Impact of Civil Engineering Design on Emergency Preparedness

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WHAT DO WE DESIGN OR CONSTRUCT FOR?

function

emergency!

profit

safety economy

fun
**TYPES OF EMERGENCIES**

**NATURAL DISASTERS**
- Earthquake, tsunami, volcano, hurricane, flood, drought, meteorite hit, epidemics (eg. SARS)

**MAN-MADE DISASTERS**
- Accepted, evolutionary
  - Nuclear (Eg. Chernobyl, 1986), food processing (Eg. Bird-Flu), industrial (Eg. Bhopal, 1984), medical (Eg. Thalidomide, 1957), forest fires
- Terrorist, revolutionary
  - Explosions (WTC, 2001), biological

**ACCIDENTS**
- Individual (Eg. Heart attack)
- Groups (Eg. Plane crash)

Is terrorism reducing attention towards other conventional emergencies?

**NATURAL DISASTERS**
- Earthquake
- Hurricane
- Volcano
- Tsunami
- Epidemic
- Flood
- Drought
- Meteorite hit

Most of these may not be applicable to Singapore!
MAN-MADE DISASTERS

Bird flu  Mad cow  Chernobyl

Thalidomide  Forest fire  Terrorism

EMERGENCY PREPAREDNESS IS EVERYBODY’S BUSINESS

- Designs that eliminate or minimise hazards during emergencies
- Designs that allow the constructor and user to meet emergency procedures without implementing too many temporary additional safety measures

Adapted by author from “Collaboration in Design to Promote Construction Safety”, Steven Hecker, University of Oregon, 2004
ATTITUDE TO EMERGENCY PREPAREDNESS

16 Reasons Why Employees May Ignore EP Procedures

1. “It can’t happen.”
2. “It can’t be prevented.”
3. “It can’t happen to me.”
4. “I don’t know how.”
5. “You can’t scare me.”
6. “I’m terrified.”
7. “I know I should but it’s a pain.”
8. “I’m an exception.”
9. “This situation is an exception.”
10. “In the real world it’s flexibility that counts.”
11. “Okay, we’ll do it by the book.”
12. “That’s not my culture.”
13. “My friends would laugh at me.”
14. “My boss doesn’t mean it about safety.”
15. “Management is sending a double message.”
16. “Screw ‘em all.”

LET US GET RID OF SOME MYTHS!

MYTH – 1:
Nah … it can’t happen here!
After New York, Bali, Sumatra, London, New Orleans, and Bangalore recently learnt, can anybody be sure?

MYTH – 2:
Even if it happens, our Government will take care of all of us.
With a few exceptional individuals, the Government can and must concentrate on group evacuation, national-level protection, and other bigger issues.

MYTH – 3:
There will be time enough to get ready before it hits.
Let us hope so, but a lot of it is sudden and fast. It would be more prudent to understand and practise!
ENGINEERING EMERGENCY

A condition of a serious nature which develops unexpectedly and endangers the integrity of an engineering structure or other facility;

... or which endangers property and human life and requires immediate action.

An event that demands a crisis response beyond the scope of any single line agency or service (e.g., beyond the scope of just the police department, fire department, etc.)

... and that presents a threat to a community or larger area.

An event that can (or should) be controlled within the scope of local capabilities.


MAJOR ASPECTS OF NATURAL DISASTER MANAGEMENT

- Hazard Analysis
- Vulnerability Analysis
- Mitigation and Prevention
- Preparedness
- Prediction and warning
- Response
- Recovery

http://dmc.engr.wisc.edu/courses/principles/AA04_gif/
CIVIL ENGINEERING RESPONSIBILITY

- Hazard Analysis (Scientific Analysis)
  - Geologic
  - Hydrologic
  - Environmental
  - Structural Design
  - Construction
- Vulnerability Analysis
  - Technical Evaluation (Civil) Engineering
  - Land Use Regulation
- Mitigation & Prevention
  - Building Standards
  - Organization
  
