SCITECH Nepal

March 2002 Vol. 6 No. 1

Chief Editor:

Deepak Bhattarai

Editors:

A.S.R. Rao
Rukmanath Paudel
Yogesh R. Mishra

Published by:

Nepal Engineering College
Changunarayan,
Bhaktapur,
Nepal.
G.P.O. Box 10210
Phone: 611744
Fax: 977-1-611681
Email: nec@healthnet.org.np

Circulation:

Bishnu Lal Shakya

Layout &
Printed at:

Time Graphics Printers
Battisputali,
Kathmandu, Nepal.
Tel: 495388

From the Editor

Historically speaking, technology came into existence as a separate discipline in order to breach the gap between the discoveries and inventions in science and the wants and needs of the society. However, we should not mistake it with applied science. It is something more. It is a field of know-how for applying the scientific theories *for the benefit of all those who do not directly contribute to the discovery of such theories*. In this respect, technology is a democratizing force. It allows all the members of the wider community to share the benefits with a few of those who achieve breakthroughs with their superior intellectual ability in forging new understanding to a given problem. Technology interprets and to an extent concretizes such understanding so that it becomes usable even by those who do not understand the science behind it.

This democratizing potential of technology has always been a source of danger to those who have, or who want to maintain, supremacy of any sort over others. In past, and even today in many parts of the world, despots and autocratic regimes vehemently control the discipline. They not only decide the nature and products of technological endeavour, but also deny access to the fruits of the discipline for others by framing laws to that affect. Recently, we have seen real and virtual MNCs effectively manipulating and hijacking the achievements of the discipline in order to increase their share in the market. They do this often by investing huge amounts into the technological research of their interests, and by creating a need among people so that their products multiply the profits far beyond the pay-offs.

Today's engineers and architects thus face an unprecedented challenge of maintaining the autonomy of the discipline while at the same time use the existing social/state structure and its resources. It is for them to achieve a fine balance between what is needed and what is desired and between what is for good and what is for profit. Quite often, the distinctions are not clear-cut. Newer areas in technological development are often ambiguous in terms of their potential for social good. Information Technology has yet to prove itself in this regard. And in view of the amount of interest and investment generated for IT Sector all over the world, it appears paradoxical.

It is an opportune moment for all of us who are somewhere near the frontiers of the discipline to justify our roles for the common good.

CONTENTS

INDIGENOUS KNOWLEDGE SYSTEMS
Conceptual Clarifications and Practical Solutions Suggested

*Yogesh Raj**

ABSTRACT

Although the term Indigenous Knowledge, IK is not a new comer in development theories, there have been several differences in opinion among the researchers on what it stands for. We find that some of the differences are conceptual while others are related to its importance and the potential role it would play in development practices. In this paper, an attempt has been made to summarize the on-going debate. At the same time, several definitions are elucidated. The differences and similarities between 'Scientific' and Indigenous Knowledge systems are put here in proper highlighting with their complimentarity questioned. IK is definitely an alternative knowledge system with high degree of reliability. However, to seek rationality in all the aspects is neither possible nor desirable. Moreover, it has been argued that the integration of IK in the current development practices is also related to questions of power. Hence, by incorporating IK, a democratization process is set up thereby accepting the alternatives to (technological) development currently dominated by top-down approach. A framework for enhancing the use of IK is also proposed.

BACKGROUND

From 26 June to 1 July 1999, delegates from over 150 countries participated in the world Conference on Science in Budapest, Hungary. The conference was jointly organized by UNESCO and International Council for Science, ICSU. The participants finalized two important documents – the Declaration on Science and the Framework for Action. However, the lengthy discussion which took place there were not smooth. Among more contentious issues were science ethics, the funding of science through debt relief and Indigenous Knowledge or IK. One of the sessions titled "Science and Other Systems of Knowledge" saw the animated debate centered on the role of local and traditional knowledge in the sustainable development. The questions raised during the discussion were: is indigenous knowledge 'science'? How to protect indigenous property? How to ensure the provision of informed consent? What are the threats posed by formal schooling? etc.

Indigenous Knowledge is no newcomer to international action plans and conventions. Rio Declaration of 1992 Earth Summit Article 8(j) on Biological Diversity addresses the 'Knowledge, innovations and practices of indigenous and local communities'. Yet, as World Conference on Science basically attracted experts on basic and natural sciences and hence, inclusion of 'indigenous and traditional knowledge' as an agenda surprised many. Dissenting voices were heard suggesting that in doing so, scientists might be lending a credibility, which was ill deserved.

