

KSI: Kinzua Site Investigation

The Forensic Study of the July 21, 2003, Collapse of the Kinzua Viaduct
Jonathan McHugh, P.E.

As professional engineers, we often design and build structures, such as the Kinzua Viaduct, albeit seldom of its magnitude. However, rarely does the opportunity arise to step outside the purely quantitative realm of design codes and material properties to conduct an investigation in the manner of a detective or private investigator.

On August 12, 2003, the Board of Inquiry (Board), a group of structural engineers, material engineers, meteorological scientists, and government engineers, proceeded to the “scene of the crime,” minus the chalk line and yellow tape, to conduct a one-day forensic investigation into the tragic collapse of this historic structure.

The case file — On the afternoon of July 21, 2003, a wide range of severe weather moved into western Pennsylvania along a north-by-northwest track, spawning widespread thunderstorms and several tornadoes. At approximately 3:20 p.m. local time, a Class F-1 tornado touched down immediately east of the Kinzua Viaduct, a structure listed on the National Register of Historic Places and designated as a Civil Engineering Landmark.

The victim — The 301-foot-tall, 2,053-foot-long, Kinzua Viaduct — an engineering landmark and the jewel of the Pennsylvania State Park system.

The scene — Kinzua State Park is located approximately six miles east of Mt. Jewett, PA, in McKean County in north central Pennsylvania. This is approximately 17 miles south of the New York-Pennsylvania border.

Investigation Procedures

As with any investigation, certain questions surrounding the structural failure

of this bridge had to be answered through both evidence gathered at the site and laboratory analysis. Aerial photography of the collapse and existing blueprints of the viaduct were provided by the state and used to determine exactly what transpired.

Laboratory analysis of failed structural components revealed the mechanics of the collapse on a microscopic level. The Board was able to answer the “what,” the “when,” the “how,” and the “to what degree or extent” through a series of forensic markers that were revealed during the site investigation and the weeks of critical examination that followed.

These markers were order markers, direction markers, separation markers, and fracture markers, and each played its own role in the determination of the exact cause of the collapse. Additionally, eyewitness testimony from workers who were present at the site on the fateful day was crucial in corroboration of the reconstructed failure sequence, which was uncovered by the Board.

Order Markers

Using aerial and site photography, engineers were able to piece together the exact collapse sequence as it occurred on July 21, 2003. Analogous to the collecting



The Kinzua Viaduct — October 2004

of fingerprints at a crime scene, inversion of the debris clusters at the site was performed using a physical compatibility approach. Logically, the towers or other members lying on top of the pile would have collapsed last. Using this reverse progression, the failure sequence was reconstructed, and a series of four distinct collapse “episodes” was determined to have occurred during a 30-second time period. This assumption was confirmed by eyewitness testimony. The site superintendent of a crew performing rehabilitation work that day said, “...I heard four or five loud booms.”

Direction Markers

The direction of both tree trunk debris and the collapsed towers at the Kinzua site led the forensic team to determine that the direction of wind and, ultimately, a structural “weak link” were responsible for the bridge’s collapse. By viewing aerial photography of the site, two distinct paths of wind attack were evident. First, tangential winds emanating directly from the tornado’s vortex impinged the structure from the east. Next, strong inflow winds, which fed the tornado, attacked

the structure from the south. These two separate wind events, with estimated speeds of up to 100 mph, occurred nearly simultaneously, differing from the common practice of structural design with regards to wind design.

From the existing bridge construction drawings, it is evident that the designer assumed the west to be the predominant wind direction and, consequently, fitted the structure with fixed bearings at the western side of the structure and nested roller bearings on the eastern side. As the wind barraged the structure from the east, these fixed western bearings acted as hinges, about which the structure rotated and toppled. Further investigation revealed that more than 75 percent of the eastern roller bearings were deteriorated and offered no resistance to the excessive uplift forces.

Separation Markers

Site examination of the bearings and anchor bolts of the Kinzua Viaduct revealed that many of these elements had failed or had been critically damaged many years prior to the structure's collapse. In fact, it is estimated that up to 75 percent of the anchor bolts were deteriorated and should have been attributed with a substantially reduced capacity or zero capacity during analysis.

Existing 1901 construction drawings indicated that all of the anchor bolts were reused from a wrought iron structure that had

been originally built at the exact same geometric configuration in 1882. Roller-bearing collar-coupling assemblies were constructed to attach the new structure to these existing bolts, as they were too short for the newer design. By examining these collar-coupling assemblies at the site, it was evident that they were all corroded, and many were critically fractured previous to July 2003. The site observation that failure occurred at this interface at every failed tower confirmed two things — the Board's theory of the mechanism of collapse, and the assumption of the anchor bolts as the structural system's weak link.

Fracture Markers

As indicated, it was evident from the site investigation that deteriorated anchor bolts had resulted in the Kinzua Viaduct's inability to withstand the violent winds of the extreme storm event. What was not apparent was what had caused the reduction in the capacity of these structural elements.

Subsequent to the field view, the Board performed a series of laboratory metallurgical tests on the anchor bolts and collar-coupling assemblies. What was observed was a series of distensions in the crystalline iron structure of the elements indicating not only tensile overstress, but also evidence of excessive cyclical fatigue stresses. These markers indicated that the majority of the structural damage to these elements had occurred, not



Fractured collar-coupling assembly

during the storm event, but during the previous 102 years, under the constant cyclical loading of wind and trains.

