification and assessment of the impact of the substandard professional service on the structural safety performance of the building
- the remedial work to affected portions of the structure



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- the closure of the affected portion of the works until such time as the building as a whole could be declared safe
- the disruptive impact on the work of the contractor and others, including standing time
- the acceleration of the works to ensure that the building could be occupied for its intended use according to the owner's requirements, and
- delayed completion.

#### Lessons learned

Errors and omissions can occur. If this occurs in an environment where the structural engineering services are of a high standard, the defective work can be readily isolated. This results in substantive savings in costs, as in this instance the cost of the repair to the slab was about one fifth of the total cost of the incident.

### HANGER DETAILS TO REINFORCED CONCRETE SLABS

The edges of the second- and third-floor slabs around a stairwell were tied to the roof slab of a multi-storey reinforced concrete building by means of steel hangers. The design was such that the connection transferred only the load for each floor onto the hanger via a bracket bolted onto the face of the slab, as indicated in Figure 1. The drawing showed the hanger to be continuous, but did not indicate how the hanger was to be made continuous, e.g. via a coupler. The contractor changed the detail to that indicated in Figure 1, without referring it back to the designer. The change in detail more than doubled the forces on the connection detail.

Directly after the release of the jacking props on the second and third floors that had been jacked up to zero deflection for the installation of the hangers, the fixing bolts of the third floor slab's brackets failed by breaking out of the concrete. The report on the failure by the consulting engineer failed to pick up the change in loading and ascribed the failure to incorrectly installed bolts and faulty workmanship.

It is of interest to note that a similar change in detail of a continuous hanger to discontinuous hangers led to one of the deadliest structural collapses in US history, which was only surpassed in 2001 with the collapse of the south tower of the World Trade Centre. The Hyatt Regency Hotel walkway collapse, Kansas City, in July 1981 claimed the lives of 114 people and injured a further 216 people (see [https://en.wikipedia.org/wiki/Hyatt\\_Regency\\_walkway\\_collapse](https://en.wikipedia.org/wiki/Hyatt_Regency_walkway_collapse)). This was caused by a design change proposed by the contractor for buildability reasons. The engineer approved the changes over the phone without viewing the sketches or performing calculations.

#### Lessons learned

Care needs to be taken to fully detail hangers, including how continuity in hangers can be practically achieved on a site. Designers need to understand the impact of discontinuity in hangers, and contractors need to obtain the approval of the structural engineer before changing details for reasons of constructability.

### IN CONCLUSION

*Risk, reliability, liability and safety* are not well enough taught (if at all) and not

properly covered in CPD (Continuing Professional Development). They are probably not discussed widely enough in institution circles either. In the view of Mann, ISE 2003 – still fully relevant today – all structural engineers should:

- have a working knowledge of classic failures and their causes
- have an understanding of the concepts of *safety* and *reliability*
- have an understanding of common construction risks allied with an understanding of safe site practice
- have an understanding of risk assessment and allied techniques
- understand that, as qualified engineers, they have to rise above the purely prescriptive assessment of structures and understand how structures can be made *safer*
- have an understanding of the basic uncertainties in the commodities engineers deal with – loading, structural performance, construction, the design process
- have an understanding particularly of site risk and the interaction between design and construction
- understand that everything is risky, but that certain risks are more tolerable than others
- understand the risks inherent to human behaviour (especially in crowds)
- learn about managing risk and taking balanced judgments
- learn the need to demonstrate that they have tried to assess the risks and manage them
- learn more about *systems* and the need to look at systems as a whole, rather than as individual elements – this would include the interrelationship between structural engineering and other disciplines such as mechanical and electrical engineering
- understand the concept of *uncertainty*
- understand Health & Safety legislation/regulations and their legal liabilities
- learn to handle financial risk and control the financial risks to their companies, and
- understand environmental risk.

We need **YOU** to help us begin to understand the problems within **OUR** industry, thereby enabling others to **LEARN** from the problems that have occurred.

Please confidentially report structural problems via the CROSS-SA website (<http://www.structural-safety.co.za>). □

