# Developing Case Studies in Failures and Ethics for Engineering Educators

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## Introduction

Over the years surveys conducted by the American Society of Civil Engineers (ASCE) Technical Council on Forensic Engineering (TCFE) Education Committee<sup>1-5</sup> have documented the following points:

- Engineering students, particularly undergraduates, should be informed about the important and historic failure cases that have shaped the profession the Quebec Bridge, the Kansas City Hyatt Regency, and others
- With appropriate course materials, these cases can be integrated into a number of civil engineering and engineering mechanics courses
- Most faculty do not have the time to develop case studies themselves, and would welcome a web-based source of case materials. Survey respondents asked in particular for a thorough online bibliography.

In response to the survey results, the National Science Foundation has funded a research project at the University of Alabama at Birmingham (UAB) entitled "Developing Case Studies in Failures and Ethics for Engineering Educators," as project number DUE 0127419. The two-year project began 1 March 2002. The project is being carried out with the support and input of the ASCE TCFE Education Committee. The case study materials developed so far are available at the following web address:

### http://www.eng.uab.edu/faculties/ndelatte/case\_studies\_project/

The site provides courses, course topics, and case study to illustrate those topics, as well as an extensive bibliography. This web site will be updated frequently during the project. As part of the project, UAB will host a one-day workshop for 24 engineering educators on 12 July 2003. Following the summer 2003 workshop, efforts will be made to provide additional workshops if there is sufficient interest. There is no registration fee for the workshop, and the workshop materials will be provided free of charge.

# **Case Studies Project**

The objectives of the case study "Proof of Concept" project are to:

- 1. Develop a master plan linking civil engineering and engineering mechanics courses, course topics, and case studies.
- 2. Identify published materials (articles, technical papers, books) covering those cases, if any.
- 3. Identify case studies requiring further research and development.
- 4. Develop some of the case studies identified.
- 5. Develop instructor's notes to accompany each case study.
- 6. Develop a web site for courses, topics, and case studies, and a version in print and CD-ROM (with PowerPoint presentations) for field-testing and dissemination. The web site is shown in figure 1.
- 7. Disseminate these materials through a one-day pilot workshop on 12 July 2003 to 24 faculty members, and follow up with them to determine how they use the materials in the classroom, and how the materials may be improved.

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Figure 1: Case studies project web page

The project is being carried out through the following steps:

- 1. Carry out a literature review to further develop the case studies bibliography.
- 2. Identify courses and lesson topics to which to link the case studies. Lesson topics should be identified for required courses in a civil engineering curriculum, including engineering mechanics courses and related courses in other curricula. Once these have been identified, it is possible to suggest case studies to support the topics.
- 3. Develop the master plan to link courses, topics and course objectives, and case studies.

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- 4. Draft an action plan to write case studies to fill in the gaps, and begin writing the case studies.
- 5. Prepare the case studies. These cases will address the following elements of each case:
  - Design and Construction
  - Collapse
  - Cause(s) of Failure
  - Legal Repercussions
  - Technical Aspects
  - Professional and Procedural Aspects
  - Ethical Aspects
  - Educational Aspects
- 6. Submit selected cases to the ASCE Journal of Performance of Constructed Facilities. This journal has already published two papers written by the author's students<sup>6, 7</sup> and has accepted another for publication.
- 7. Develop the materials in three formats web, CD-ROM, and print.
- 8. Disseminate the materials during a one-day workshop hosted by the University of Alabama at Birmingham on 12 July 2003.

# Web Site Materials

As shown in figure 1, the web site has an introduction that describes the background and rationale for the project, provides the detailed online bibliography, and discusses the faculty workshop. The heart of the web site is contained in the pages that link courses, topics, and cases. The material takes full advantage of the web's hypertext capability.

The background and rationale for the web site has been reviewed elsewhere<sup>5</sup> and will not be addressed here. The online bibliography is an important element requested by respondents to the ASCE TCFE Education Committee surveys<sup>1-5</sup>. The bibliography web page is shown in figure 2.

