ECSA (Engineering Council of South Africa) has prepared five case studies arising from the contravention of ECSA's Rules of Conduct for Registered Persons. These case studies are offered to the engineering fraternity as advisory notes to minimise the risk of recurrence. *Civil Engineering* will be publishing these case studies over five editions – herewith then the first of these case studies.

The consequences of the collapse

of a portion of a three-storey office block structure

THE PROJECT

The project: a three-storey office block, with a reinforced concrete structure, comprising spread footings, columns, floor slabs and basement retaining walls.

BACKGROUND TO THE CASE

The building occupied a footprint of approximately 75 m x 40 m. It comprised a parking basement with two office floors above, and a tiled roof supported by timber trusses, resting on external walls.

Following construction of the reinforced concrete structure, during placing of roof tiles and while building of the internal brick walls were under way, the concrete structure collapsed over roughly half the plan area of the building. Thirteen workers were reportedly injured, one was killed and another went missing in the accident. The Department of Labour and ECSA began investigating the incident immediately. It transpired that an engineer registered with ECSA had been involved. The immediate inspection done by an ECSA expert revealed that the cause of failure of the structure was likely to have been 'punching' of the columns through the flat floor slab. The design had been carried out by the engineer concerned. ECSA accordingly proceeded with a full investigation.

DETAILS OF THE PROBLEM

ECSA's expert was requested to establish if any *prima facie* evidence existed of improper conduct by the registered engineer, judged in terms of the ECSA Rules of Conduct for Registered Persons. During interviews the following points were noted:

- The engineer did sign the 'A19' form of the local authority confirming his appointment as the person responsible for design.
- The engineer designed the floor slab reinforcing but did not issue drawings or bending schedules, only providing A4 sketches instead.
- Calculations for the design of the structure could not be retrieved.
- Openings in the floor slab were not taken specifically into account in the design.
- No geotechnical investigation was done for foundation design; a safe bearing pressure under the footings had been assumed. This may have been insufficient.
- The engineer relied on verbal instructions given on site, including increasing concrete strengths, and indicating reinforcement bar bending details.
- Saw cuts in the ground floor suspended slab had been introduced, apparently to allow for thermal movement.
- The engineer did his own checking of his calculations and/or details.

An analysis of the concrete structure was carried out by the expert, who found the design to be deficient in a number of respects, including:

- The first floor was carried partly by the columns and partly by load-bearing brick walls on the ground floor, but the brick walls were not located over the column lines.
- The ground floor was acting as a 'load transfer' slab, but had not been designed as such.
- The floors were built as 'flat slabs' (without beams), but the reinforcement for this was insufficient, particularly in the vicinity of the columns.
- The risk of a 'punching' shear failure in a slab around the column was greatly increased.

- The suspended ground floor slab should not have had saw cut joints cut into it – this weakened the slab considerably.

It was concluded that the engineer was not competent to design the structure in question, and his method of executing the design and drawings showed negligence and no appreciation of the design complexity.

The engineer was accordingly charged with contravening ECSA's Rules of Conduct as follows:

> 3(1)(a): Failed to discharge his duties to his client and the public effectively with skill, efficiency, professionalism, knowledge, competence, due care and diligence.
>
> 3(1)(b): Undertook work of a nature for which his education, training and experience have not rendered him competent to perform.
>
> 3(1)(c): Failed to engage and adhere to acceptable practices.
>
> 3(2)(b): Undertook work under conditions or terms that compromised his ability to carry his responsibilities in accordance with acceptable professional standards.
>
> 3(3)(a): Did not have due regard and priority for public health, safety and interest.
>
> 3(5)(c): Did not provide work or services of quality and scope and to a level which is commensurate with accepted standards and practices in the profession.

In view of the seriousness of the matter, ECSA sought to temporarily suspend the registration of the engineer, pending a hearing by a Tribunal. The suspension was approved at a suspension hearing, taking into consideration that two other complaints against the engineer had been received in the interim. The suspension was enforced until the disciplinary hearing to consider the charges against the engineer, which charges he denied, had taken place.

The disciplinary hearing by a Tribunal took place at ECSA a month later. The engineer maintained *inter alia* that the collapse was not caused solely by him, that he was not responsible for producing the structural design, that he did not err when reacting to the punching failure, that the design was altered without his knowledge, that his scope of work included only limited site visits, and that the design changes altered the loading on the structure, culminating in overloading during construction. The Tribunal found the engineer to be guilty on all six counts as charged. The sentence handed down was that the engineer be deregistered. The engineer appealed against the decision of the Tribunal, but the appeal was dismissed by the ECSA Council. The cancellation of the engineer's registration was subsequently published in the Government Gazette.