  → Preparedness

EMERGENCY PREPAREDNESS

- Community Planning
  - Procedures
  - Stockpiling
  - Awareness
  - Resource Inventory
  - Logistics Planning
  - Communications Planning

PLUS ... (Author)
Technical Planning in Civil Engineering
PHASES OF EMERGENCY MANAGEMENT

- Awareness of possibility and scope of emergency
- Evaluation of emergency
  - Likelihood of exposure to emergency
  - Severity of consequences of emergency
  [Note there is no absolute or exact answer!]
- Planning and preparation for emergency
- Response to (control of) emergency
- Communication, at every stage
- Follow-up, debriefing, rebuilding, fine-tuning, ...

Frankly, ... this kind of work never ends!

REACH AND IMPACT OF EMERGENCIES

- Individual, community, nation, and world
- Project-wise (Micro), industry-wide, or global (Macro)
- Government, and Politics
- Medical and Health Services
- Commerce, industry, tourism
- Security and Defense
- Communications and Media
- Administrative and Social Services
WHEN EMERGENCY INTERVENTION IS EFFECTIVE

Designer must be an integral part of the life cycle!

COST EFFECTIVENESS OF EARLY INTERVENTION ON SAFETY PROBLEMS IN CONSTRUCTION

$10 ... To change a philosophy

$100 ... To change a drawing

$10,000 ... To make a field change

$10,000,000 ... To clear up after emergency
EASE AND COST OF SAFETY IMPLEMENTATION

Moving emergency preparedness from an afterthought to a forethought in the design process.

Ease of safety implementation

Cost of safety implementation

Safe Design ← Retrofit (Modify)

Concept  Design  Construction  Commission  Use  Maintain  De-commission  Recycle

Emergency preparedness is most effective in the concept and design phases of a project.

SO WHAT CAN DESIGNERS DO?

Five specific designer tasks that can increase civil engineering emergency preparedness:

1. Review for emergency preparedness
2. Design for emergency preparedness
3. Procure for emergency preparedness
4. Review submittals for emergency preparedness
5. Inspect for emergency preparedness

“THINK Emergency Preparedness!”
WHY SHOULD DESIGNERS WORRY ABOUT ENGINEERING PREPAREDNESS?

Designers have a “duty of care” to their clients and the community, which goes beyond strict confines of a legal contract.

They may not have the time or the resources to do more than what they have agreed to do, but they have a professional obligation, a moral and ethical duty to at the least:

(a) Clearly define the boundaries of their commitment, so that no one may innocently or willfully extend them

(b) Document the assumptions they make and the details of computer models they create in their work

(More)

DESIGNERS’ DUTY OF CARE (Contd.)

Moral or ethical duty to at the least:

(c) Point out real risks and potential hazards within the scope of their work, and in the tasks that may be related to their design

(d) Review all aspects of their design and rework it as necessary if and when the contractor has difficulty implementing the design, or the owner insists on some sudden change.

Code writers, and government agencies are beginning to remind and urge, and may even stipulate, the inclusion of safety features, emergency preparedness and response measures into design procedures.
OPINIONS ON DESIGNERS (UK)

60% of accidents studied could have been eliminated or reduced with more thought during design (European Foundation 1991)

50% of general contractors interviewed identified poor design features as affecting safety (Smallwood 1996)

47% of likelihood of reduction of 100 construction accidents studied, by design changes (Gibb et al 2004)

42% of 224 fatality incidents linked to design (1990-2003 in U.S.) (Behm 2004)

22% of 226 injury incidents linked to design (2000-2002 in OR, WA and CA)

ADAPTED FROM ASCE POLICY STATEMENT

Civil engineers and constructors must be ready to quickly and effectively respond to both man-made and natural hazards on the physical infrastructure.

Events of September 11, 2001 and subsequent terrorist acts around the world have focused nation’s attention on infrastructure vulnerabilities and the critical role of civil engineers and constructors as first responders.

Authorities need to identify available resources and best practices to engage civil engineers and constructors in support of search and rescue efforts and in emergency response activities, after disasters.

