# UNIT III - ENGINEERING AS SOCIAL EXPERIMENTATION

**To undertake a great work and especially a work of novel type means, carrying out an experiment. It means taking up a struggle with the forces of nature without the assurance of emerging as a victor after the first attack.**

Louis Marie Henri Navier (1785 - 1836) - *Founder of Structural Analysis*

## ENGINEERING AS EXPERIMENTATION

- Experimentation (Preliminary tests or Simulations) plays a vital role in the design of a product or process.
- In all stages of converting a new engineering concept into a design like,
  - ⇨ first rough cut design,
  - ⇨ usage of different types of materials and processes,
  - ⇨ detailed design,
  - ⇨ further stages of work design and
  - ⇨ the finished product,

Experiments and tests are conducted to evaluate the product. Modifications are made based on the outcome of these experiments.

- The normal design process is thus iterative (modifications being made on the basis of feedback information acquired from the tests).

Even though various tests and experiments are conducted at various stages, the engineering project as a whole in its *totality* can be viewed as an *experiment.*

## SIMILARITIES TO STANDARD EXPERIMENTS

1. Any project is carried out in partial ignorance due to
   - The uncertainties in the abstract model used for the design calculations,
   - The uncertainties in the precise characteristics of the materials purchased,

- The uncertainties caused by variations in processing and fabrication of materials and
- The uncertainties about the nature of stresses the finished product will encounter.

Indeed, Engineer's success lies in the *ability to accomplish tasks* with only a *partial knowledge* of scientific laws about nature and society.

2. The final outcome of engineering projects, like those of experiments, is generally uncertain. Very often, possible outcomes are not even known and great risks may be presented which could never be thought of.

3. Effective Engineering relies upon knowledge gained about products both before and after they leave the factory- knowledge needed for improving current products and creating better ones. That is, ongoing success in engineering depends upon gaining new knowledge.

**LEARNING FROM THE PAST**

Engineers should learn not only from their own earlier design and operating results, but also from other engineers.

Engineers repeat the past mistakes of others due to the following reasons.

- Lack of established channels of communication.
- Misplaced pride in not asking for information
- Embarrassment at failure or fear of litigation (legal problems).
- Negligence.

***Examples*:**

1. The *Titanic* lacked sufficient number of life boats resulting in the death of 1522 out of 2227 (life boat capacity available was only 825), a few decades later *Arctic* perished due to the same problem.

2. In June 1966, a section of the Milford Haven Bridge in Wales collapsed during construction. A bridge of similar design, erected by the same bridge- builder in Melbourne, Australia, also partially collapsed in the month of October, same year. During this incident 33 people were killed and many were injured.

3. Malfunctions occurred at nuclear reactors at various locations and the information reports were with Babcock and Wilcox, the reactor manufacturer. In spite of these, no attention was paid leading to a pressure relief valve giving rise to the Three Mile Island nuclear accident on March 28, 1979.

**CONTRASTS WITH STANDARD EXPERIMENTS**

**1. EXPERIMENTAL CONTROL:** In standard experiments, members are in two different groups. Members of *one group receive special* experimental treatment. The other group members, called '*control group' do not receive* special treatment, though they are from the same environment in all other respects.

But this is not true in engineering, since most of the experiments are not conducted in laboratories. The subjects of experiments are human beings who are outside the experimenter's control.

Thus it is not possible to study the effects of changes in variable on different groups. Hence only historical and retrospective data available about various target groups has to be used for evaluation. Hence engineering as a social experimentation seems to be an extended usage of the concept of experimentation.

**2. INFORMED CONSENT**: has two elements, *knowledge* and *voluntariness*. The subjects (human beings) should be given all the information needed to make a reasonable decision. Next, they must get into the experiment without being subjected to *force, fraud or deception*. Supplying complete information is neither necessary nor in most cases possible. But *all relevant information* needed for making a reasonable decision on whether to participate should be conveyed. Generally, we all prefer to be the subject of our own experiments rather than those of somebody else.