So far the outline bibliography lists the following references:

- 17 books
- 2 periodicals
- 20 journal papers on use of case studies
- 28 journal papers describing case studies
- 5 investigation reports
- Web sites, videos, television programs. The portion of the online bibliography listing web sites is shown in figure 3.

The faculty workshop will be discussed later in the paper. The "Courses" web page lists common courses in the engineering mechanics and civil engineering undergraduate curriculum.

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There are many sources for case studies. Three excellent texts are Feld and Carper (1997), Kamintzsky (1991) and Levy and Salvadori (1992). McKaig (1962) is also good. Ross (1984) contains cases reprinted from <i>Engineering News Record</i> , which is another useful source. The quarterly <i>Journal of Performance of Constructed Facilities</i> , published by the American Society of Civil Engineers, is an excellent source. Other ASCE journals, such as the <i>Journal of Structural Engineering</i> and <i>Journal of Professional Issues in Engineering Education and Practice</i> , occasionally feature useful case studies. Shepherd and Frost (1995) has short summaries of a wide variety of cases. Excellent recent source of case studies are the proceedings of the First and Second ASCE Congress in Forensic Engineering (Rens 1997, Rens et al, 2000b). A useful biblography on failures was assembled by Nicastro (1996). Puri (1998) and Carper (2000) list several references that would be useful in any failure analysis course. Some books and papers, such as Levy and Salvadori (1992) and Petroski (1985) do an excellent job of explaining fundamental structural behavior without relying on complex theories or mathematics, and are particularly appropriate for lower-division undergraduate students.					vy and , erican g and pherd lings on	
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Figure 2: Bibliography page

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Assorted Case Studies	University of Guelph	
	University of Toronto	
GH Investigations	Simpson Gumpertz & Heger	
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	The College of St. Catherine Physics (with movie)	
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Figure 3: Bibliography list of web sites

Each course listed has its own page, with links to cases. A number of the case studies apply to several courses. One example of such a case study courses is the collapse of the Kansas City Hyatt Regency walkways (figure 4). This case study relates to the following topics:

- Statics free body diagram<sup>8</sup>
- Structural Analysis load paths
- Design of Steel Structures connections
- Ethics, Professional Issues, and Capstone Design responsibility, actions of Missouri board and ASCE



Figure 4: The Hyatt Regency Walkway case study page

The cases developed so far, listed on the case studies page, includes:

- Hyatt Regency
- T.W. Love Dam
- Tacoma Narrows
- Hartford Civic Center
- L'Ambiance Plaza
- Quebec Bridge
- New York Coliseum
- Willow Island cooling tower
- 2000 Commonwealth Ave.
- Bailey's Crossroads
- Harbor Cay Condominium
- Citicorp

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An example of a course web page is shown in figure 5. The page lists some of the key references and major topics typically addressed in the course. Under each topic, hypertext links are provided to the cases listed on another page.

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Design of Reinforced Concrete Structures
Chapters 7 and 8 of Feld and Carper address case studies associated with concrete structures (Feld and Carper, 1997). Also see Chapter 2 of Kaminetzky (Kaminetzy, 1991).
Structural Integrity of Formwork
New York Coliseum
Strength Development of Concrete
Willow Island cooling tower     2000 Commonwealth Avenue, Boston     Bailey's Crossroads, Virginia
Flexural Strength
Auris, Wimal, and Khan, Mohammed S., "Performance of Prestressed Concrete Roofs during Hurricane Andrew," ASCE Journal of the Performance of Constructed Facilities, Vol. 8, No. 1, February 1994.
The Oklahoma City Bombing: Improving Building Performance Through Multi-Hazard Mitigation, Federal Emergency Management Agency Report 277 (with ASCE), August 1996.
Serviceability, Deflections, and Crack Control
Mattar, S. G. and Morstead, T. R., "Shrinkage in Concrete Masonry Walls: A Case Study," ASCE Journal of the
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Figure 5: Design of Reinforced Concrete Structures course page

The course pages developed so far include:

- Statics and Dynamics
- Mechanics of Materials
- Structural Analysis
- Design of Steel Structures
- Soil Mechanics and Geotechnical Engineering
- Fluid Mechanics and Hydraulics
- Transportation and Highway Engineering
- Environmental Engineering
- Construction Materials
- Ethics, Professional Issues, and Capstone Design

Because this is a work in progress, some of the course pages are developed much more thoroughly than others.