Various planning initiatives should be coordinated and incorporated into emergency response planning and implementation, including training for first responders.

ASCE participates in development and implementation of emergency preparedness and response strategies.

EMERGENCY PLANNING ZONE ACTIVITIES

The Hazard Assessment includes determination of size of geographic area surrounding the site, known as the Emergency Planning Zone (EPZ).

Within EPZ special planning and preparedness activities are required to reduce the potential health and safety impacts from the emergency.

EPZ should support authorities in these activities to protect people living and working there.

These activities are:

- Identification of response organizations;
- Establishment of effective communications to notify the public and responsible authorities within the EPZ;
- Training and provision of equipment for offsite emergency workers;
- Identification of predetermined response actions; and,
- Development and testing of response procedures.
**IMPACTS OF EMERGENCIES**

- Extent of impact
  - Primary and secondary impacts
  - Estimate the spread under various scenarios
  - Estimate local concentrations

- Population that can be affected
  - Population density
  - Population demographics
  - Impact on necessary services

- Effect on property
  - Economic impacts due to interruption
  - Longer term economic impacts

- Short/long term effects on the environment

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**FACTORS IN PROGRESS OF EMERGENCY**

The City of New Orleans

- Flooding areas with different levels of water

- Dispersion of toxic fumes or radiation due to:
  - Temperature
  - Weather conditions
  - Wind speed, direction

Yellow areas (Y) are below water level
### BARRIERS TO DESIGNING FOR EMERGENCY PREPAREDNESS

- Feeling that the emergency won’t happen to us, or here, or now
- Confidence that “others”, and the government will take care of it for us
- Fear of liability
- Designers’ lack of expertise in emergency preparedness
- Designers’ lack of understanding of other phases of the life cycle
- Professional fees
- Contract terms (Presently forbidding designer intervention, in some codes!)

### FACTORS WHICH MIGHT TRIGGER OR WORSEN EMERGENCIES

- Lack of correct or any information
- Lack of guidance by authorities
- Ignorance of affected groups
- Negligence by a few uncaring individuals
- Use of wrong equipment
- Use of untrained personnel
- Unanticipated combination of two or more disasters
WHAT CAN BE DONE TO MINIMISE ADVERSE CONSEQUENCES DURING EMERGENCIES?

- Complete potential problem analyses
- Develop safe operating procedures for various feasible and worst-case scenarios
- Make response processes inherently safe
- Provide operator and volunteer training
- Conduct mock / rehearsal disasters
- Disseminate information, brief media, conduct seminars
- Involve citizens with familiarisation meetings and exercises
- Include in school and college curricula

NECESSARY EFFORTS FOR EMERGENCY PREPAREDNESS AND MANAGEMENT

- Knowledge of all processes involved
- Knowledge of properties of all materials involved
- Knowledge of all relevant regulations
- Knowledge of safe operating methods for all tasks
- Ability to work effectively with experts from many disciplines
- Interaction guidelines and implementation between different groups, disciplines, industries, etc.
- Chain of command protocols between different departments
Thus, Civil Engineering permeates almost every aspect of human life!

MAJOR (DIRECT) IMPACT OF CIVIL ENGRG.

- Living quarters
- Offices, businesses
- Manufacturing plants
- Roads
- Bridges
- Airport runways
- Tunnels
- Dams
- Power plants
- Ports

Products
Facilities
Distribution
Services

Civil Engineering
Aeronautical Engineering
Chemical Engineering
Electrical Engineering
Mechanical Engineering
Other Engineering
Structures, including bridges, dams, and tunnels
Water supply
Sanitary engineering
Transportation engineering
Environmental engineering
Support services
Imagine yourself having to rush, with a huge crowd, down the steps at right ► or the ones at left
(... if you don’t see the problem right away, compare the topmost step height with that of other steps!)