**Conditions defining *Informed or Valid Consent***

a. The consent is given voluntarily
b. The consent is based on information a rational person would want, together with any other information requested and presented to them in understandable form.
c. The consenter was competent to process the information and make rational decisions.
d. Information has been widely disseminated.
e. The subject's consent is offered by proxy by a group that collectively represents many subjects like interests, concerns and exposure to risk.

'Engineering experiments are not conducted to gain new knowledge unlike scientific experiments'. Is this distinction necessary?

This distinction is not vital because we are concerned *about the manner* in which the experiment is conducted, such as *valid consent* of human subjects being sought, *safety measures* taken and means exist for *terminating* the experiment *at any time* and providing all participants a *safe exit*.

**Features of morally responsible engineers in social experimentation**

***Conscientiousness*:** A primary obligation to protect the safety of human subjects and respect their right of consent.

***Relevant information*****:** A constant awareness of the experimental nature of any project, imaginative forecasting of its possible side effects and a reasonable effort to monitor them.
*Moral autonomy*: Autonomous, personal involvement in all steps of the project.
*Accountability*: Accepting accountability for the results of the project.

**CONSCIENTIOUSNESS:**

- Conscientious moral commitment means sensitivity to the full range of relevant moral values.
- Sensitivity to responsibilities that is relevant.
- Willingness to develop the skill and expend the effort needed to reach the best balance possible among these considerations.
- Conscientiousness means consciousness because mere intent is not sufficient.

Conceiving engineering as social experimentation restores the vision of engineers as guardians of the public interest in that they are duty bound to guard the welfare and safety of those affected by engg projects.

**RELEVANT INFORMATION:**

Conscientiousness is blind without relevant factual information. Moral concern involves a commitment to obtain and assess all available pertinent information. Another dimension to factual information is the consequences of what one does. While regarding engg as social experimentation points out the importance of context, it also urges the engineer to view his or her specialized activities in a project as part of a larger whole having a social impact that may involve a variety of unintended effects. It may be better to practice 'defensive engg' (Chauncy Starr) or 'preventive engg' (Ruth Davis).

**MORAL AUTONOMY**

- People are morally autonomous when their moral conduct and principles of action are their own.

- Moral beliefs and attitudes must be a critical reflection and not a passive adoption of the particular conventions of one's society, religion or profession.
- Moral beliefs and attitudes cannot be agreed to formally and adhered to merely verbally.
- They must be integrated into the core of one's personality and should lead to committed action.
- It is wrong to think that as an employee when one performs '*acts'* serving company's interests, one is no longer morally and personally identified with one's actions.
- Viewing engg as a social experimentation helps to overcome this flawed thought and restores a sense of autonomous participation in one's work.
  - As an experimenter, an engineer is exercising the specialized training that forms the core of one's identity as a professional.
  - A social experiment that can result in unknown consequences should help inspire a critical and questioning attitude about the adequacy of current economic and safety standards.
  - In turn, this leads to better personal involvement with work.

**ACCOUNTABILITY:**

- Responsible people accept moral responsibility for their actions.
- Accountability is the willingness to submit one's actions to moral scrutiny and be open and responsive to the assessment of others.
- It should be understood as being culpable and blameworthy for misdeeds.

Submission to an employer's authority creates in many people a narrow sense of accountability for the consequences of their action. This is because of

i) Only a small contribution is made by one individual, when large scale engineering work is fragmented. The final product which is far away from one's immediate workplace, does not give a proper understanding of the consequences of one's action.

ii) Due to the fragmentation of work, a vast diffusion of accountability takes place. The area of personal accountability is delimited to the portion of work being carried out by one.

iii) The pressure to move on to another new project does not allow one to complete the observations long enough. This makes people accountable only for meeting schedules and not for the consequences of action.

iv) To avoid getting into legal issues, engineers tend to concentrate more on legal liabilities than the containment of the potential risks involved in their area of work.

Viewing engineering as a social experimentation makes one overcome these difficulties and see the problem in whole rather than as part.

