Karagozian & Case

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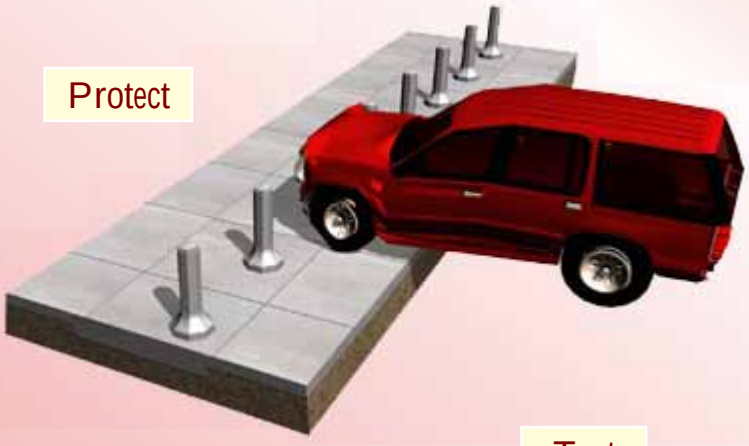
Design

Protect



Test

Partnering
with
Experts
for Your
Security

John E. Crawford
President, K & C

To our potential and existing clientele, I want to say a few words to describe our company.

Karagozian & Case has provided protective design engineering services for four decades to protect your personnel, property, and the functionality of your operations. We focus primarily on developing protective designs and devices for extreme load environments such as those associated with blast, shock, and high-velocity impacts. In addition, we provide risk assessments and conduct research and development activities related to blast effects and high-energy impacts.

Our purpose is to deliver designs to insure your security from risks associated with extreme events, especially malevolent threats such as those related to terrorist attacks that could involve blasts, high-velocity fragments and projectiles, and impacts from vehicles, ships, and airplanes. This includes a complete package of engineering design services, construction drawings and supervision, testing to demonstrate the validity of our designs, and educational seminars to explain the technology behind our work.

We have provided protective designs for a wide range of new and existing buildings and of other types of facilities (e.g., sports arenas), bridges and other components of the infrastructure (e.g., dams, locks), and processing and manufacturing facilities (e.g., petrochemical plants). This encompasses protection for structural, mechanical, and electrical systems, including structural components such as steel and reinforced concrete columns and girders; piping and processing equipment; electrical devices; and walls and glazing facades. We have invented a number of unique and novel protective devices and design strategies, and have been instrumental in developing design tools and guides and advancing the state-of-the-art through our research and development activities and our blast and impacts testing.

The result is that commercial firms and Government agencies that use our services are able to build structures and deploy equipment that will better withstand all kinds of terrorist and explosive threats, vastly reducing risks to life and property. We also have aided a number of commercial firms in bringing their products for enhancing blast and impact resistance to market.

The reason we are able to do this is our long experience in blast effects consulting, protective design, and the testing of systems to evaluate blast and impact effects. We've handled a wide range of protective design problems and worked with a broad assortment of clients. We are deep in experience, which allows us great flexibility and speed of reaction in meeting your needs. Several of our staff have over 30 years experience in protective design and most have advanced degrees. Moreover, our staff in the last five years has authored over 1,000 scientific papers, reports, and other documents concerning protective design.

We believe in absolute integrity, and will gladly partner with you and other engineers and consultants to ensure your security. This involves a true hands-on approach in an unmatched effort to give you what you want and need to ensure your safety, at an overall cost less than anyone else. The initial price for our work is a little higher than with other, less-qualified firms, but we ultimately save you many times our costs by offering you designs that are cost effective, fit with your operations, and blend with your aesthetic goals. We stand behind our designs and have conducted hundreds of blast and impact tests to validate them, and to verify our understanding of blast and impact effects.

We will put our experts at your disposal to do whatever it takes to help you achieve your project goals at a price you can afford.

John E. Crawford, P.E.

President K & C

K&C EXPERTISE

K&C was founded in 1945. It is a well respected member of the consulting engineering community, recognized for its capabilities nationally and internationally.

