ECSA

THE ENGINEERING COUNCIL OF SOUTH AFRICA

CASE STUDIES ARISING FROM CONTRAVENTION OF ECSA's RULES OF CONDUCT FOR REGISTERED PERSONS.

PUBLISHED BY ECSA TO MINIMISE THE RISK OF RECURRENCE

Case Study No. 2012/3 : Inadequate design and lack of monitoring of erection leading to collapse of a staircase

THE PROJECT

A new staircase in an existing building, to provide public pedestrian access between two floors.

BACKGROUND TO THE CASE

The new owners of an existing building in a city centre required to improve pedestrian access between two floors of the building, to accommodate public assemblies. The lower floor consisted of an auditorium with seating to be accessed by members of the public from the floor above. A firm of consulting structural engineers was engaged to design two large staircases, one on each side of the auditorium. Each stair led from auditorium floor level to the floor above through an opening cut into the upper floor structure. One was a mirror image of the other. A registered professional engineer of the firm was put in charge of the assignment.

Shortly after the staircases were completed and the building was taken into use by the owners, one of the staircases collapsed on to the floor of the auditorium. The stair was in use at the time with people on it. Some 80 persons were injured, but there were no fatalities. The collapsed structure was removed and replaced with a new structure. The other undamaged stair had to be considerably modified to make it safe.

ECSA appointed an expert to investigate the structure and report to the Investigating Committee if *prima facie* evidence existed of any contravention by the engineer of ECSA's Rules of Conduct, arising from the collapse. Evidence was established and the engineer was charged. The engineer pleaded guilty and in a settlement agreement agreed to pay a fine of R20 000.

DETAILS OF THE PROBLEM

Each stair was constructed with steel stringers and treads carrying granite panel inlays. The stair comprised a first flight ascending to an intermediate landing, a second flight to a 6m long walkway, a third flight to another intermediate landing and a longer fourth flight to the upper floor. The vertical distance between floors was 6m and there was a change in direction at each intermediate landing. At the bottom the stair rested on the auditorium floor structure. The walkway and flights 3 and 4 were supported by hangers fixed to the floor above, which was a suspended concrete slab of coffered construction.

By arrangement between the consulting engineer and the steelwork subcontractor, the final detail design and preparation of shop drawings for fabrication were carried out by the subcontractor and approved by the Engineer.

The expert's investigation revealed a number of faults:

a) The walkway had to be lengthened by 1.4m to agree with the General Arrangement drawings.
b) The placing of the hangers on site did not correspond with the positions on the drawings
c) Fewer hangers were installed on site than shown on the drawings
d) As a result some hangers were carrying heavier loads than designed for.
e) This was aggravated by too low a design load on the stair being used to design the hangers (4 kN/sq.m instead of 7 kN/sq.m)
f) The subcontractor elected to weld the lower ends of the hangers to the top flanges of the channel stringers of the walkway instead of using a bracket detail shown by the Engineer.
g) The coffered slab construction of the upper floor structure prevented the use of the Engineer's fixing detail for the tops of the hangers. A row of 3 or 4 bolts held an inverted channel beam to the underside of the coffer rib with a cantilevered end from which the hanger was suspended. This was a very unsatisfactory solution as it placed bending in the beam about its weak axis and severe tensile forces on the bolts nearest to the cantilevered end.

The collapse of the staircase was triggered by failure of a number of hangers at their connections, simultaneously and in sequence while the stair was carrying a load of pedestrians.

Further faults were noted in the investigation at the openings cut into the existing floor structure to receive the 4th stair flight. The Engineer had specified galvanised mild steel strengthening plates anchored and epoxied to the underside of the slab, to compensate for the weakening brought about by the new opening. The plates installed were red oxide coated (reducing epoxy adhesion) and not all plates were continuous, with butt joints being unconnected or not welded together. Some plates moreover had been fixed into a weak concrete/rubble infill which had been placed to make up for overbreak. These latter faults did not however cause the stair to collapse when it did.