Conclusion

With the evidence collected and documented, and all questions answered, the Board prepared a report of its findings to the bridge's owner, the Pennsylvania Department of Conservation of Natural Resources (DCNR). The report summarizes the meteorological, metallurgical, and engineering evidence and provides collapse diagrams, back-calculation of wind loading, summaries of eyewitness testimony, and even a computer-generated animation of the collapse. This report is available online at <http://www.dcnr.state.pa.us/info/kinzuabridgreport/kinzua.html>.

Therefore, the final piece of the puzzle can be fit into place:

The culprit — The Kinzua Viaduct was unable to withstand the 94 mph winds of the extreme mesocyclonic storm event at the site due to a series of hidden fractures in the structure's collar-coupling assemblies and anchor bolts in its bearings. Fatigue most likely incapacitated these elements years before the tornado, which ultimately caused the historic railroad viaduct's demise. ■

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Aerial photography of the Kinzua site was crucial in determining the cause and order of collapse

On Capitol Hill

John D. Wanner, CAE

PSPE aims to head off design professional restriction

Last month, a bill amending the Uniform Construction Code had a provision added that would prohibit municipalities from requiring that a construction document bear the seal of a design professional unless the work is regulated under a statute like the architects or engineers registration laws. Such a provision would lead to a situation in which municipalities are asked to determine the scope of practice for engineers and other design professionals. PSPE has already contacted House officials to ask that the prohibition be removed. The bill is expected to come before the full House in April. Our lobbyists hope to have the offending provision stricken at that time.

Tort reform passes House, headed to Governor

A bill that repeals Pennsylvania's joint and several liability doctrine passed the House on March 14th. Joint and several has long been criticized as the "deep pocket" awards problem. It can require companies only 1% responsible for the cause of an accident or injury to pay up to 100% of the damages. If the Governor signs Senate Bill 435, a company may not be required to pay a higher percentage of damages than it was responsible for causing. A similar proposal was passed several years ago, but the courts voided it because of improper legislative procedure. The key vote in the House was on the Gannon amendment that would have watered down the bill. That amendment was defeated by one vote. It is unclear at this time if Governor Rendell will sign or veto the bill.

Governor's Office Announces Regulatory Agenda

Executive Order 1996-1 requires all agencies under the jurisdiction of the

Governor to submit for publication an agenda of regulations under development or consideration. The following regulation of interest to PSPE was published in the February 4, 2006 PA Bulletin.

Department of Community & Economic Development (DCED) - Building Energy Conservation Standards 12 Pa. Code Chapter 147 (final regulation with rulemaking omitted) The regulation will repeal this chapter, as the statute upon which this chapter is based was repealed by the Pennsylvania Construction Code Act. The regulation is scheduled to be published in "Spring 2006". Contact Jill B. Busch (717- 720-7314) for more information.

Legislative Activity

HB 1467 RE: Residential Construction Dispute Resolution Act (by Rep. Tom Stevenson, et al)

Establishes dispute resolution procedures relating to residential construction defects between contractors and homeowners or members of associations. In an action under the legislation, the claimant must notify the contractor of a claim at least 75 days before initiating action. The contractor would have 15 days to respond. The legislation would not apply to any claim for personal injury or death.

Amended on third consideration, and passed Senate, 2/14/2006 (45-2)

House concurred in Senate amendments, with amendments 2/14/2006 (156-41)

Senate Concurred in House amends to Senate amendments, 2/15/2006 (45-2)

Signed in the Senate, 2/15/2006

Signed in the House, 3/6/2006

In the hands of the Governor, 3/7/2006.

HB 1862 RE: Competitive Bidding Threshold (by Rep. Kate Harper, et al)

Amends the act entitled "An act to authorize and empower cities, boroughs,

towns, and townships, separately or jointly, to provide for protection against floods by erecting and constructing certain works and improvements, located within or without their territorial limits, and within or without the county in which situate; and to expend moneys and incur indebtedness; to assess benefits against property benefited; to issue improvement bonds imposing no municipal liability; and to acquire, take, injure or destroy property for such purposes" further providing for competitive bidding of contracts by stating that no works or improvements involving an expenditure by any municipality or municipalities of more than \$25,000 (increased from \$10,000) would be erected or constructed or provided until advertised in at least one newspaper of general circulation. Written or telephonic price quotations from at least three qualified and responsible contractors would be requested for all contracts that exceed \$10,000 (current law is \$4,000). The legislation provides for the annual adjustment of these amounts based on the Consumer Price Index for All Urban Consumers.

Passed House, 1/31/2006 (191-1)

Referred to Senate Local Government Committee, 2/24/2006

HB 1868 RE: Competitive Bidding Threshold (by Rep. Vincent Biancucci, et al)

Amends the Second Class City Law further regulating contracts, contract procedures and advertising for bids by stating that for competitive bidding on contracts involving an amount exceeding \$25,000 (current law is \$10,000) invitations for bids would be issued pursuant to reasonable notice, which would be by advertisement and all bids would be filed with the city controller and opened publicly at a designated time and place, and the figures would be announced

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to persons present. Additionally, for competitive bidding on contracts involving an amount of \$25,000 (current law is \$10,000) the Director of the Department of Supplies may obtain oral bids or letter bids or may proceed by a comparison of specific prices as set forth in the sellers’ literature. The legislation provides for the annual adjustment of these amounts based on the Consumer Price Index for All Urban Consumers.

