

Integrating Wind Engineering Research to Curriculum Through Multimedia

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ABSTRACT

A courseware development project, which aims to transfer the research results to curriculum through the multimedia technology in the multi-disciplinary area of wind engineering, is discussed in this article. This courseware, containing four modules, is designed to supplement certain senior undergraduate-level and introductory graduate-level courses in Civil Engineering, Atmospheric Science, and Architecture. The contents of the modules are based upon the research accomplishments in wind engineering at Texas Tech University. The purpose of this courseware is to enhance classroom instruction in universities which offer regular or short courses in wind-related subject areas.

I. INTRODUCTION

Buildings, industrial structures, and lifelines are major elements of civil and mechanical infrastructure in this country. The eastern and southern regions, with their vast coastline, are extremely vulnerable to hurricanes, and other parts of the country, identified as “tornado alley,” are ravaged by hundreds of tornadoes each year. Understanding the dynamics of the atmosphere and the mechanisms of the wind-generated forces on civil and mechanical infrastructures, and then optimally designing the various elements of the infrastructure to withstand extreme wind climate, poses a major challenge to the engineering community. In the last few years, wind-related damage from tornadoes and hurricanes to the civil and mechanical infrastructures has far surpassed any damage caused by other natural forces. Educating our students in different science and engineering disciplines to understand wind and its effects, and teaching them various means to mitigate its potential damage to the built environment, will contribute to improved infrastructure and quality of life. This project is the first of its kind in the nation in attempting to integrate wind engineering research into curriculum.

Each of the four courseware modules developed in this project can be used to assimilate instructional materials interactively on-line. These materials can be presented for various duration as needed in a 50 to 80-minute lecture period. The modules can also be used by students outside the classroom for further pursuing the topics for research. It is noted that these modules will be used as supplementary lecture materials in existing courses in the areas of civil and mechanical engineering, architecture, and atmospheric science. A given course may utilize one to four modules (10 % to 25 % of the total course content). These modules will also be useful in short courses for professional continuing education. The four modules, which are in development, are (a) Thunderstorms, Tornadoes and Hurricanes — A General Overview, (b) Damage Caused by Hurricanes and Tornadoes, (c) Impact of Windborne Debris, and (d) Wind Loading on Low-Rise Buildings.



11. BACKGROUND

The following statistics attempt to emphasize the importance of wind engineering in the context of the country's infrastructure. Hurricanes, tornadoes and thunderstorms cause an enormous amount of property loss on an annual basis in the United States. It was estimated by the property claim services that during the period of January 1986 to December 1992 insured losses in catastrophes were \$45 billion; of these losses, wind-related damage was 88%, while damage caused by earthquakes was 3% and fire was 5%. Wind-related damage continues to rise because of increasing population centers along coastlines as well as the lack of adequate wind-resistant design measures for buildings constructed in these areas. The damage figures quoted above indicate the significance of the wind-related hazard and its effects on civil, architectural, and mechanical infrastructure and, thereby, its qualification as a subject of national importance. Wind-related damage need not be caused by extreme winds only. Moderate to low winds can cause vibrations in structures resulting in fatigue in structural components and perceptible motions unacceptable to the users, or it can cause dust storms which could become a health or traffic hazard.

Wind engineering research at Texas Tech University (TTU) was initiated in 1970 after a tornado devastated the city of Lubbock, where TTU is located. The tornado damaged almost 20% of this city of 170,000 people. It was at this time that the Institute for Disaster Research (IDR) at TTU was formed. A significant amount of research since then has been performed under the banner of IDR, primarily studying the effects of tornadoes and hurricanes and documenting the damage caused by these extreme wind events. Texas Tech personnel have documented more than 60 separate windstorm events during the past two decades. This documentation, consisting of notes, maps and photographs, is organized in damage documentation files. Cumulatively, there are close to 10,000 photographs and slides in the wind engineering library at TTU.

Subsequently, the need for conducting research in various fields of wind engineering emerged; this led to the foundation of the Wind Engineering Research Center (WERC) at TTU in 1985. In the beginning, the main thrust of this research was in the area of low-rise buildings. The WERC was involved in a National Science Foundation sponsored project, Cooperative Program for Wind Engineering (CPWE) with Colorado State University for a five-year period which ended in 1994. This multidisciplinary project involved faculty and students from various departments such as Civil, Chemical and Mechanical Engineering, as well as Atmospheric Science. CPWE has been extremely successful and it is being continued into the next five-year phase (1995-2000).