The design calculations by the Engineer were generally correct but did not take into account the coffered slab construction of the upper floor, which led to the failure of the inadequate fixing of the hangers to the floor. The investigation found the Engineer to be seriously at fault in not ensuring that the construction of the staircase was done in compliance with the specified requirements and details

While the Engineer is not responsible for errors and poor workmanship of the Contractor, it is inconceivable the Engineer would have approved of the defects if he had seen or been informed of them. It follows that the Engineer did not inspect, or failed to notice, or negligently approved the numerous incorrect actions of the Contractor, and it was these actions which led to the collapse.

In response to ECSA the Engineer pointed out that the construction monitoring duties had been delegated to two members of his staff, both of whom were qualified with a B.Sc. Eng. degree, and each having at least 5 years' experience. It transpired these persons were Candidates for ECSA registration. Since their involvement did not shift any responsibility from the Engineer, no action was taken against them.

The Engineer was charged with contravening the following ECSA Rules of Conduct:

> Rule 3(1)(a) in that the Engineer failed to discharge his duties to his client effectively with skill, efficiency, professionalism, knowledge, competency, due care and diligence;
>
> Rule 3(3)(a) in that the Engineer failed to have due regard and priority for public health, safety and interest;
>
> Rule 3(5)(c) in that the Engineer failed to provide work or services of quality and scope, and to a level, which is commensurate with accepted standards and practices in the profession;
>
> The Engineer pleaded guilty to the charges, in particular the contravention of Rule 3(5)(c). A settlement agreement was reached, with a fine of R20 000 being imposed by ECSA

WHAT LESSONS CAN BE LEARNED ?

Lessons to be learned are chiefly in the area of construction monitoring by the Engineer and construction by the Contractor:-

Lessons for the Engineer:

1. Notwithstanding the Contractor's responsibility to construct the Works in accordance with the contract specifications and requirements, irrespective of the Engineer's approval, the Engineer remains responsible for monitoring the Contractor's work in a professional manner, with due skill, care and diligence, if monitoring is included in his agreement with his client.

2. This responsibility stays with the Engineer even if the duty is delegated to a subordinate person. In particular if such a person is a Candidate engineer, Section 18(4) of the Engineering Profession Act requires that a candidate "must perform

work in the engineering profession only under supervision and control of a professional of a category as prescribed". This in effect extends the responsibility of the Engineer.

3. Shop drawings for steelwork fabrication prepared by a subcontractor must be examined by the Engineer, to confirm that sections, key connections, leading dimensions and method of erection comply with the Engineer's design.

4. When alteration to existing structures are involved to accommodate new structural elements, the Engineer must ensure he is fully informed as to the nature and dimensions of the existing structure and that strengthening measures designed by him are correctly fabricated and installed.

5. The Engineer should ensure that bolt fixings, epoxy resin-based connections and surface preparation are correctly done, according to his details.

6. No reliance should be placed on the Contractor by the Engineer to alert him to any need to alter his details or his design due to unforeseen conditions on site – the Engineer is obliged to keep himself familiar with all conditions on site which could pose a risk to a successful installation.

Lessons for the Contractor/subcontractor:

7. Be aware that the constructing parties carry full responsibility for their materials and workmanship meeting requirements, including rectification of defects, irrespective of the extent of construction monitoring being exercised by the Engineer

8. Ensure the design information, erection procedures and fabrication details to be furnished by the Engineer are sufficient for their purpose, without the Contractor having to make assumptions or misinterpretations.

9. Advise the Engineer immediately of any discrepancies in dimensions or inconsistency of details, to be resolved by an Engineer's clarification or instruction.

10. Ensure all fastenings and fixing bolts are correctly positioned and installed in sound parent material, without cutting or redrilling, which could weaken the connection.

11. Do not provide any alternative fixing methods or fabricate any modifications to the structure or connections without confirming the need for them and approval thereof by the Engineer.

12. Ensure that all materials, fixings and connections shown by the Engineer are installed, with any article being omitted (say due to lack of fit) brought immediately to the Engineer's attention.

-o0o-