Passed House, 1/31/2006 (191-1)

Referred to Senate Local Government Committee, 2/24/2006

HB 1869 RE: RE: Competitive Bidding Threshold (by Rep. John Payne, et al)

Amends the Housing Authorities Law further providing for awards of contracts, completion bond, additional bond for protection of materialmen and others by adding that whenever the estimated cost of a construction project, service or supplies exceeds \$25,000 (increased from \$10,000), the work must be performed pursuant to a contract awarded to the lowest responsible bidder, after advertisement for bids. Written or telephonic price quotations from at least three qualified and responsible contractors would be required for all contracts that exceed \$10,000 (increased from \$4,000), but are less than \$25,000. The legislation provides for the annual adjustment of these amounts based on the Consumer Price Index for All Urban Consumers.

Passed House, 1/31/2006 (191-1)

Referred to Senate Urban Affairs and Housing Committee, 2/24/2006

HB 1870 RE: Minimum Bid Requirement (by Rep. David Hickernell, et al)

Amends the act entitled “An act regulating the letting of certain contracts for the erection, construction, and alteration of public buildings,” increasing the minimum bid requirement to \$25,000 from \$4,000.

Passed House, 1/30/2006 (191-1)

Referred to Senate Transportation Committee, 2/24/2006

HB 2441 RE: Electronic Bidding (by Rep. Curt Sonney, et al)

Amends Title 62 (Procurement) by adding a chapter providing for electronic bidding by local government units. The bill states that a local government unit may permit the electronic submission of bids and may receive bids electronically if the local government unit has the electronic capability to maintain the confidentiality of the bid until the bid opening time. The bill defines “local government unit” as “a county, city, borough, incorporated town, township, school district, vocational school district, county institution district, home rule municipality, local authority or any joint or cooperative body of local government units or any instrumentality, authority or corporation which has the authority to enter into contracts”.

Reported as committed from House Local Government Committee, read first time, and laid on the table, 3/7/2006

HB 2468 RE: Highway Capital Budget Project Itemization Act (by Rep. Matthew Good, et al)

Provides for an itemization of public highway projects for the fiscal year 2005-2006.

Reported as committed from House Transportation Committee, read first time, and laid on the table, 3/15/2006

HB 2499 RE: 2006-07 Budget (by Rep. Brett Feese, et al)

This is the General Appropriation Act of 2006 providing for expenses of the Executive, Legislative and Judicial Departments, the public debt, for the public schools for the fiscal year July 1, 2006, to June 30, 2007. This is the House Republican proposal, NOT the Governor’s budget.

Reported as committed from House Appropriations Committee, read first time, and laid on the table, 3/15/2006

SB 435 RE: Comparative Negligence (by Sen. Jake Corman, et al)

Amends Title 42 (Judiciary) providing for comparative negligence by adding that

where recovery is allowed against more than one person, including actions for strict liability, and where liability is attributed to more than one defendant, each defendant would be liable for that proportion of the total dollar amount awarded as damages in the ratio of the amount of that defendant’s liability to the amount of liability attributed to all defendants and other persons to whom liability is apportioned. Also, a defendant’s liability would be several and not joint, and the court would enter a separate and several judgment in favor of the plaintiff and against each defendant for the apportioned amount of that defendant’s liability. Nothing in this section would be construed in any way to create, abolish or modify a cause of action or to limit a party’s right to join another potentially responsible party.

Passed Senate, 12/6/2005 (32-18)

Passed House, 3/14/2006 (118-81)

Signed in Senate and House, 3/15/2006

In the hands of the Governor, 3/15/2006.

SB 1000 RE: Home Improvement Consumer Protection Act (by Sen. Tommy Tomlinson, et al)

Provides that no person would hold himself out as a contractor nor would a person perform any home improvement without first registering with the Bureau of Consumer Protection in the Office of Attorney General. The bill also states that no business entity registered pursuant to this act would be relieved of responsibility for the conduct and acts of its agents, employees, officers or directors, nor would any person be relieved of responsibility under this act by reason of his employment or relationship with such business entity. The bill states that the bureau would maintain a toll-free telephone number from which a caller can obtain information as to whether a contractor is registered with the bureau. The bill outlines the procedures for registration as a contractor, and requires that each application for a certificate for a home improvement contractor or renewal of that certificate would be accompanied by a fee of \$50, and would be renewed on a biennial basis.

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The legislation also outlines the requirements in home improvement contracts. Lastly, the bill provides for the offense of home improvement fraud, and provides for penalties.

Reported from Senate Consumer Protection and Licensure Committee, read first time, and referred to Senate Appropriations Committee, 1/24/2006

Reported as committed from Senate Appropriations Committee, 2/13/2006

SB 1104 RE: One Call System (by Sen. Tommy Tomlinson, et al)

Amends the Underground Utility Line Protection Law, further providing for the title of the act, for definitions, for duties of facility owners and for the duties of the One Call System; providing for liability, fees and governance of the One Call System; further providing for applicability; providing for the duties of project owners and for rights of the Auditor General; further providing for the governing board of the One Call System, for fines and penalties and for applicability to certain pipeline systems and facilities; providing for a voluntary dispute resolution process, for best efforts and for removal or tampering with a marking; further providing for expiration; and repealing provisions of the Propane and Liquefied Petroleum Gas Act, concerning the prohibition of certain liquefied petroleum gas facilities or distributors from being subject to the Underground Utility Line Protection Law.