Protective Design

K&C offers a wide ranging and unique set of design skills to prevent or mitigate the risks from terrorist or accidental explosive threats and threats represented by high-velocity impacts from bullets, fragments, vehicles, and aircraft.

Vulnerability & Risk Analysis

K&C uses their advanced understanding of blast effects to estimate casualties and predict damage to assist owners in understanding vulnerability and risk, evaluate protective options, prioritize actions, and develop specific plans to manage risk.

R&D, and Testing of Blast and Impact Effects

As USA's leading firm in advancing the understanding of blast and impact effects and enhancing protection from them, K&C has conducted numerous R&D studies. We have also played a key role in assisting the U.S. Government with advancements in protective design for over 30 years. K&C is one of the few firms in the world that are truly qualified to evaluate blast and impact effects on structures and equipment. We have developed many unique and novel ideas for protection of buildings and other facilities, and their occupants and functionality.

Perimeter Defense Engineering

K&C's expertise includes the design and specification of passive and active vehicle barrier systems, forced entry and ballistic resistant wall/door/window systems, and perimeter wall and fence systems. K&C has also developed and installed several blast walls and shields.

Education and Training Seminars

K&C offers a variety of seminars to train engineers, owners, and Government officials on protective design techniques and behaviors related to blast and impact effects. We also teach the use of advanced analytic modeling techniques using physics-based simulation tools so engineers can perform their own design/analysis studies.

A Sampling of Our Clientele

Government Agencies

Air Force Research Laboratory, Eglin AFB
Air Force Research Laboratory, Tyndall AFB
Army Engineering Research and Development Center, Vicksburg
Defense Threat Reduction Agency
Department of State
Energetic Materials Research and Testing Center
General Services Administration
Korean Agency for Defense Development
Los Alamos National Laboratory
Ministry of Homeland Affairs, Singapore
Naval Facilities Engineering Services Center
Senate Sergeant at Arms

Contractors and Manufacturers

AutoGate
Chugach Management Services, JV
ConVault, Inc.
DuPont Corporation
Fibrecom
Kellogg, Brown & Root
PROTECH Armored Products
Royal Building Services
RSA Protective Technologies, LLC
Traco Glass
VSL, Australia Pty. Ltd.

Architects and Engineers

ACTA, Inc.
Amkor, A&E, Inc.
Applied Research Associates, Inc.
Black & Veatch
CPG Consultants Pte Ltd
Degenkolb Engineers
Gabor Lorant Architects, Inc.
General Dynamics
Gensler
HNTB Architects Engineers Planners
Magnusson Klemencic Associates
Ove Arup & Partners International, LTD
Science Applications International Corp.
Severud Associates
URS Corporation
Wiss, Janney, Elstner Associates Inc.

Building and Facility Owners

BP (British Petroleum)
Changi Airport, Singapore
Detroit Airport
Goldman-Sachs
Hovensa
Los Angeles International Airport
Marathon Ashland Petroleum
Phoenix Sky Harbor Airport
The Prudential Life Insurance Co.
World Bank

Education and Training Seminars

Security Risk Assessment and Protective Design, Panama Canal Authority, September 2007
Seminars in China at Changsha, Tsinghua (Beijing), and Tongji (Shanghai) Universities, September 2006 and October 2007
LS-DYNA Modeling of Blast/Impact Effects, Singapore, September 2006
An introduction to Explosion Effects and Design for Blast, Sydney, December 2005
Blast Effects Design/Analysis, University of Western Australia, December 2005
Blast Effects Design and Analysis of Structural and Mechanical Systems, Nanyang Technological University, Singapore, December 2004

KEY PERSONNEL

Karagozian & Case
K&C
www.kcse.com

John E. Crawford, P.E.

Forty years of analysis and design for survival from blast and shock loads. Developed innovative and practical concepts to mitigate blast and shock effects for structures, windows, façades, and occupants. Spearheaded using composites and new materials like polymers in effective and esthetic blast-resistant designs. Prepared designs for reducing the risk of terrorist attack for embassies and Government buildings. Authored over 350 reports on blast and shock effects.