MORAL
There is nothing “minor” about emergencies. During an emergency evacuation or a panic (or “greed”) stampede, small obstacles can lead to multiple crushing deaths. (Eg. Rock concert fires, Haj pilgrimage, terrorist rumour)

Case Study 1
Terrorist Attack
World Trade Center, New York
TWIN TOWERS COLLAPSE (Sept. 11, 2001)

08:45 Eastern Time, 1-WTC (North Tower) was struck by AA Flt. 11, a Boeing 767.

Stood for 103 mins

TOTAL DEAD
2795

DESTROYED!
33 of 59 perimeter columns
20 of 47 core columns (centre)

09:05 Eastern Time, 2-WTC (South Tower) was struck by UA Flt. 175, a Boeing 767.

Stood for 53 mins

DESTROYED!
29 of 59 perimeter columns
5 of 47 core cols. (SE corner)

Fireproofing stripped from beams and columns in the path of debris created by the planes penetrating the buildings

AT THE BATHTUB

Author with Jack Donnelly, Project Manager, On Dec. 18, 2002
CIVIL ENGINEERING ASPECTS

1. STRUCTURAL REDUNDANCY

Redundancy is the incorporation of more strength and safety features than are strictly necessary, with sole aim of protecting human lives, environmental damage, etc. from unexpected risks.

("Rule of Two": Double lanyard?)

- "The design should also have sufficient redundancy to prevent a catastrophic collapse in the event of a failure of any particular element." (Nicoll COI Report)

WTC INTERNAL STRUCTURE

WHY THE TOWERS COLLAPSED

The impact of the plane crash destabilized a number of perimeter columns on several floors of the building, severely weakening the entire system.

As fires spread to the upper floors, the heat gradually affected the remaining structure.

Eventually, one entire floor collapsed, and this impact carried all of the floors above, creating the "cascade" effect typical of the collapse.

The columns, designed to support only the vertical load, failed.

Floor trusses are supported by both the perimeter columns and the central core.

The floor slabs failed when the perimeter columns and the central core could not sustain the weight of the building.

A hollow tube of closely spaced perimeter columns forms the main structural component of the towers.
REDUNDANCY OF COLUMNS SAVED THE WTC FROM IMMEDIATE COLLAPSE

External mullion tubes of the windows shared and redistributed the loads with the inner core columns through the medium of the floor slabs and trusses.

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CIVIL ENGINEERING ASPECTS (Contd.)

2. SAFETY ENGINEERING – RISK ANALYSIS

The statistics for the world trade center indicate:

- Approximately 2500 people perished in the incident

- If all employees had been at work, the number would have been about 27,500 personnel in the buildings

- So up to 22,000 people survived the terrorist attacks.

Safety engineering was a factor in this survival rate. Apart from redundancy, design had included:

(a) Fire protection for 1½ to 2 hours
(b) Evacuation methods and facilities
(c) Designed for an airplane crash
2.(b) EMERGENCY EGRESS DESIGN

The design of the WTC included stairways located near the center of the structure, next to the central support pillars (http://www.Skyscraper.Org/tallest/t_wtc.Htm)

- The doors to the stairs were of fire-resistant construction
- Entries were marked with exit signs
- Most of doors were available and most people escaped via the stairs.
  - Only 4 people above the impact areas were known to have survived because the stairs were destroyed in that region
  - These designs were included in the original construction for anytime the elevators were not functional

UNPLANNED EGRESS ROUTES – SOMETIMES YOU ARE LUCKY

The elevators in the WTC served to provide escape routes to a number of people

- The design used a series of elevators to cover the 110 stories
- There were change stations at the 44th and 78th floors
- As a consequence, the lower section elevators were running even while the fire was burning above
- While not intended for this purpose, these elevators provided extra egress routes.
ANOTHER FACTOR WAS EMERGENCY PREPARATION

THE EH&S ENGINEER NEEDS TO MAKE CERTAIN THAT PERSONNEL CAN USE THE EMERGENCY FACILITIES

- An emergency plan should be developed to anticipate incidents
- This may require personnel training
- Communication systems need to be established
- There may have been floor safety officers at the WTC who helped people to safety
- The system also has to be user-friendly
- Signage needs to be designed so personnel under pressure can find escape routes

RAPID RESPONSE/EMERGENCY RESPONSE TEAMS

Rapid response teams are configured to deliver necessary services at an incident.