Reported as amended from Senate Consumer Protection and Licensure Committee, and read first time, 3/14/2006

New Bills Introduced

HB 2474 RE: Electrical Contractors Licensing Act (by Rep. Steve Cappelli, et al)

Provides for the licensing of electrical contractors; establishes the State Board of Electrical Contractors; provides for powers and duties of the State Board of Electrical Contractors; and makes an appropriation of \$85,000 from Professional Licensure Augmentation Account to the Department of State for the payment of costs associated with this act.

Referred to House Professional Licensure Committee, 3/6/2006

Remaining 2006 HOUSE Spring Session Schedule

- March 20 (non-voting)
- April 3, 4, 5, 10 (non-voting), 24, 25, 26

- May 1, 2, 3, 8 (non-voting), 22, 23, 24
- June 5, 6, 7, 12, 13, 14, 19, 20, 21, 26, 27, 28, 29, 30

Remaining 2006 SENATE Spring Session Schedule

- March 20, 21, 22, 27, 28, 29
- April 3, 4, 5, 17, 18, 19, 24, 25, 26
- May 1, 2, 3, 22, 23, 24
- June 5, 6, 7, 12, 13, 14, 19, 20, 21, 22 (non-voting), 26, 27, 28, 29, 30

Copies of all bills of interest are available from the PSPE office, or they can be accessed via the Internet at <http://www.legis.state.pa.us/WU01/LI/BI/billroom.htm>. ■

PSPE Calendar of Events

	29	30	1	2
	2006			
May 11-15	Lockheed Martin National MATHCOUNTS Arlington, VA			
May 18	PSPE Executive Committee Meeting Sheraton Park Ridge King of Prussia, PA			
May 20	PSPE Board of Directors Meeting Sheraton Park Ridge King of Prussia, PA			
May 18-20	PSPE Annual Conference Sheraton Park Ridge King of Prussia, PA			
June 13, 14, 20	PEPP Seminar: Life after Bilt-Rite, Contract & Electronic Documents, & Risk Management Valley Forge, New Cumberland, Monroeville			
July 6-11	NSPE Annual Convention Boston, MA			

Pass the Professional Engineering Licensure Exams (PE and FE)

Dennis Dahlquist, P.E.

Now is the time to get ready for the professional engineering exams and review strategies for passing the Professional Engineering examinations (Fundamentals of Engineering, FE and Professional Engineer, PE.)

Following are strategies that people find useful in preparing for and taking the exam. Dennis Dahlquist PE teaches review courses for the Fundamentals of Engineering, FE (formerly known as the Engineering in Training examination, EIT) and the Electrical Engineering Professional Engineering Exam, EE PE.

If you are interested in taking the Professional Engineering exams, contact the state board of the state in which you want to be licensed (in Pennsylvania - State Board of Professional Engineers, Land Surveyors and Geologists - <http://www.dos.state.pa.us/bpoa/cwp/view.asp?a=1104&q=432715>). To find the state board contact information, you could use your favorite web search engine or Professional Publications Inc. (PPI) has a nice page showing the US map to find your state of interest (www.ppi2pass.com/ppi/PPIInfo_pg_map-usalink.html). You will also want to refer to National Council of Examiners for Engineering and Surveying (NCEES) web site, www.ncees.org. You may also consider taking a review course before the exam. Check around. There are many for the FE and some for the PE's (CE, ME, EE, etc.). To find review courses check with NSPE (www.nspe.org) or check out PPI's web site, www.ppi2pass.com/ppi/PPIInfo_pg_review-review.html. PPI is also a good source for review books.

These examinations require review. They are not to be taken lightly. The State Board of Registration has the latest data on the previous exams; however the pass rates (number of people passing) are in the range of 20% to 50% (National data, 70% to 80%, www.ncees.org/exams/pass_rates.) This varies from exam to exam and year to year. The passing data can be confusing. Looking at the national passing data, the passing rates look much higher. Keep in mind however, that these passing scores are averaged with many other states. Check with the state board in the state you are going to take the exam in for the best data on the exam passing rates.

The exams are not easy and this is by design. The exams are designed by engineers, for engineers. The key point here is that the exam is a multi-level test of one's engineering ability. To pass the exam, you must engineer your way to the exam and through the exam. You engineer your way to the exam by studying and reviewing the necessary material, and engineer your way through the exam by using good engineering technique. The bad news is that you need to take a different approach to the exam than the old college way (especially if you crammed the night before exams). The good news is that the approach you need to take for the exam is an engineering approach (one you are more familiar with now).

Exam Format

The first of the licensing exam series is the Fundamentals of Engineering (FE). It is a multiple-choice, closed-book test (however, a reference book is provided, www.ncees.org/exams/study_materials/fe_handbook/). The exam includes a morning of general engineering problems and is followed by the afternoon section where you have your choice of a general or a discipline specific exam. The second test of the series, The Professional Engineer exam, is discipline specific. It is also a multiple choice exam, but is an open-book exam with a combination of breadth (morning) and depth (afternoon) of the discipline. You qualify to take this exam after passing the FE and completing some years as a practicing engineer (this varies somewhat state to state, but usually ranges from 2 to 4 years, check with the state board).