Kenneth B. Morrill, P.E., G.E.

Thirty years experience analyzing civil and aerospace structures subjected to static and dynamic loads. Background in finite element analysis of structures-related seismic ground motions, and aeronautical and blast loading. Principal investigator developing blast and shock design methodologies for tunnels. Designed and conducted numerous full-scale blast effects tests. Published 50 plus reports.

Shengrui Lan, Ph.D.

Dr. Lan has twenty years experience in structural engineering, especially finite element and boundary element analyses of engineering structures under static, dynamic, and blast loads. Conducted many full-scale explosive tests of structural components, including designing test articles and posttest analyses. Awarded the prestigious Defense Technology Prize by the Ministry of Defense, Singapore. Published over 30 papers on structural engineering and blast effects.

Ruben Martinez, M.S.

With K&C since 2003, Ruben Martinez is a project engineer who specializes in the design, construction, and explosive testing of full- and sub-scale test articles. He heads the Albuquerque satellite office and conducts blast testing at various Government test ranges in New Mexico. He holds a B.S. in Civil Engineering, and an M.S. in Engineering Mechanics with a specialization in explosives engineering.

Engineering Services Tailored to Meet the Clients Needs

Karagozian & Case

K&C

www.kcsc.com

KEY PERSONNEL

Joe Magallanes, P.E.

Mr. Magallanes has performed numerous blast effects analyses and blast-resistant design work for test planning, prediction projects, and anti-terrorism work at international airports, petrochemical plants, and Government facilities. He has used predictive damage codes and methods along with military technical manuals to analyze and design structural elements and systems, new hardened military facilities, and conventional/industrial structures for service loads and blast/impact resistance.

Hyung Jin Choi, Ph.D.

Dr. Choi has a Ph.D. in structural dynamics, specializing in system identification and statistical approaches to structural analysis. Ten years at one of Korea's largest consulting/construction companies, he rose to head engineer. At K&C, he has focused on blast and high-fidelity physics-based finite element analyses. He heads the team developing new technologies in protective engineering design. He has published more than 30 papers.

Brian Dunn, P.E., S.E.

Mr. Dunn, with K& C since 1988, has designed commercial, industrial, and hospital structures, as well as structures to resist to conventional and nuclear weapons effects. He has performed blast effects analyses and prepared drawings for blast-resistant designs for airports, office buildings, embassies, and petrochemical facilities. He is familiar with various analytic tools and Government guidelines related to performing vulnerability and progressive collapse analyses. He has extensive experience designing perimeter protection devices.

Craig S. Sheffield, M.S.

Mr. Sheffield has sixteen years of experience conducting numerous high-explosive airblast tests, managing projects, performing analytic studies related to airblast and ground shock computer simulations to help design field tests, and documenting and interpreting test data. Currently, he is a project manager for several test programs including studying the response of steel structures to blast loads. He is also involved in design projects for various Government agencies.

Designs to Meet the Extremes of Tomorrow's World

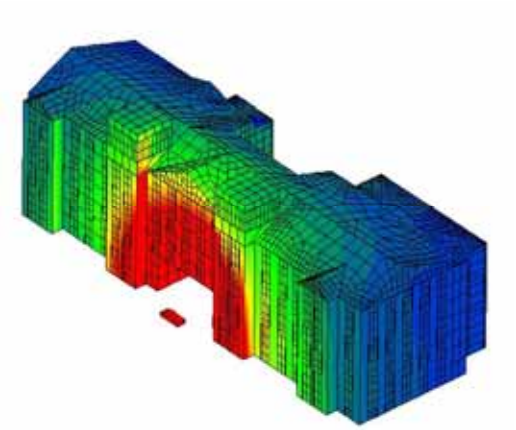
Examples of Vulnerability Analysis / and Risk Management