In addition to extensive wind-related damage documentation and research regarding wind effects on buildings and structures, these research centers have excelled through accomplishments such as development of a full-scale low-rise building test facility, a missile impact test facility, a glass testing laboratory, and a wind engineering library containing numerous wind-related documents. The centers also conducted research on other aspects of wind engineering such as structural vibrations, air pollution and wind damage of glass, that are considered important subjects in any engineering community. Results of any research are measured by the number (200 plus) and quality of publications. It can be stated that these publications have a significant impact on the wind engineering community. Some of the pertinent research results are described next.

SPECIFIC RESULTS OF THE RESEARCH:

The research accomplishments at TTU in wind engineering are translated into items usable by professional practitioners and the public at large through short courses, consulting and by supplying wind-related documents. Items such as the blueprint of an in-house tornado shelter available from the wind library



and damage documentation files are in high demand. These results are directly visible in the engineering community, including:

a) Estimation of peak wind speeds in tornadoes (Mehta, McDonald and Kiesling, 1975; Mehta, McDonald and Minor, 1976): The maximum wind speed in a tornado used to be considered as high as 500" mph, but through research and documentation of damage, it has been reduced to the range of 200-250 mph.

(b) Advisory to the public was provided through the National Weather Service (NWS) that opening a window when a tornado approaches is futile. In addition, NWS has revised its advisory for actions to take in the event of a tornado using TTU research results.

(c) Occupant protective design (Harris and Mehta, 1991): Design methodology for occupant protection in schools and other buildings during tornadoes has been developed and blueprints for in-residence shelters are provided to the public upon request.

(d) Guide to the Use of the Wind Load Provisions of ASCE 7-88 (Mehta, Marshall and Perry, 1991): This is a major research accomplishment. The knowledge gained through research at TTU has assisted in specifying wind load provisions of ANSI A58. 1-1982 and ASCE 7-88 (1990). These national standards are used by professionals across the country.

Kiesling et. al. (1995) discusses how these research results were translated into practice.

III. COURSEWARE OBJECTIVE

The results of the wind engineering research accomplishments (as mentioned in the previous section) need to be transferred to the curriculum of the departments involved in wind engineering, such as Civil and Mechanical Engineering, Atmospheric Science, and Architecture. This objective is being achieved by developing educational modules, using the latest multimedia computer technology and wind engineering research results, through which complex wind-structure problems could be presented in a simplified form. These instructional aids will be integrated into different courses offered in the above mentioned departments, both at the undergraduate and graduate levels. This integration will help to reinforce the present curriculum and will create a stronger educational program in engineering, architecture, and atmospheric science at various universities. The primary thrust will be to upgrade the undergraduate curriculum, first at Texas Tech University and then at other universities. However, some modules are designed for use in a few introductory graduate courses as well. The following is a partial list of generic courses where the modules are planned to be used. Unless stated as a graduate level course (GR), all courses listed are undergraduate courses. The courses are: (a) Structural Analysis I, (b) Design of Steel Structures, (c) Design of Concrete Structures, (d) Design of Masonry and Timber Construction, (e) Principles of Structural Design, (f) Design of Engineering Systems, (g) Wind Engineering (GR), (h) Introduction to Atmospheric Science, (i) General Meteorology, (j) Aerodynamics, and (k) Fluid Mechanics.

IV. COURSEWARE CONTENT AND ORGANIZATION

The research accomplishments outlined earlier are being translated into educational modules dealing with different aspects of wind engineering. These educational modules, based on a multimedia approach, are complete in themselves; each module will highlight one important component in the understanding of wind and its effects on the built environment using research results. These modules include detailed descriptions of the subject areas in the form of text; supplemented by video clippings, computer animations, color slides, and user-oriented interactive computer programs, which will highlight specific principles. These modules can be used by instructors in the classroom as well as by students and other professionals outside the classroom.



The structure and special features of the courseware are briefly described next. The main screen branches into four modules. Each module has a series of subtopics and each subtopic has a series of screens containing text, and icons for getting access to photographs or videos or animations. The user has access to the glossary or the credits section on every screen. The glossary contains definitions of a few hundred words related to the subjects covered in all the four modules. The options of quitting a subtopic and going to another topic or subtopic and exiting the courseware are provided on each screen. A few important words in the text are highlighted (hypertext) so that the user can access the glossary and see its definition by directly clicking on these words. A computer-generated audio option is provided which can translate the text on any screen to audio. Easy access of the photographs or videos or animations is provided through specific icons. A zooming capability is included with each photograph for enlarged viewing. Information from any module can be obtained with random-like access rather than sequential access which distinguishes this courseware distinctly from other forms of instruction or presentation.

Following are the titles of the proposed educational modules with a short description of each module.