Each case provides a narrative and illustrations. Figure 6 provides an excerpt from the 2000 Commonwealth Avenue case study on punching shear, illustrating the punching shear mechanism. At the end of each case study narrative, a list of references is provided.



Figure 6: The 2000 Commonwealth Avenue case study and punching shear

# **Faculty Workshop**

The faculty workshop is scheduled for 12 July 2003. Twenty four faculty will be invited to attend the one day workshop. The workshop page, with links to application materials, is illustrated in figure 7.

Participants will be provided with a copy of the following materials:

- A copy of Feld, J., and Carper, K. (1997). Construction Failure. 2<sup>nd</sup> Ed., John Wiley & Sons, New York, N. Y.
- A copy of Shepherd, R., and Frost, J. D. (1995). Failures in Civil Engineering: Structural, Foundation, and Geoenvironmental Case Studies. ASCE. New York, N. Y.
- A binder with photocopies of papers, board notes, presentation slides, and other printed materials.
- A CD-ROM with presentations and other electronic materials (board notes, etc.).
- The CD-ROM will include a copy of the "Failure Vignettes" developed by the TCFE Committee on the Dissemination of Failure Information (CDFI).

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<ul> <li>A copy of Feld, J., and Carper</li> <li>A copy of Shepherd, R., and F Geoenvironmental Case Studie</li> <li>A binder with photocopies of p</li> <li>A CD-ROM with presentation</li> <li>The CD-ROM will include a co of Failure Information (CDFI).</li> </ul>	K. (1997). Construction Failure. 2 <sup>nd</sup> Ed., John Wiley & Sons, New York, N. Y. cost, J. D. (1995). Failures in Civil Engineering: Structural, Foundation, and S. ASCE. New York, N. Y. apers, board notes, presentation slides, and other printed materials. and other electronic materials (board notes, etc.). py of the "Failure Vignettes" developed by the TCFE Committee on the Dissemination
You may apply for the summer 2003 <sup>.</sup>	vorkshop over the web.
Apply for the workshop	
Colleagues	
The following members of the ASCE this project. Find out more about AS	Fechnical Council on Forensic Engineering Education Committee have been assisting on 2E at <u>www.asce.org</u>
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Figure 7: The faculty workshop page

The workshop outline is as follows:

- Introduction
- Sources for case materials
- Engineering Mechanics cases
- Structural Engineering cases
- Other CE courses
- Ethics, Professional Issues, and Capstone Design
- Forensic engineering courses
- Group discussion and brainstorming

Several colleagues from the ASCE TCFE Education Committee – Kevin Rens, Paul Bosela, Ken Carper, and Oswald Rendon-Herrero – will assist in the workshop as instructors.

# **Future Activities**

This is a "proof-of-concept" project, and ideally it will be possible to follow up this work by developing additional cases and hosting more workshops. As a result, the next logical step will be to work with the ASCE TCFE Education Committee in order to reach more engineering faculty across the country.

### **Summary and Conclusions**

The ASCE TCFE Education Committee survey responses indicate that civil engineering departments and faculty across the country want an online case study bibliography and well developed case study materials. The case study materials developed so far are a response to this need, but more work remains to be done.

#### Acknowledgements

Support for this research was provided by the National Science Foundation under the project "Developing Case Studies in Failures and Ethics for Engineering Educators," project number DUE 0127419. Some of the cases discussed in this paper were developed by Rachel Martin, Carlos Nazario, Suzanne King, and Cynthia Rouse. The support of members of the ASCE TCFE Education Committee including Kevin Rens, Paul Bosela, Ken Carper, and Oswald Rendon-Herrero is gratefully acknowledged.

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#### **Biographic Information**

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