Design Concept

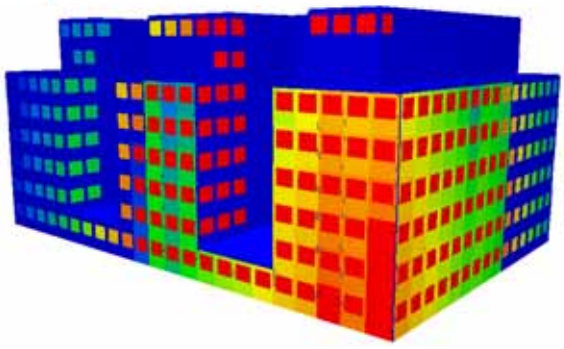
K&C uses their advanced understanding in blast effects, physical security engineering, seismic effects, estimating casualties, and damage predictions to assist owners in understanding vulnerability and risk. K&C's expertise allows them to evaluate protective options, prioritize actions, and develop specific plans to mitigate and manage risk.

- **Risk Analysis/Design Guidance relative to terrorist attacks and accidental explosions are provided for a range of needs, including assessing building vulnerability to terrorist bombings, improving a building's blast resistance, and actions that can be taken to reduce occupant risks.**
- **Utilizing the latest computer modeling tools to perform blast and impact analyses, K&C specializes in nonlinear dynamic analyses using commercial codes like LS-DYNA, AUTODYN, and ABAQUS; restricted Government codes like CTH and DYNA3D; and our own in-house finite element codes—especially applicable to exotic situations like the two-phase analyses associated with liquefaction studies.**

Blast Effects Analysis



Vulnerability Assessment Using Computer Modeling



Examples of Protective Design

Column Strengthening

Design Concept

- **Add capacity and ductility to existing reinforced concrete columns**
- **Accomplished with steel jackets and FRP wrap (Fiber Reinforced Polymer)**
- **FRP easily and rapidly installed**
- **Protection for both vehicle bombs and satchel charges**

Steel Jacket

FRP

Examples of Perimeter Defense Engineering

Anti-Ram Walls and Bollards

Anti-Ram Concept

- **K&C bollard designs offer the most advanced technology in standoff protection.**
- **Existing anti-ram walls provide too little capacity for newly emerging threats from large trucks at high speed. To ensure that these trucks can safely be kept beyond a facility's perimeter, K&C designed a new type of anti-ram barrier, which has more than four times the capacity of those currently rated by the Government.**
- **K&C provides design, analysis and Testing of Anti-Ram Devices**

Anti-Ram Bollards

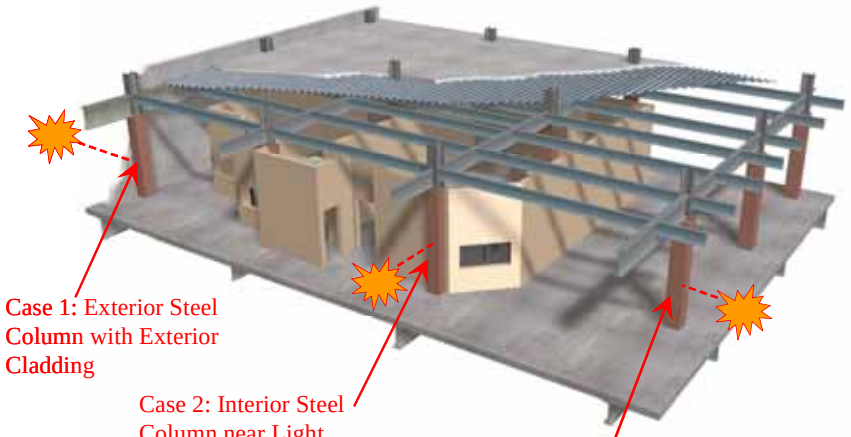
Anti-Ram Wall

Examples of R&D Testing Related to Blast, Impact, and Ballistic Effects

Design Concept

- **K&C designs lab and field tests related to blast and impact effects.**
- **Blast effects testing of steel and reinforced concrete columns; buildings; and rooms—including their windows; furniture and its mitigation or exacerbation of blasts; and on Anthropomorphic Test Dummies (ATDs) to test survivability and injury following various types of blasts and loads.**
- **Impact tests, including tests of anti-ram devices to vehicle impacts and ballistic resistance for small and large caliber arms.**
- **Test results are compared with K&C's computer-modeled predictions, which are remarkably accurate.**