At 26th General Assembly of ICSU in Cairo, Egypt in the same year, some delegates took exception to the phrase 'traditional and local knowledge systems' and expressed concern

* Assistant Professor, Nepal Engineering College

that this would open the door to anti- and pseudo- scientific approaches such as creationism and astrology. As a matter of fact, it would be more than true if we say that the relationship between science and these other systems of knowledge is not clear. Of course, if indigenous knowledge is conceived as just another information set from which data can be extracted to plug into scientific frameworks of understanding, then we do not trouble the scientific world vies. However, this practical approach – that of pharmaceutical companies or conservation ecologists, who validate traditional information and use it to attain pre-defined ends – any threaten the integrity of traditional knowledge systems. On the other hand, if science is seen as one knowledge system among many, then scientists must reflect on the relativity of their knowledge and their interpretations of reality. Thus for the survival of traditional knowledge as a dynamic living and culturally meaningful system, this debate can not be avoided.

(PSEUDO?) DISTINCTION BETWEEN SCIENCE AND IK

In 1980, David Brokensha, Oswald Werner and Dr D Michael Warren were struggling to find a term that would replace 'traditional' in the designation 'traditional knowledge'. In their view, 'traditional' denoted the 19th century attitudes of simple, savage and static. They wanted a term that represented the dynamic contributions of any community to problem solving, based on their own perceptions and conceptions, and the ways they have identified, categorized and classified phenomena important to them. At the same time, Robert Chambers and his group at Sussex University were also struggling with the same issue. Independent of each other, they both came up with the term 'indigenous'. It is acknowledged however, that the term 'indigenous' does have its own set of problems and misinterpretations.

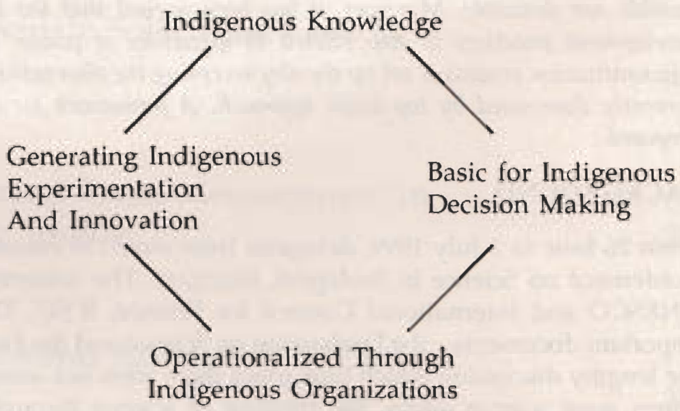


Figure 1.

Indigenous Knowledge represents generations of creative thought and action within each individual community, as it struggles with an ever-changing set of conditions and problems. (Figure 1). All case studies indicate that the mechanisms for changing knowledge systems at the local or ethnic level are identical to the global knowledge systems, such as 'science'. Taking more critical approach, Agrawal (1995) presents, as he puts it 'certain contradictions and conceptual weaknesses in most of the writings on indigenous knowledge'. He evaluates the three grounds on which Indigenous Knowledge is claimed to be different than Western and scientific Knowledge:

1. Substantive grounds – the subject matter and characteristics of Indigenous and Western Knowledge are different.
2. Methodological and epistemological grounds – the two forms of knowledge employ different methods to evaluate reality.
3. Contextual grounds – traditional/ indigenous knowledge is more deeply rooted in its environment.

He views the three grounds as fictitious, and thinks that the supposed dichotomy between indigenous and scientific/western knowledge systems is a resurrection of the ideas present in the works of anthropologists such as Malinowski, Boas, Levi-Bruhl, Mauss, Evans-Pitchard and in particular Levi-Strauss. Levi-Strauss (1962, 1966) anticipated many of the arguments advanced today twp create a demarcation line between indigenous and Western knowledge. Levi-Strauss suggested that 'primitive' cultures are more embedded in their environments tan modern cultures; 'primitive' peoples are less prone than scientific investigators to analytic reasoning; and 'primitive' thought systems are more closed than scientific modes of thoughts etc.