Becoming a P.E. (short version)

Acquire a good education, a Bachelors (BS) or a Masters (MS) engineering degree from an ABET (Accreditation Board for Engineering and Technology www.abet.org) accredited school. This will save you some qualifying time for the exams. Take the FE while you are finishing school (if not, take a review course tailored for people who have been out of school for some time). Work in your discipline for the number of years required by the Board, (this varies based upon education, discipline, and state), and take the PE exam in your discipline. Upon passing the exam you become a Licensed Professional Engineer and you can now legally put P.E. after your name.

I am signed up for the exam what do I do now?

How do you engineer your way to the exam? Seek out review courses near you. Find others who are planning to take the exam and form a study group. Work problems, problems, problems. Obviously, you have other obligations; however, you want to make a commitment to yourself to pass this exam. Set up a schedule for studying. You are preparing yourself for a mental marathon. Just as you wouldn't try to run 26 miles without training for it, you cannot expect to pass the exams without studying. The more problems you work, the better. However, you don't want to just work on the problems you like. Working on the other problems expands your ability to work a larger range of problems.

Materials You Will Need

When working practice problems in preparation for the exam; use the same materials that you will be using on the exam, calculator(s) and reference books. You want to be very familiar with your tools.

Reference books: For the FE your FE Reference Handbook (http://www.ncees.org/exams/study_materials/fe_handbook/) will be provided to you (so prior to the exam you want to be familiar with it). The PE is open book, so you can take what you want. But, you had best know the references you are planning to take into the exam, because there is no time during the exam to read books.

Calculators: No computers or any calculator with communication capability are currently allowed during the exam. To find out the latest information on calculators allowed on the exam, check out NCEES Calculator Policy (<http://www.ncees.org/exams/calculators/>). Also make sure to check with the state board for the current rules on what is acceptable in the exam.

Exam Preparation and Performance

While you are doing your practice problems, try to not use your calculator very much. "What do you mean? This is

engineering; you HAVE to use the calculator!"...you might say. However, remember that the exam is a test of your engineering ability, not how well you use a calculator. This is an engineering exam, not a math test. Calculator time is "dead" time. Every time you use your calculator it is time you are not spending "thinking" about (engineering) the problem at hand. Yes, you will need to use your calculator, just use it wisely. How does one calculate without using a calculator? Use your brain, it is much faster! For example, what is the common log of 1000? Before you reach for your calculator, think about it. What is the power of ten representation of 1000? 1000 is ten to the third power. What is the log of 1000, it is 3! See you can do it without a calculator. Fine you say, but what about the log of 2,354? Well, you can come up with a close approximation of 2,354. You know the log of 1,000 is 3 and the log of 10,000 is 4, so the log of 2,354 is between 3 and 4, and closer to 3. This may be enough information to isolate an answer in a multiple-choice question or at least throw out some answers.

Try to check your answers as much as possible. I realize that you are under time restrictions; however, you want to at least estimate your answer. Under the "stress of test" you can hit extra keys on the calculator (or maybe make a calculation error) and by mentally estimating or doing an alternate solution, you will be able to catch these errors.

Study hard and study well. You want to practice exam conditions when solving the practice problems. This means you probably will not have a TV (or computer) during the exam, so don't study with the TV. On the other hand, you probably will not have a completely quiet and isolated room either, so study accordingly.

FE Reference Handbook: For the FE exam, get a hard copy of the book and use it while you are studying. You will want to be as familiar with this reference as you can, it will be the only reference you will have

during the exam. You will not be able to take in your copy of the FE Reference Handbook to the FE exam, but they will give you a new copy at the exam (so, make sure when you are studying you are using the version that will be at the FE exam).

For the PE exam, I would also recommend getting a hard copy of the Fundamentals of Engineering Reference Handbook and including it with your reference materials you take into the exam. The FE Reference Handbook has the discipline specific information, which would make it a good reference for the PE exams. It would certainly help on the breath section of the exam (the morning part of the PE exam).

Just before the exam, get two good nights of sleep. This is not to imply that you sleep for 16 hours before the exam. That will create another set of problems. It seems that today's society is run by a lot of people under sleep deprivation and you want a useful rested brain for the exam.

Don't cram before the exam. This may have worked in college, but it doesn't work well for the Professional Engineering exams. Being rested for the exams is very important. You will know a lot of information for the exam if you have studied along the way. However, it will be of no use to you if your brain is asleep on the exam day.

Strategies During the Exam

You want to develop a plan for the exam. One I recommend is to read the exam. Read through all the questions and classify them into; "easy", "will require some work", and "I don't know." This should take 6 - 12 minutes, depending on the exam and you. Implement your plan. The easy ones are best to answer during the first pass through as you read them; however, watch the time. Don't spend all of your time on the problem(s) you like. Get them done as soon as possible. You are going to have to spend your time on the others, i.e., the ones you don't like as much. If the whole exam is easy for you, great, do it and go home. For most people,

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there aren't enough of the “easy” problems for them to pass the exam (otherwise the pass rates would be higher).