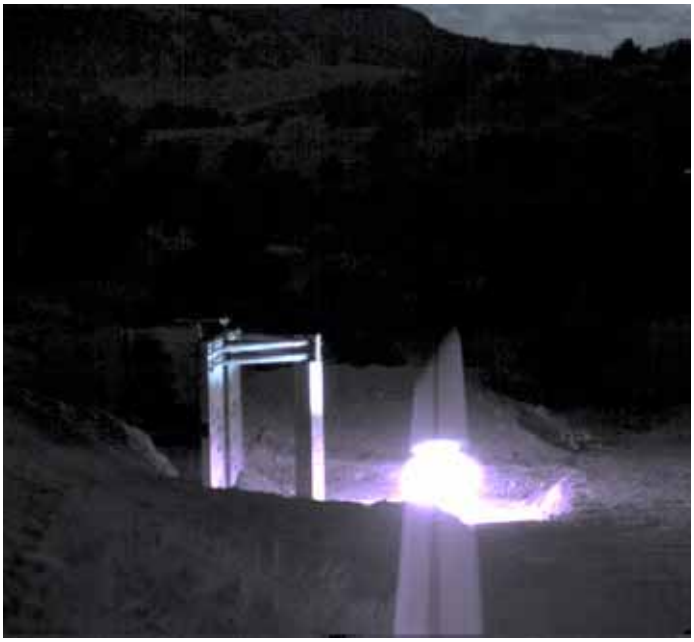
Blast Effects on Columns



Field Test

The crew is ready for the first test of the day

The area is cleared while the blasts occur



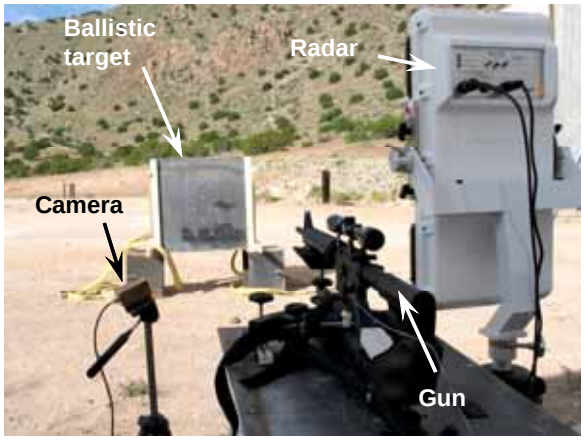
Nighttime test

Posttest measurements on a column

Design of Low Cost Ballistic Resistant Systems and Their Testing

Protective Design Using Standard Stud Wall Construction

Testing



Typical Threat

Close-Up of Perforation

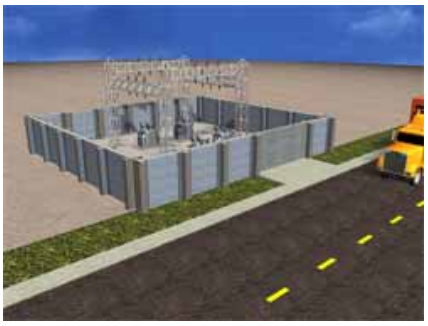
Interstitial Fill Between Studs Used to Stop Ballistic Perforations

Front Face of Wall

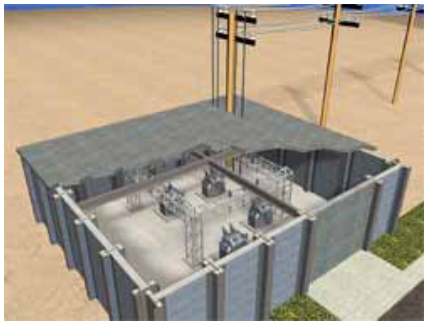
Rear Face of Wall (No Perforation Occurs)