The safety engineer design for implementation considers:

- Transportation of the team to the site
- Evacuation of the site
- Communication during the whole activity
- Working with local government, utility and commercial groups involved in response

Emergency response teams are set up to

- Aid the victims of the incident
- Communicate with those concerned about actual or potential victims
RAPID RESPONSE TO THE WTC DISASTER

The fire and police departments responded to the WTC by:

- Bringing emergency resources to the site
- Setting up a central command post
  - This unfortunately was located in the basement of one of the towers
- Sealing off the area so people could evacuate quickly
- Assisting people in evacuation from the area

An evacuation plan had been developed after the 1993 attack on the WTC. This plan was implemented to evacuate the buildings.


EMERGENCY RESPONSE TO WTC DISASTER

The emergency response included setting up systems to provide victims and their families with information

- How to provide or receive aid
  (http://www.fema.gov/diz01/e3169n04.htm)
- Information about air quality the area
- Information regarding transportation and utility resources through the area

Other activities included:

- Developing systems to remove the wreckage, dispose of the materials, and collect necessary information
- Plans for repair of affected utility and transportation systems
SAFETY ENGINEERS DESIGNED FIRE CONTROL (SURPRESSION) SYSTEMS INTO THE WTC

The WTC was provided with water based fire suppression systems, adequate to handle fires based on available fuels.

(http://www.cnn.com/2001/community/09/13/rittenhouse.cnna/)

The building was designed with fireproofing on the steel to resist temperatures between 1500 – 2000°F for a period of 1 ½ hours, the time assumed required to vacate the building by stairs.

It is estimated the temperatures actually reached 4000°F, so the steel weakened and collapsed in a shorter time frame.

(http://cem.colorado.edu/archives/fl2001/wtc.html)

FORENSIC SAFETY ENGINEERING RELATED TO THE WTC INCIDENT

EH&S safety engineers attempt to reconstruct the incident from the available evidence, and review incidents to determine:

- How to assign responsibility for incidents
- How to prevent similar incidents in the future

Forensic safety engineers have been doing the following:

- Attempts to use DNA to identify human remains discovered in the wreckage
  (http://www.sfweekly.com/issues/2002-03-06/smith.html/1/index.html)

- Damaged steel is being analyzed as part of the reconstruction of the collapse
  (http://www.construction.com/newscenter/headlines/ar/20020110r.jsp)

- The conditions during the fire and collapse are being reviewed to determine if the structural codes are adequate
  (http://news.bbc.co.uk/hi/english/sci/tech/newsid_1579000/1579092.stm)
SAFETY ENGINEERING RELATED TO THE WTC INCIDENT - SUMMARY

Safety engineering provided some of the components that were positive during the WTC incident.

- Safety in design provided more time for people to escape.
- Evacuation planning facilitated evacuation.
- Emergency planning led to coordination among emergency units.
- Rapid and emergency response operations minimized the impacts on the community.
- Forensic engineering will help identify victims and determine how the structural failures occurred.

FINAL RECOMMENDATIONS

- FAA needs to be concerned with hazards related to planes flying off course.
- Location of emergency coordination centers should be remote from the site.
- More consideration for structural collapse before sending emergency personnel into buildings.
- Fire protection measures and inspection must be tightened.
- Skyscrapers need designs that incorporate bridges between adjacent buildings to provide additional egress.
**Low Risk**

- Develop a family emergency plan. Share it with family and friends, and practice it.
- Create an “Emergency Supply Kit” for your household.
- Be informed.
- Know where to shelter and how to turn off utilities (power, gas, and water) to your home.
- Participate in volunteer opportunities in your community, such as Citizen Corps, Volunteers in Police Service, Neighborhood Watch or others.
- Consider completing a course in first aid or CPR, or Community Emergency Response Team (CERT).