On the “will require some work” problems, don't spend your time completely calculating the problems. A natural human reaction is to start at the beginning and serially move to the end. You don't have time for that. Check as you are calculating, to see if you have enough information to isolate the answer. For multiple-choice questions, if two answers are correct and there is a selection for “all”, select it and go on. Don't take the time to prove to yourself all the answers are correct. Use the answers from multiple choice questions to back calculate, this can save you time. You need to be efficient with your time.

Make sure that when you are answering a question, you are filling in the answer for that question. For example, if you are answering question 33, make sure you are

filling in the answer for 33. It may seem unnecessary to even mention this; of course for problem 33 you would fill the answer for problem 33. But you must remember during the stress of test you might not. Many times I have heard from people after taking the exam. They thought they had done quite well upon leaving the exam realize their answer sheet did not reflect the questions they had skipped over. Taking the last 5 to 10 minutes of the exam to check your answers will not work very well on these exams. You will need to develop your own methods of check to make sure you have answered the correct question.

By reading the “I don't know” problems again, you may discover that they can be moved into the category of “may require some work”. If not, do some intelligent guessing. If you find yourself in a problem and it just looks too hard, remind yourself that you are not “looking” at it correctly. This helps in two main ways. First is that this will cause you to re-look at the problem and

there may be something you missed. The second is more of a psychological help. If you think it is too hard for you, you may convince yourself and give up. Don't give up; just look at it differently. That is the main point of being an engineer. Don't give up; try another way. That's what being an engineer is all about, trying until you find a solution. The people who give up are not engineers; the people who get it done are engineers. ■

Dennis Dahlquist, P.E is a consulting engineer in California. He teaches Electrical Engineering and general Engineering courses at California State University, Sacramento. He has taught review courses for 20 years for the Fundamentals of Engineering (FE) and Electrical Engineering (EPE) licensing exams, with pass rates near 90%. He can be reached by email at: d.dahlquist@ieee.org. Reprinted with permission from the California Society of Professional Engineers.

Summary Check List:

Before the exam:

- Check with the Board for an Application and current requirements for the exams.
- Develop a plan for the exam. How are you going to engineer your way to and through the exam? One specialty area is not enough to pass the exam.
- Study for the exam, take a review course, and/or form a study group.
- Familiarize yourself with your calculator and reference materials.
- Make sure you going into the exam fully rested.

On the exam:

- Read all the problems and sort by difficulty.
- Estimate as much as possible.
- Make efficient use of the calculator and your time.
- Keep in mind, if it looks too hard you are not looking at it correctly.
- Check the answers; make sure your answer is the answer to the question asked.

Links for further information:

- ABET, Accreditation Board for Engineering and Technology www.abet.org
- PEI, Professional Engineering Institute: www.pereview.com
- PPI, Professional Publications, Incorporated: www.ppi2pass.com
- State Board locator: www.ppi2pass.com/ppi/PPIInfo_pg_map-usalink.html
- NCEES, National Council of Examiners for Engineering and Surveying (NCEES): www.ncees.org
- FE your reference book www.ncees.org/exams/study_materials/fe_handbook
- Calculator Policy www.ncees.org/exams/calculators

Pennsylvania **MATHCOUNTS** Highlights

Pennsylvania MATHCOUNTS 2006 Top Three Teams



The team from Sandy Run Middle school took first place for the second year in a row. Students l-r: Ben Zauzmer, Matt Tanzer, Matt Gordon, and Todd Warszawski. (Mitchell Sacks was not on the team, but was the second place individual in Valley Forge.) Adults l-r: Harry Garman, P.E., PSPE President; Bill Gorman, P.E., MATHCOUNTS State Coordinator; Sandy VanHorn, Coach.

Congratulations to **Matt Tanzer** (Sandy Run Middle School) for his first place finish at the Pennsylvania State MATHCOUNTS competition. 159 students from 77 Pennsylvania schools competed in the state MATHCOUNTS competition.

Matt will join **Nicholas Yannacone** (St. Aloysius Academy), **Anthony Wang** (Valley Forge Middle School), and **Ben Zauzmer** (Sandy Run Middle School) to compete as the Pennsylvania team at the National MATHCOUNTS competition, May 11-14, 2006 in Arlington, VA.

The MATHCOUNTS team from **Sandy Run Middle School**, coached by **Sandy VanHorn**, placed first in Pennsylvania, taking home the traveling team trophy. Team members **Matt Tanzer**, **Ben Zauzmer**, **Todd Warszawski**, and **Matthew Gordon** scored the highest of 25 schools in the state competition. Sandy Van Horn will coach the Pennsylvania team headed to Nationals. Coach VanHorn is a veteran of two previous National competitions.

Prior to the state competition, over 2,500 students participated in regional MATHCOUNTS competitions across the state.



Team members from Valley Forge middle school placed second at the state MATHCOUNTS competition. Pictured l-r Allison Long (coach), Harry Garman, P.E., Robert Xu, Anthony Wang, Benjamin Lei, Bill Gorman, and Emma Boettcher.



Team members from Moravian Academy placed 3rd at the state MATHCOUNTS competition. Pictured l-r: Allison Overdorf (coach), David Stone, P.E., Michael Boreen, Harry Garman, P.E., John Oberbeck, Allan Chandler (coach), Kavita Jain-Cocks, Benjamin Kraft and Bill Gorman, P.E.