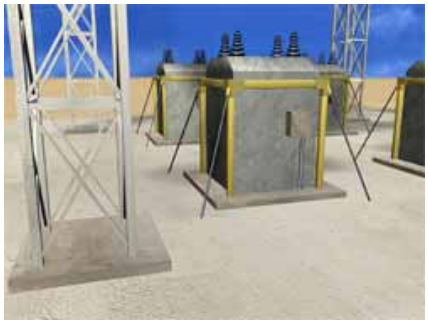
Protection of Industrial Facilities

Identifying Vulnerability of Processing Units

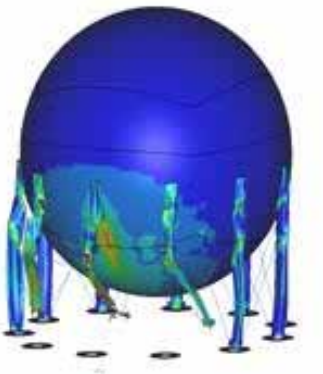


Enhanced Blast Resistance for Tankage and Electrical Distribution Systems





Evaluating Blast Resistance of Systems and Devices used in Refining Processes, Gas Storage Tanks



INSTALLATION OF BLAST WALLS

Blast Barrier

With 20-foot Obscuration Shield on Top

Before

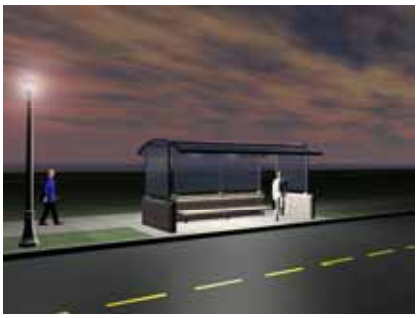
After

Shield

Blast Wall

Manufacture and Development of
Devices for Perimeter Protection
Examples Illustrate How Perimeter
Defense Can Be Made to Blend
Aesthetically with the Surroundings

Anti-ram bollards blended with the street furniture.