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**Emergency Kits**

- **Shelter**
  - Tarp
  - Sheets
  - Tent
  - Blanket
- **Equipment**
  - Radio
  - Dust mask
  - Flashlight
  - Spare batteries
- **Personal**
  - Toothbrush and paste
  - Deodorant, soap, toilet paper
  - Personal documents, identification
  - Medications, personal prescription
  - Spare prescription glasses
  - Quarters for pay phone
  - Sunscreen
  - Entertainment (e.g., cards)
  - First aid kit
  - Pets: water, food
- **Other**
  - Rags and duct tape
  - Garbage bags
  - Signal flare
  - Tools (saw, hammer, nails, wrench, pliers)
  - Personal items (food, cards, money, personal power)
  - Spare hoses and vehicle keys
- **First Aid Kit**
- **Waters**
  - Water purification tablets or chlorine bleach and medicine dropper
- **Clothing**
  - Shirts, shoes
  - Jacket
  - Hat and gloves
  - Socks, underwear
  - Pants, sweater
  - Rain gear

TERRORIST ATTACK THREAT LEVELS

Guarded Risk

😊 Complete recommended steps at level green.

😊 Review stored disaster supplies and replace items that are outdated.

😊 Be alert to suspicious activity and report it to proper authorities.

Elevated Risk

😊 Complete recommended steps at levels green and blue.

😊 Ensure disaster supplies are stocked and ready.

😊 Check and update telephone numbers in family emergency plan.

😊 Develop and practise alternate routes to and from work or school.

😊 Continue to be alert for suspicious activity and report it to authorities.
TERRORIST ATTACK THREAT LEVELS

High Risk

😊 Complete recommended steps at lower levels.

😊 Exercise caution when traveling, pay attention to travel advisories.

😊 Review your family emergency plan and make sure all family members know what to do.

😊 Be Patient. Expect some delays, baggage searches and restrictions at public buildings.

😊 Check on neighbors or others that might need assistance in an emergency.

TERRORIST ATTACK THREAT LEVELS

Severe Risk

😊 Complete all recommended actions at lower levels.

😊 Listen to local emergency management officials.

😊 Stay tuned to TV or radio for current information/instructions.

😊 Be prepared to shelter or evacuate, as instructed.

😊 Expect traffic delays and restrictions.

😊 Provide volunteer services only as requested.

😊 Contact your school/business to determine status of work day.
HOWARD ST. TUNNEL FIRE, BALTIMORE CITY, USA, 18 JULY, 2001

**Events**
- Derailment
- Hazardous materials
- Water main break
- Fire

**Depts. Involved**
- City Fire, Police, Public Works, Emer. Mgmt.
- State DOT, DOE
- U.S. Coast Guard, EPA

**HOward St. Tunnel Fire, 2001 (Contd.)**

▲ Smoke Billows From the Tunnel's South Portal, with the Baltimore City Skyline in the Background.

All pictures, Source: Baltimore Sun

Evacuating Orioles Park at the Camden Yards Station ►

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**Short Term Impacts (Day of Accident)**
- Evacuation of offices and business centres
- Closing of streets
- Closing of Metro station
- Disruption of light rail, metro, bus, boat, & freight services

**Medium Term Impacts (Days 2 to 5)**
- Fire fighting and clean up of hazardous materials
- Continued disruption of passenger and freight transport
- Disruption of telecommunications and internet services

**Long Term Impacts (Days 6 to 55)**
- Repair of water main
- Repair of light rail track
- Concrete cracked up due to high temperature!
- Business drop 80%
- Football games cancel loss ≈ US$2 m
HOWARD ST. TUNNEL 2001 FIRE, FINDINGS

- Three competing priorities: Environmental hazard, fire, and transport mobility
- Combination of hazardous materials spill and fire not anticipated, so priorities and commands confused.
- Agency overlap and system redundancy (bus bridge for transport) helped
- Importance of on-going training and practice, and identifying all resources as the key to developing and maintaining incident response capabilities stressed
- Coordination between city, state, and federal agencies needs improvement in legal matters, funding, authority, responsibility, insurance, communication strategy and priority, etc.
- Suppression of information for security a problem.