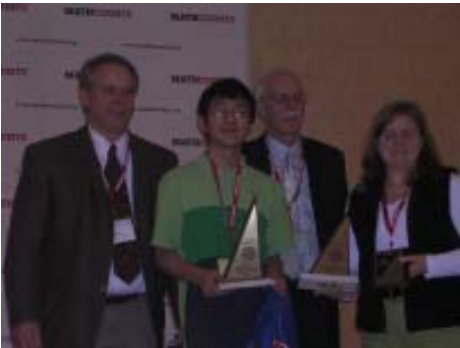
Pennsylvania MATHCOUNTS 2006 Top Ten Individuals



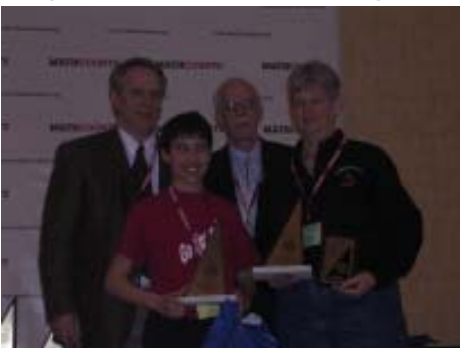
Pictured l-r: Harry Garman, P.E., Matt Tanzer, Bill Gorman, P.E., Sandy VanHorn.



Pictured l-r: Harry Garman, P.E., Nicolas Yannacone, Dominic D'Amico.



Pictured l-r: Harry Garman, P.E., Anthony Wang, Bill Gorman, P.E., Allison Long.



Pictured l-r: Harry Garman, P.E., Ben Zauzmer, Bill Gorman, P.E., Sandy VanHorn.

Matt Tanzer

Sandy Run Middle School
Coach: Sandy Van Horn
Valley Forge Chapter

Nicholas Yannacone

St. Aloysius Academy
Coach: Dominic D'Amico
Delaware County Chapter

Anthony Wang

Valley Forge Middle School
Coach: Allison Long
Chester County Chapter

Ben Zauzmer

Sandy Run Middle School
Coach: Sandy Van Horn
Valley Forge Chapter

Douglas Komandt

Franklin Regional Middle School
Coach: Linda Lazzaro
Westmoreland Chapter

Benjamin Lei

Valley Forge Middle School
Coach: Allison Long
Chester County Chapter

Matthew Gordon

Sandy Run Middle School
Coach: Sandy Van Horn
Valley Forge Chapter

Timothy Wall

Grey Nun Academy
Coach: Geoff Wall
Bucks County Chapter

Arsenij Kouriatov

Tredyffrin-Easttown Middle School
Coach: Troy Deckebach
Chester County Chapter

Jonathan Katzman

Hershey Middle School
Coaches: Kevin Adams & David Yingst
Harrisburg Chapter

National Bound!



Pictured left to right: Douglas Komandt (alternate), Anthony Wang, Matt Tanzer, Ben Zauzmer, Sandy VanHorn, Nick Yannacone, and team mascot Crystal Wang. We wish the team great skill and success at the National competition May 11-14 in Arlington, Virginia. Go Pennsylvania!

President's Message

Harry E. Garman, P.E., PLS



On March 18th, I had the pleasure of attending the Pennsylvania MATHCOUNTS competition in Harrisburg and participate in presenting awards to the top scoring Mathletes®. I commend everyone that was involved in the MATHCOUNTS program. NSPE and PSPE are proud to be Founding Sponsors of the program. I am often informed by NSPE members, whether here in Pennsylvania or from other states that MATHCOUNTS is the most successful program that we have.

Last year, when NSPE was considering backing off on its level of support for MATHCOUNTS, NSPE members from across the country voiced their concern and as a result NSPE remains committed to MATHCOUNTS and encourages the continued support by the state society and local chapters. PSPE should be extremely

proud in that we have one of, if not, the largest participation of 7th and 8th grade students. All of our chapters put together the local events which lead to the state competition. I wish success to the Pennsylvania team which will travel to Arlington Virginia for the national competition in May. Again, I commend everyone associated with the MATHCOUNTS program, students, parents, teachers, coaches, chapter and state coordinators and especially all of the volunteers. You can read more about MATHCOUNTS in this edition of the PE Reporter or visit www.pspe.org to learn more.

On another matter, I recently came across an article that ranked various professions according to the prestige associated with each profession. Engineering ranked in the middle of the list of thirty-some professions that were evaluated. Engineers trailed professions such as Doctors, Teachers, Police Officers and Firefighters and was ahead of professions such as Attorneys, Architects, Realtors, Accountants and Professional Athletes. Supposedly, this is an indication of how people feel when they think of a person

in a particular profession. I guess we can take solace in the fact we fared better than the lawyers and architects; but, should we be comfortable with being in the middle of the pack?

The NSPE Mission says that through education, licensure advocacy, leadership training, multi-disciplinary networking, and outreach, NSPE enhances the image of its members and their ability to ethically and professionally practice engineering. NSPE and PSPE offer ample opportunity to their members to take advantage of these means to advance their image as engineers and hone their leadership and technical skills. PSPE offers such an opportunity at its annual conference which is will take place in Valley Forge from May 18th through the 20th. Not only can you show your support for your officers, you can have an enjoyable time and possibly learn something and improve your image as an engineer. Go to Valley Forge and give your support to Harve Hnatiuk and your officers as they begin a new year under their leadership. Hope to see many of you there. ■

Thank you, sponsors

The following firms, individuals, and organizations were instrumental in the success of Pennsylvania MATHCOUNTS 2006. We gratefully recognize their ongoing support and the value they add. On behalf of the students, coaches, parents and volunteers who enjoy the state MATHCOUNTS program, thank you.