Anti-ram bus stop

Anti-ram park bench

Anti-ram fencing

Decorative Bollards

Access denial with anti-ram walls

Pretest

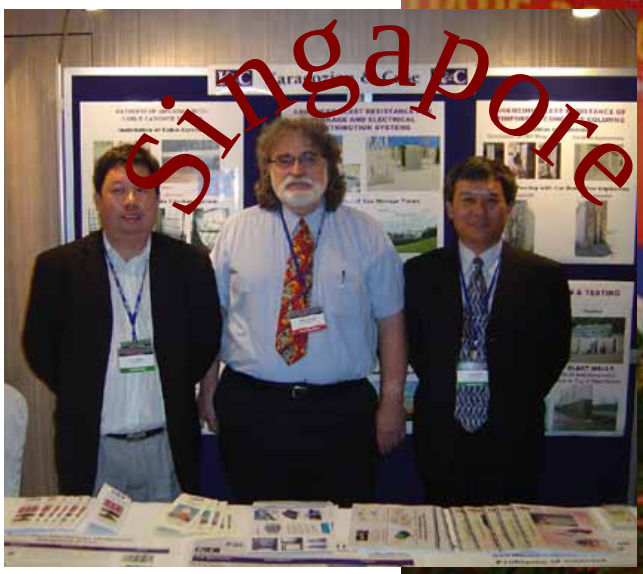
Posttest

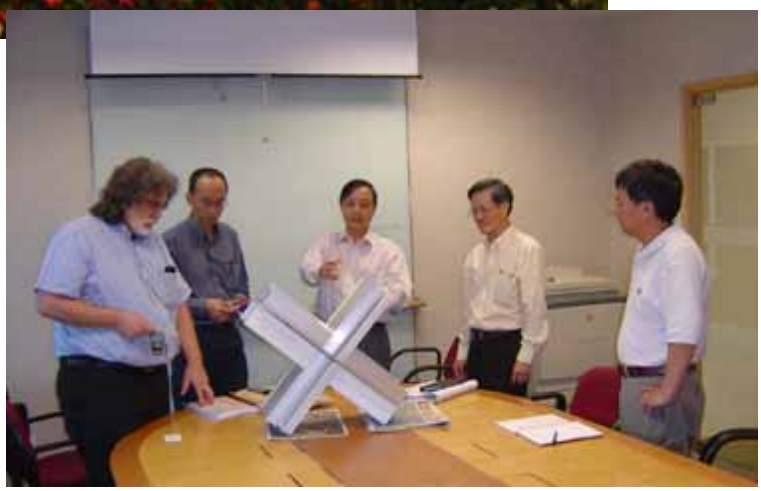
Posttest ATD

Posttest Flexure-Membrane Response

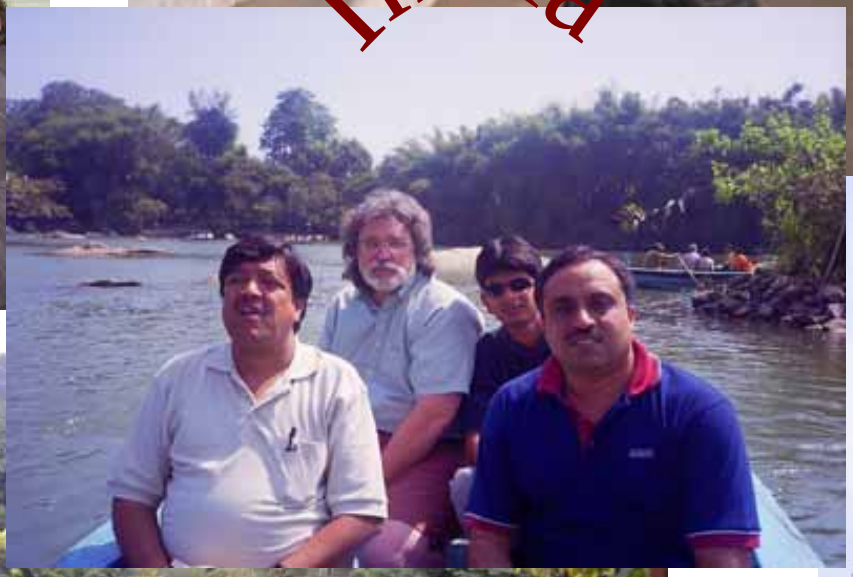
Posttest ATD

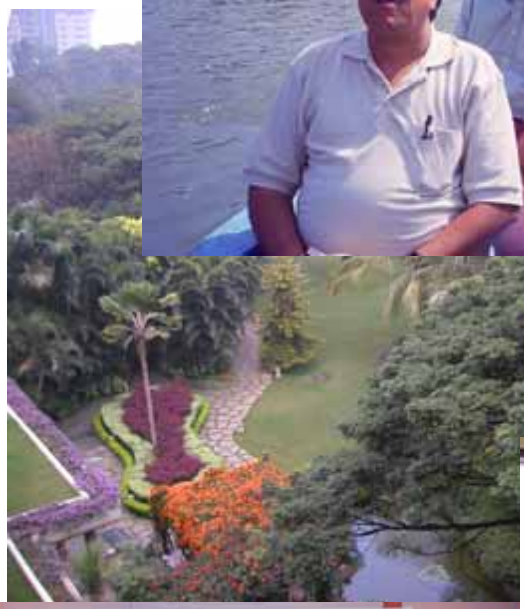
Education, Training, Seminars





India





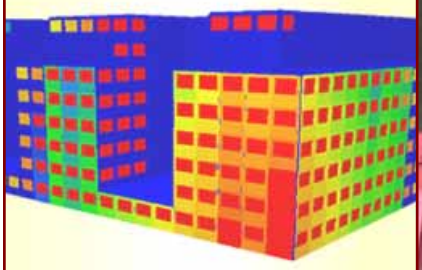
Oxnard













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