WHAT LESSONS CAN BE LEARNED?

A number of lessons to be learned exist in various areas:

In the design of the structure:

1. No geotechnical investigation was carried out to enable appropriate foundations to be designed. Reliance was placed on the properties of the subsurface materials occurring generally in the area. The check of the design of the structure indicated that the bearing pressures on the soil beneath the footings could have exceeded the assumed values. This could cause uneven settlement in the structure and stress in the floor slabs which had not been designed for. It is thus vital, to avoid such risk, that a foundation investigation should be done at the site of the building by a geotechnical engineering specialist.

2. The approach to the design of the structure was inadequate, in that an effective arrangement, to ensure that all loads were transferred to the ground, was lacking. The first floor slab was supported in part by walls resting on the suspended ground floor, and in part by the columns. No attempt was made in the design to transfer the wall loads through the suspended ground floor to the columns below. The design approach must include a check to ensure that all loads (dead and live, horizontal or vertical) acting on the structure can be carried safely to the ground.

3. The design of the suspended ground floor slab was inadequate. It was constructed as a 'flat slab', but insufficient top reinforcement was provided, particularly over the columns. This could lead to overstressing the underside of the slab in the spans between columns and severely reduce the resistance of the slab to 'punching' by the columns through the slab.

4. This was aggravated by saw cuts made in the slab, across the building width, allegedly for expansion joints. Such cuts also severely reduce the bending resistance of the slab and should never be made, unless the joint is a designed one, with the slab resting on twin columns below. This was not the case in the above situation.

5. To rely on sketches and ad hoc details instead of drawings for construction, is unacceptable. The latter should include dimensioned layouts, reinforcement fixing drawings and rebar bending schedules, at the very least.

6. Self-checking of designs and drawings does not give assurance that the design and drawings are free of error. This needs to be done by another party, even if confined to an overall review of the design to ensure the approach and analysis are correctly done, and random independent checking of drawings, to indicate that correct processes are being followed.

In execution of the assignment:

7. There was apparently no written agreement between client and engineer; arrangements were agreed and instructions given verbally. In design and construction of projects such as the above a proper consulting agreement (particularly specifying the site monitoring duties required of the engineer) and proper contract documentation, including instructions given and changes ordered, are essential.

8. In terms of National Building Regulation A19 the person appointed by the owner to be responsible for the design is required to sign the Building Control form of the local authority. This regulation requires appointment of "a professional engineer or other approved competent

person" to undertake responsibility for the design and inspection of the work, to check compliance with the approved design and to inform the authority "if it appears that any structural work is being carried out in a manner which may endanger the strength, stability or serviceability of the building". This form should not be signed by a person unable to assume such responsibility. Also, a failure to inform the authority could be construed as contravention of ECSA's Rules of Conduct.

In complying with ECSA's Rules of Conduct:

9. The conduct of the engineer clearly showed that Rules 3(1)(a) (lack of due skill, due care and diligence), 3(1)(b) (lack of competency), 3(1)(c) (unacceptable practices), 3(2)(b) (inability to carry responsibilities), 3(3)(a) (disregard for public health and safety) and 3(5)(c) (non-compliance with accepted standards) had been contravened. A lesson is to be learned from each one of these contraventions – a registered person must comply with all these rules to avoid sanction. In this case non-compliance with all the rules cited justified the sanction of deregistration.

10. ECSA has power to temporarily suspend a person's registration pending a disciplinary hearing if it is deemed that the seriousness of the matter justifies such a move. Clauses 14(g) and 14(j) of the Engineering Profession Act (EPA) state that the Council may *inter alia* take any steps it considers necessary "for protection of the public in their dealings with registered persons" and "where public health and safety is prejudiced". It is thus worthy to note that temporary deregistration can take place before finalisation of pending disciplinary proceedings, including appeals.

11. In terms of section 32(5) of the EPA, ECSA is enjoined to publish the findings and sanction imposed by a Disciplinary Tribunal in the Government Gazette. Such publication lists the Rules of Conduct which have been contravened by the registered person, and the sanction imposed. In the case above the sanction was cancellation of registration in terms of section 32(3)(a)(iv) of the Act.

12. A great number of contraventions of ECSA's Rules of Conduct arise from structural failures or mishaps, where the registered person believes he/she has the attributes necessary to undertake structural engineering work. Too often this is not so. A Code of Practice for Structural Engineering, which clearly states the attributes required to practise in this sub-discipline, is in preparation by ECSA.

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