## ENGINEERING CODES OF ETHICS

Engineering Codes of Ethics have evolved over time

**EARLY CODES**

- Codes of personal behavior
- Codes for honesty in business dealings and fair business practices
- Employee/employer relations

**NEWER CODES**

- Emphasize commitments to safety, public health and environmental protection
- Express the rights, duties and obligations of members of the Profession
- Do not express new ethical principles, but coherently restate existing standards of responsible engineering practice
- Create an environment within the Profession where ethical behavior is the norm
- Not legally binding; an engineer cannot be arrested for violating an ethical code (but may be expelled from or censured by the engineering society)

***Are Engineering Codes Needed*? NO:**

–Engineers are capable of fending for themselves

–Common law is available to defend in ethical disputes

–Offended public can seek redress through courts

***Are Engineering Codes Needed*? YES:**

–Engineers have few or no resources to defend themselves in an ethical dispute

–Common law is available in reality only with great difficulty

–Conversely, the public has similar problems in seeking redress through legal channels

***Objections* to Existing Engineering Codes of Ethics:**

–Relatively few engineers are members of engineering societies.

–Non-members don't necessarily follow the ethical codes.

–Many engineers either don't know that the codes exist, or have not read them.

Which ethical codes apply?

–Depending upon your discipline and organizational affiliations, you may be bound by one, two or even more ethical codes:

•Discipline related (ASME, IEEE, ASCE, IIE etc.)

•National Society of Professional Engineers (NSPE)

•Employee codes (corporation, university, etc.)

•Union Codes

**Engineering Ethics**

Our engineering ethics codes are derived from a Western cultural tradition

–Ancient Greeks

–Judeo-Christian religions

–Philosophers and thinkers (e.g. Locke, Kant, Mills)

**The Hammurabi Code**

If a builder has built a house for a man and has not made his work sound, and the house he has built has fallen down and so caused the death of the householder, that builder shall be put to death. If it causes the death of the householder's son, they shall put the builder's son to death….

(Hammurabi, King of Babylon, 1758 B.C.)

**Code of Ethics for Engineers**

Accreditation Board for Engineering and Technology
(ABET)
The Fundamental Principles

*Engineers shall uphold and advance the integrity, honor, and dignity of the engineering profession by:*

- *using their knowledge and skill for the enhancement of the human race;*
- *being honest and impartial and serving with fidelity the public, their employers, and clients;*
- *striving to increase the competence and prestige of the engineering profession.*
- *supporting the professional and technical societies of their discipline.*

**The Fundamental Cannons**

Engineers shall

- *hold paramount the safety, health, and welfare of the public in the performance of their professional duties;*
- *perform service only in areas of their competence;*
- *issue public statements only in an objective and truthful manner;*

• *act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest;*

• *build their professional reputations on the merits of their services and shall not compete unfairly with others*

• *act in such manner as to uphold and enhance the honor, integrity and dignity of the profession;*

• *continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision.*

## **CODES OF ETHICS - *ROLES OR FUNCTIONS***

**1. Inspiration and Guidance:**

- ❖ Codes provide positive stimulus for ethical conduct and helpful guidance by using positive language.
- ❖ Codes should be brief to be effective and hence such codes offer only general guidance.
- ❖ Supplementary statements or guidelines to give specific directions are added by a number of societies or professional bodies.

**2. Support:**

- ❖ Codes give positive support to those seeking to act ethically.
- ❖ An engineer under pressure to act unethically can use one of the publicly proclaimed codes to get support for his stand on specific moral issues.
- ❖ Codes also serve as legal support for engineers.

**3. Deterrence and discipline:**

- ❖ Codes can be used as a basis for conducting investigations on unethical conduct.
- ❖ They also provide a deterrent for engineers to act immorally.
- ❖ Engineers who are punished by professional societies for proven unethical behaviour by revoking the rights to practice as engineers are also subjected to public ridicule and loss of respect from colleagues and local community.