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McMahon Associates Inc.
Pennonni Associates Inc.
Pennsylvania Federation of Business and Professional Women's Clubs Inc.
Pickering Corts & Summerson
UPS

Individuals

Loretta and William R. Gorman Jr., P.E.
Arthur P. Luthy P.E.
Joe and Claire Tanzer

Scholarships

Drexel University
Gannon University
Pennsylvania Engineering Foundation
Pennsylvania State University
Temple University
University of Pittsburgh
University of Pittsburgh at Johnstown

Risky Business

Part II: Some Days the Glass Just Might Be Half-empty

Rebecca Bowman, Esq. PE

This is the second of a five-part series examining competent risk assessment. (I'd recommend saving this section so you can review all five parts at once.) Just to refresh your recollection, there are five components required for a competent risk assessment. First, the organization must define critical assets. Second, the organization must agree on goals, objectives, and standards. Third, the organization must achieve agreement on reasonably foreseeable hazards to those assets. Fourth, the effects of these hazards on the critical assets must be evaluated. Finally, the design of the assets must be adjusted to address and incorporate loss prevention strategies to assure that the goals and objectives can be met in the event of a hazard.

We have talked about the need to set aside positive assumptions to assume the worst. We have explored the process of identifying your organization's critical assets. This second part will examine the second component of risk assessment: setting performance and organizational goals, objectives, and standards for critical assets.

After carefully reading the column in the January/February issue of the *PE Reporter*, you have completely identified your organization's critical assets, right? Now, you can move on to Step 2, establishing goals, objectives, and standards for those critical assets.

How long can your business be without your critical assets before the business is irreparably damaged? What happens if the critical assets are missing? What if they're gone? Can you replace them? How quickly? If something happened to your main piece of equipment, could you jury-rig a substitute? Use a combination of smaller equipment? Use

some other piece of equipment for a purpose other than its design purpose? How long would that be acceptable? For some companies, two hours is too long. For some companies, two months might be survivable. For some of my clients with seasonal businesses, a disaster in the off-season would be annoying, while a disaster in the prime season could bring them to their knees.

The questions are somewhat different if your primary product is information. If your data sources are destroyed or compromised, what will happen? Do your clients have complete sets of data? Are all the data elements stored on the web? How long would it take to construct the data? Can your business survive that timeline?

While you complete this task, it is important to stay focused on the question. It is easy, especially for us problem-fixing engineers, to drift away from goals, objectives, and standards into solutions. I did not ask *how* to jury-rig a substitute, just *whether* one could be jury-rigged.

Another challenge for us problem-fixers is to stay focused on the strategic issues, not the tactical ones. You need to take the analysis to the most basic level. "To keep my business going, I need to be able to produce X Widgets in a day" may not be the real answer. If you were not around (or do not love history), talk to someone who was around in World War II. Talk to them about dealing with shortages of coffee, shoe leather, people, and replacement parts. No one planned on not being able to get those things, but when the moment came when those resources were not available, businesses dealt with it. They figured out a way. Companies that never dreamed of producing anything other than sewing machines

How long can your business be without your critical assets before the business is irreparably damaged? What happens if the critical assets are missing? What if they're gone?

discovered that they were very capable of making airplane and artillery components. A tolerance is a tolerance and metal is metal.

Maybe, when you take the analysis to the most basic level, the answer is more like "To keep my business going, I need to keep Machinist Tom, Engineer Debra, and Inspector Bill productive. My other resources are replaceable and/or interchangeable." That sort of analysis frees you to consider that perhaps you do not HAVE to be producing Widgets at all to keep your business going. Perhaps, instead of producing designs and components for residential swimming pool cleaning systems, you could be producing designs and components for a completely different market, such as tankers. How long and what resources would you need to switch? Those may become your critical assets and that becomes your goal/objective/standard. Would you need to team with another company to make the switch? How long would it take to establish that relationship? If you lost your CADD capability, your newly-retired drafter

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might be revealed as your most critical asset and your objective might be finding a way to persuade him to come back a couple of days each week or full-time for two months, whatever the timeline reveals. Your analysis might show that with him back, your survivability timeline is six months, but without him, your survivability timeline is six weeks.

Now that you have identified your organization’s critical assets (Step 1), and established performance and operational goals, objectives and criteria for your critical assets (Step 2), you are ready to proceed to Step 3, assessing hazards. We will look at that next time. In the meantime, time well spent identifying your standards can help you prevent yours from being a Risky Business.

The “Risky Business” column offers articles covering liability from both the legal and engineering perspective. Mrs. Bowman’s articles share general information and should not be relied upon as professional legal advice of either a general or specific nature. Rebecca Bowman is a civil engineer-attorney in solo private practice in McMurray, Pennsylvania for more than 25 years. Her practice is a certified woman-owned business. Her B.S. in Civil Engineering is from the University of North Dakota.