Is it true then, that neither Levi-Strauss's arguments nor current attempts to separate indigenous knowledge from Western knowledge can be sustained? Yes, if we believe Agrawal. The attempts for the dichotomy between the two knowledge systems apparently rests on the possibility that a small and finite number of characteristics can define the elements contained within each class. Agrawal cites for example, that exactly as any indigenous knowledge, Western Knowledge too is concerned with the immediate and concrete necessities of peoples' daily livelihoods. That the latter attempts to construct general explanations and is one more step removed from the daily concerns for the people does not hold water. To prove his point, he takes up the area of agro-forestry and the multiple tree-cropping systems of small holders in any part of the world, agronomy and the indigenous techniques for the domestication of crops, taxonomy and plant classification systems. He claims, thus, that the artificial classification into indigenous and western/ scientific knowledge fails at another, more fundamental level. It seeks to separate and fix in time and space the knowledge systems that can never be so separated or fixed. Evidences suggest not the tight compartments but contact, diversity, exchange, communication, learning and transformation among different systems of knowledge.

Regarding the methodological and epistemological differences, it is better not to dwell in detail as numerous philosophers of science, including Leibnitz, Popper, Carnap, Grunbaum and Lakotas, have failed to find satisfactory demarcation criteria between science and non-science. Kulka (1977) has summarized all these failed attempts. Dirks *et al.* (1994) on the other hand remark that it was the virtual absence of historical investigation in anthropology which made cultural systems appear timeless, at least until ruptured by 'cultural contact'. So to put it concisely, neither the science is open, systematic, objective and analytical – not as much we want it to be – nor, the IK closed, non-systematic and holistic.

The proposed contextual differences between the two systems of knowledge are also not valid, as maintained by Agrawal. It has become clear today that most of the technical-solution oriented development policies of the last five decades have failed because they ignored the social, political and cultural contexts in which they were implemented. Does it not lead us to acknowledge that so-called technical solutions are as anchored in a specific milieu as any other systems of knowledge? Many contemporary philosophers of science focus on the social moorings of science, and in doing so, question the stock assessment of science as objective and rational. Most recent accounts insist on 'multiplicity, patchiness and heterogeneity of the space in which scientists work' (Pickering, 1992:8). This view of science as practice and culture successfully goes beyond not just earlier epistemologies rooted in rationalism, but also the later reductive representations that saw science as 'relative to culture' or as 'relative to interests'.

There are however, a few questions over Agrawal's sweeping generalizations. Agrawal equates 'scientific' knowledge with 'western' knowledge and confuses scientific knowledge with the technical application of science. It is not merely the problem of nomenclature. There seems to be some substantive differences between the two systems of knowledge as opposed to Agrawal's belief. *These differences may not be in the subject matter as much than in the motivations behind the innovations.* For example, the evolution of post harvest technologies as practiced by Newars in Kathmandu Valley is clearly motivated by 'immediate and concrete necessities', while the development of certain aspects of knowledge concerned with particle physics at CERN is not. Agrawal fails to see the qualitative difference between the dependence of the scientific discoveries and the dependence of indigenous knowledge on its environment. Physicist's knowledge of particle physics is the result of focussing on certain discipline – internal questions within their sub-culture and is largely independent of the broader culture and background of the practitioner. A particle physicist may be a Muslim from Indonesia or a Hindu from Nepal. In the case of indigenous knowledge, however, the 'environment' encompasses the full context of lived experiences, as qualified by the broader culture and its values, and the moulding power of place.

COMPLIMENTARY PRINCIPLE?

It is also noteworthy here that many of the experts in the indigenous knowledge do not put more emphasis on the dichotomy between indigenous knowledge and scientific knowledge. They observe, as Agrawal does, identical mechanisms within both the systems for reactions to perceived problems, as well as for the ways of incorporating external knowledge, technologies and methodologies. They are more concerned with the potential useful role that indigenous knowledge systems can play in establishing an understanding the reality.

The interaction between Indigenous and 'scientific' knowledge systems can be summarized by Figure 3.