CHUNNEL FIRE, NOV. 1996

No one seriously hurt … imaging system helped identify evacuation and fire fighting access routes

http://www.constructmyfuture.com/haul-chunnel.html
CHUNNEL FIRE, NOV. 1996 (Contd.)

- Despite the fact that the blaze literally turned the running tunnel into an oven, all passengers and crew were released from the hospital within 24 hours.

- Police and rescue workers on the English side of the Chunnel were able to use an imaging system of engineering drawings to locate access evacuation routes. The fire caused no significant damage to the tunnel's concrete liner.

- However, the concrete segments used in the tunnel were engineered to withstand enormous heat and pressure. The performance of the concrete was improved by controlling the type of aggregate used and adding protective linings.

EMERGENCY RESPONSE AFTER A BAY AREA INCIDENT (TUNNEL FIRE)

In January 1979, a fire occurred in one of the trans-bay tube BART tunnels. When the train stopped in the tunnel, it was not clear to passengers how to safely exit to the emergency escape tunnel that sits between the two train tunnels. 46 people suffered minor injuries and one fire-fighter who entered from the east end of the tunnel was killed. As a result of this incident, all the signage in the BART trains and in the tunnels was revised. Emergency plans were revised for all points on the system. Train operators were given additional emergency response safety training.
Case Study 3

Hurricane / Flood
New Orleans, Louisiana, USA

KATRINA’S IMPACT

28 Aug 2005, Sunday: Katrina becomes a Category 5 storm with 175 mph winds

29 Aug 2005, Monday: Refugees in the Superdome
NEW ORLEANS LEVEE SYSTEM

Much of New Orleans was flooded with water after Hurricane Katrina's storm surges broke two levees built to hold water back. About 70 percent of the city is below sea level, as shown in the cross section at right.

http://en.wikipedia.org/wiki/Hurricane_Katrina

KATRINA’S IMPACT (Contd.)

- Floodwall breach
- Sand and gravel bagging
... extremely dangerous hurricane Katrina continues to approach the Mississippi river delta ... devastation expected ... most of the area will be uninhabitable for weeks ... perhaps longer.

At least one half of well constructed homes will have roof and wall failure. All gabled roofs will fail ... leaving those homes severely damaged or destroyed. ... The majority of industrial buildings will become non functional. Partial to complete wall and roof failure is expected. All wood framed low rising apartment buildings will be destroyed. Concrete block low rise apartments will sustain major damage ... including some wall and roof failure. ... High rise office and apartment buildings will sway dangerously ... a few to the point of total collapse. All windows will blow out.

Airborne debris will be widespread ... and may include heavy items such as household appliances and even light vehicles. Sport utility vehicles and light trucks will be moved. The blown debris will create additional destruction. Persons ... pets ... and livestock exposed to the winds will face certain death if struck. ... Power outages will last for weeks ... as most power poles will be down and transformers destroyed.

Water shortages will make human suffering incredible by modern standards.

The vast majority of native trees will be snapped or uprooted. Only the heartiest will remain standing ... but be totally defoliated. Few crops will remain. Livestock left exposed to the winds will be killed.
Robert Bea, a University of California, Berkeley professor who led a National Science Foundation investigation of the levee failures, said the mistakes made by the engineers on the project were hard to accept because the project was so "straightforward."

"It's hard to understand, because it seemed so simple, and because the failure has become so large," Bea said.

"This is the largest civil engineering disaster in the history of the United States. Nothing has come close to the $300 billion in damages and half-million people out of their homes and the lives lost," he said.

"Nothing this big has ever happened before in civil engineering."

NEW ORLEANS LEVEE PROBLEMS

1998 documents indicate the contractor complained about weakness of the soil and the lack of structural integrity of existing sheet piles around which concrete was poured.