- This helps to produce ethical conduct even though this can be viewed as a negative way of motivation.

**4. Education and mutual understanding**:

The codes can be used for discussion and reflection on moral issues and thereby improve the understanding of moral responsibilities among all engineers, clients, public and good organizations.

**5. Contributing to the profession's public image:**

Codes present the engineering profession as an ethically committed society in the eyes of the public thus enhancing their image.

**6. Protecting status quo:**

Codes establish ethical conventions, which can help promote an agreed upon minimum level of ethical conduct.

**7. Promoting business interests:**

Codes can place unwarranted restraints of commerce on business dealings.

**Relative importance of the various functions of codes of ethics**

- The perspective of engg as social experimentation clearly emphasizes the primary role 'supportive function' of the codes of ethics. This is so because, only this support enables engineers, speak out clearly and openly their views, to those affected by engg projects.
- The, 'inspiration and guidance' and 'educative' functions are also important in promoting mutual understanding and in motivating engineers to act with higher moral standards.
- The 'disciplinary' function in engg codes is of secondary importance. Those with unethical conduct when exposed are subject to law. Developing elaborate paralegal procedures within professional societies duplicates a function which can be done better by legal system. At best, codes should try to discipline engineers in areas which are not covered by law.

- ❖ The worst abuse of codes has been to restrict honest moral effort in the name of 'preserving profession's public mage' and 'protecting status quo'. The best way to increase trust is by encouraging and aiding engineers to speak freely and responsibly about public safety.

***Limitations* of Codes of Ethics**

1. Codes are restricted to general and vague wording. They cannot be straightaway applied to all situations. It is impossible to foresee the full range of moral problems that can arise in a complex profession like engg.

2. It is easy for different clauses of codes to come into conflict with each other. Usually codes provide no guidance as to which clause should have priority in those cases, creating moral dilemmas.

3. They cannot serve as the final moral authority for professional conduct. If the code of a professional society is taken as the last word, it means that we are getting into a particular set of conventions i.e. ethical conventionalism.

*4. Andrew Oldenquist and Edward Slowter pointed out how the existence of separate codes for different professional societies can give members the feeling that ethical conduct is more relative than it is and that it can convey to the public the view that none is 'really right'. The current codes are by no means perfect but are definitely steps in the right direction.*

**The problems of law in engineering**

1. The greatest problem of law in engg is of 'minimal compliance'. Engineers and employers can search for loop holes in the law to barely keep to its letter while violating its spirit. Engineers will tend to refer to standard readymade specifications rather than come up with innovative ideas. Minimal compliance led to the tragedy of the 'Titanic'.

2. Continually updating laws and regulations may be counter-productive and will make law always lag behind technology. This also overburdens the rules and regulators.

3. Many laws are ‘non-laws’ i.e. laws without enforceable sanctions. These merely serve as window dressing, frequently gives a false sense of security to the public.

4. The opponents of the law may burden it intentionally with many unreasonable provisions that a repeal will not be far off.

5. Highly powerful organizations, like the government can violate the laws when they think they can get away with it by inviting would be challengers, to face them in lengthy and costly court proceedings. This also creates frustration with the law.

**Role of law in engineering**

- It is wrong to write off rule-making and rule following as futile. Good laws, effectively enforced, clearly produce benefits.
- Reasonable minimum standards are ensured of professional conduct.
- It also provides a self-interested motive for most people and corporations to comply.
- They also serve as powerful support and defense for those who wish to act ethicallyin situations where ethical conduct might not be welcome.
- Viewing engineering as social experimentation provides engineers with a better perspective on laws and regulations.
- Precise rules and enforceable sanctions are appropriate in cases of ethical misconduct that involve violations of well established and regularly reexamined procedures that have as their purpose the safety of public.
- In areas of experimentation, rules must not attempt to cover all possible outcomes of an experiment, nor must they force the engineer to adopt a rigidly specified course of action. Here the regulations should be broad based guidelines but should hold the engineer accountable for his or her decisions.