Half Day Seminar on "Failure in Structures – Learning from the Structural Failures and Mistakes of Structural Engineers"

By : Ir. Ong Sang Woh

One hundred and twenty participants attended the half-day seminar on ***"Failures in Structures – Learning from the Structural Failures and Mistakes of Structural Engineers"*** by Mr. Leon Grill on 15 January 2005 at Bangunan Ingenieur, IEM. Mr. Leon Grill is at present, an independent consultant and has 48 years of experience in structural design, detailing, structural failures and diagnosis of the causes, problems of Codes of Practice and strengthening/ repair of the existing structures. He has also been practicing as Chief Proof Checking Engineer in Europe, South America, Australia as well as in Singapore and Malaysia.

The seminar was presented in two parts – i.e. *"Failures of Reinforced Concrete Structures"*, and *"Pathology of Steel Structures"*. Mr. Leon highlighted the reasons for structural failures, lessons learnt from these failures and the importance of reducing the unacceptably high number and frequency of failures. The use of competent Forensic Engi-neering reports and the compilation of reported failures into a data bank were reported. These are useful reference materials for cross-checking by the engineering profession in crucial investigative matters.

The lecture on *"Failures of Reinforced Concrete Structures"* commenced with a given report on the statistics of structural failures from various countries and the root causes of these failures. It was reported that between 43% to 59% of all these structural failures are caused specifically by design shortcomings only – some of which are incorrect choice of general design concept, poor detailing or details being left to the contractor, improper choice of materials and errors in design calculations. Other causes of structural failures (besides design defects) are attributed to poor con-struction by builders, use of defective construction materials, and misuse and/or improper maintenance of structures. Mr. Leon highlighted that the cost of wrong detailing or lack of detailing has increased dramatically as compared to the other causes of design failures. He also mentioned that the heavy reliance on the use of computer-aided design in the recent past has resulted in detailing being (sometimes) dangerously neglected.

A typical case history, which described the structural failure of a reinforced concrete cantilever roof of a sports stadium, was discussed. The speaker highlighted the presence of cracks at the top surface of the component, which may have contributed to the collapse of the cantilever structure. These cracks occurred, not at the face of the columns as expected, but close to the centre-line of the supporting columns – in total contradiction of the studied theory or as described in Codes of Practice. Consequently, laboratory tests were carried out and the experimental results obtained have confirmed that the type of structural failure found (as in the case of the RC cantilever roof of the sports stadium) is neither exceptional nor unique.

From thereon, the subject of design of corbels and the use of Codes of Practice was discussed. The speaker reported that laboratory tests conducted indicated that the general safety factor recommended by Codes of Practice was not always satisfactory. *(Note: The speaker recommended a factor of safety of at least 2.5 for live load in the design of corbels).* In addition, it was stressed that the proper detailing for the corbels is just as critical.

The second part of the seminar deals on the topic entitled, *"Pathology of Steel Structures"*. It was mentioned that the most repeated causes of structural steel failures are human in nature, i.e. ignorance, negligence and lack of foresight. The general known means of prevention are as follows:-

- Quality assurance through quality control at all stages during design and construction.
- Strict control of the quality of the materials to be used.
- Proof checking at all the stages of engineering design (specifications, conceptual, calculation, and detailing).
- Site control of assembly and provision of stability during erection.

Statistics and photographs showing collapse of steel structures and causes of reported failure were presented. Three categories of the causes of failures were identified as follow:-

(a) Those which occurs during erection.
(b) Those that are due to instability caused by buckling of members or thin plates.
(c) Those resulting from faulty assemblies.

In conclusion, the speaker introduced two practical recommen-dations to improve on the practice of engineering. They are:-

(a) To introduce short courses on structural failures in the universities.
(b) To have an independent peer review or proof checking at all stages of engineering design.

In addition, the speaker emphasized that the checking of design should ***not*** be limited to assuring that all parts of the design are in full agreement with the provisions in Codes of Practice, but must also based on sound and reliable engineering judgment. The speaker also gave a list of useful references on related subjects on structural failures.

During the discussion session, major issues pertaining to the use of Codes in design was debated and the speaker ended the session stating that engineers should always consider the Codes as a Guide and not use it as a Manual. ■