The ruling also referenced the flimsiness of the sheet piling.

The construction company said as a result of these problems the walls were shifting and did not meet some design specifications.

Nevertheless, the Army Corps of Engineers accepted the work.

http://outhouserag.typepad.com/hurricane_watch/katrina_levee_system/index.html
COSTLY DESIGN / CONSTRUCTION FLAWS

Army Corps of Engineers underestimated the weak soil layers 10 to 25 feet below the levee, the state's investigation team ('Team Louisiana') concluded in a report to be released in Nov. 2005. (Recent seepage ignored.)

That miscalculation was so obvious and fundamental, investigators said, they "could not fathom" how the design team of engineers from the Corps, local firm Eustis Engineering, and the national firm Modjeski and Masters could have missed what is being termed the costliest engineering mistake in American history.

"You use the Corps cookbook, and you usually have to work it out using Corps (computer) programs," Billy Prochaska, a consulting engineer in the team said.

The Corps has long claimed the sheet piling was driven to 17.5 feet deep, but Team Louisiana recently used sophisticated ground sonar to prove it was only 10 feet. (Drawings showed only 10 feet.)

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EVACUATION, HOUSING, TRANSPORT

Refugees bringing their belongings and lining up to get into the Superdome

Hurricane evacuees relocated on a highway being helped by the Air National Guard
MISCOMMUNICATION(S)

Buses left unused during the evacuations, after miscommunication between State Government and FEMA.

IMPORTANCE OF INFORMATION AND COMMUNICATION

Where it is impractical to eliminate hazards through design selection, or to reduce the associated risk to an acceptable level with safety and warning devices, special procedures and training must be incorporated.

*Information (alone) is not a good method of risk control!*

If the use of procedures is the only practical method of achieving emergency preparedness, it should be recognized that the chances of error are high.

Public awareness and appreciation, and media cooperation and dissemination must be very clear.
PROPER COMMUNICATION FACTORS

1. Correct and complete communication is essential to avoid panic, establish control, and organise efforts.

2. Emergency Preparedness (EP) perception is a lot more than mortality statistics.

3. Moral categories mean more than EP data. Emotions too (ethnicity in Singapore, rich vs. poor elsewhere) must be seen as legitimate.

4. Policy decisions may be seen as either risky or safe.

5. Equity and control issues underlie most EP controversies.

6. EP decisions are better when the public shares the power ... and the responsibility.

7. Explaining EP information is difficult but not impossible, if the motivation is there.

Adapted from: Peter Sandman [http://www.psandman.com/articles/explain3.htm]

EMERGENCY PREPAREDNESS LESSONS

Ultimately, each one of us has to take responsibility for our own safety, to understand state guidelines, and follow proper procedures in times of emergency “Think of the end when you start”. This applies to everyone and all activities.

The end of the designer’s and contractor’s product is the user of the product. His/her safety and survival in an emergency should be their first and last aim.

Able-bodied persons should understand implications of modern metropolitan life, and be prepared for the emergencies that can (may) occur. Each must be ready, willing, and able to contribute his/her share to the family, community, and national effort.

Do not be paranoid ... but do not be over-confident.

Do not take on work for which you are not trained! (Meaning, if you wish to volunteer, get trained.)
THE DESIGN DILEMMA ... AND CLOSURE

- Anybody can ask: Why can’t the designers produce a fail-safe solution for any problem: A structure that can withstand the worst earthquake; a computer that will last forever, etc., etc.

- The answer is, of course, everything in our life is limited by (a) natural resources available, and (b) personal or national resources to acquire, convert, and utilise these natural resources.

- Thus it is that a contractor decides how many workers will be hurt in his project; a hospital decides who will receive a kidney and who will not; and a nation must decide how much effort and resources should be invested into emergency preparedness.

- In the final analysis, regardless of massive material resources and all the advanced technology, it is the human spirit and the human will that will decide how a community faces and manages any emergency.

The End
(Or just the beginning ?)