MODULE 1. Thunderstorms, Tornadoes and Hurricanes — A General Overview: A general overview of the principles behind the origin, formation and dynamic characteristics of tornadoes, hurricanes and thunderstorms is provided. The menu provides the option to enter either the tornadoes, hurricanes or thunderstorms section. The videos provide information on a variety of topics, such as tornado rotation, vorticity associated with tornadoes, usage of doppler radar, land inundation during hurricane, etc. One animation shows rotation of a tornado, wall cloud formation and translational movement of a tornado.

MODULE 2. Damage Caused by Hurricanes and Tornadoes: Damage caused to civil and mechanical structures and structural components during a tornado and a hurricane are illustrated. This module illuminates the devastating nature of tornadoes and hurricanes. Excellent photographs of damaged infrastructure from a number of different tornadoes and hurricanes documented by IDR are provided along with text to interpret wind damage to buildings and other structures.

MODULE 3. Impact of Windborne Debris: Different types of missiles are introduced through text and photographs. The devastating effect of tornado missile impact on buildings and structures is illustrated. The laboratory testing Facility and the design principles to reduce the effect of such impacts is presented. One video footage shows flying debris in a tornado. A user-interactive program allows a user to choose a particular missile under the influence of a design tornado and put a target in its path. The program calculates the trajectory of the missile and shows the effect of the missile on the target which is known *a priori* through research at TTU.

MODULE 4. Wind Loading on Low-Rise Buildings: Different aerodynamic phenomena and methods influencing wind loading on various components of low buildings are discussed. This includes the ASCE 7-95 (design standard for wind loads) provisions. The animations in this module show wind flow around buildings. The videos illustrate roof failure modes in a hurricane, roof-corner vortices generated, etc.

IV. DEVELOPING THE COURSEWARE

The courseware is being developed on a Macintosh platform. It was an obvious choice at the beginning of this project because in our opinion the PCs were not as advanced as the Apple Macs in terms of graphics and multimedia capabilities at that time. A Power Macintosh 6100/60 AV is used for this project. Other peripheral units include an Apple Scanner and a VCR linked to the Power Macintosh. Macromedia Director version 4.0 (Director in short) is used as an authoring tool. This software marketed by Macromedia Inc. can be used for creating animation, working with sounds, creating special effects, adding interactivity to a movie and creating hypertext. The screens are designed first to contain text, photo or video icons and menu items with the help of graphics software such as Adobe Photoshop or Director. Director's scripting language "Lingo" is used to link each screen.



Video clips can be recorded directly with recording software such as Fusion Recorder from Video Fusion, Inc. Playback is accomplished using QuickTime Software for Macs. QuickTime is part of the systems software so it need not be acquired separately. The size of the video clip which can be played back depends on the RAM available. A 16 MB RAM works well for video clips no longer than 1.5 minutes. The video clips also occupy most of the memory on the hard drive so the number of video clips in a module is dictated by the memory of the CD-ROM on which the modules will be finally made available (about 640 MB). A KODAK PCD Writer 225, which is a CD writer, will be used to write the courseware on the CD-ROMs for distribution.

The modules developed on the Macintosh platform will be transferred to a PC platform later in order to maximize the usage of this courseware. Initial attempts have shown that it is possible to do so using the PC version of the Macromedia Director software although there are some difficulties associated with this transfer.

V. ASSESSMENT OF THE COURSEWARE

The modules will be sent out for evaluation to a team of reviewers in various universities and research institutions. The comments of the reviewers will be incorporated into the courseware before the final version is released sometime in August 1996.

VI. PROJECT IMPACT

The impact on the overall engineering curriculum will be through the emphasis of application of principles of atmospheric science, fluid mechanics, aerodynamics, structural mechanics, structural analysis and design, and experimental methods, to engineering design. Alternately, it will be a transfer of technology to engineering design problems.

There is a research program called REU (Research Experience for Undergraduates) supported by NSF through which the undergraduates at Texas Tech University are being benefited by this project. The REUs get a hands-on experience with some of the ongoing research projects. They develop skills for research and for writing technical reports. There have been twenty undergraduates in this REU program who are involved in wind engineering research. The number of students who will benefit from this program at Texas Tech University every year is around 1000 undergraduates and 100 graduates in various disciplines. It will also affect the undergraduate and graduate students of other universities once they start using the prepared modules.

Short courses for practicing professional are taught by Texas Tech personnel on a regular basis. The total number of professionals who registered for the short courses related to wind engineering as offered by Texas Tech personnel is more than 1200 over the past two decades. This gives an estimate of how many professionals are likely to benefit in the future from the proposed improvement in the short course curriculum.

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