Showers (1996) for example discusses how local environmental knowledge and indigenous knowledge have the potential to supply accurate descriptions of visible environmental processes and how that could be a valuable source for any environment impact assessment, EIA. It is a known fact that most environmental problems took many years to develop and are the results of unimagined interactions among highly diverse factors. To analyze these problems, Western science requires quantitative descriptions of the events and processes involved. Yet because of the unavailability of many environmental components, construction of a baseline remains illusive. Without baseline data, calculations of rate of

1: Change and development in Indigenous Knowledge systems
2: Limiting force operating against the introduction of established scientific knowledge into Indigenous Knowledge systems. This ranges from environmentalists to those who are against the *ex situ* conservation of indigenous practices.
3: Research and development within IK systems. These are being attempted not only by extension workers involved in development projects but also by greedy transnational companies surreptitiously looking for profit from IK database.
4: The adaptation of established scientific knowledge systems to local conditions.
5: Limiting forces against the research and development of IK systems.
6: Change and Development within established 'scientific' knowledge systems.

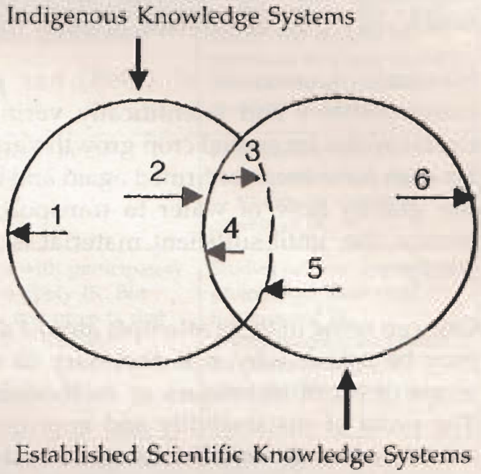


Figure 2. Dynamics of Knowledge Systems Adapted after Adunga (1996)

change are complicated and highly contentious. It is also difficult to distinguish between a normal variation and an absolute change in environmental conditions. The question that is called now is that whether quantitative descriptions are the only – or even sufficient forms by which to describe the environment. If they are, then the past environmental function of vast areas of the earth's surface is unknowable. If they are not, researchers should explore alternative sources of information. As Showers has effectively shown, a framework for understanding human-induced environmental change using local environmental knowledge is provided by what she has designated as Historical Environmental Impact Assessment, or HEIA. HEIA is patterned on the steps involved in any EIA, but reconstructs the effects of past interventions in landscapes. HEIA clearly favors neither Western Science nor Indigenous Knowledge. It takes the two as complementary sources of data collection.

The holders of this complimentary principle believe that both indigenous knowledge and western science are an attempt to characterize and understand the 'universe' of a given society. At any given point of time, both knowledge systems represent 'the best estimates', which means that both are in a constant state of evolution.

SEEKING RATIONALITY IN IK

There have been numerous efforts to test IK and to match the results from the 'scientific' standards. The zeal of these researches is inspiring, indeed. Lawas and Luning (1996) attempted to input farmers' knowledge on elevation and cropping intensity in GIS which made retrieval and quantification of such indigenous information easier. They conclude that like established scientific knowledge, farmers' knowledge is valid and *rational*. This conclusions justifies the view of Howes (1979) that, to quote, "localized indigenous knowledge may also provide the basis for the *preliminary* formulation of hypotheses which may then be referred *upwards* for refinement and specific testing."

Similarly, Lamers *et al.* (1995) has proved that in Western Niger, farmers have comprehensive and scientifically verifiable knowledge about their occupations. Their explanations for spatial crop growth variability as well and the management they employ for such have been confirmed again and again. In Benguet province, the Philipines, farmers use gravity flow of water to transport stones, debris and soil from the source to the terrace site, until sufficient material is accumulated to construct the terrace (Mandoza, 1999).

One can sense in these attempts almost a guilt-ridden consciousness at work. The question may be asked: why is it necessary to verify or validate the indigenous knowledge in terms of set of techniques or methodologies employed in scientific knowledge system? The proof of sustainability and appropriateness of an indigenous knowledge is its very existence in a given point of space and time. As we have said earlier, it is also the best estimate of the reality enveloping the community in question. Moreover, these seekers of rationality have limited the Indigenous Knowledge systems to ethno-scientific sub-systems such as medicinal plants, pharmacopoeia or natural resources management techniques. It is important to realize that that such delimitation may lead to a division in indigenous psyche.

Differences of Type	Differences of Degree	
	Community based Indigenous Knowledge	Global, World wide Knowledge
Empirical, ordinary knowledge	Ethno-scientific systems (including Western ones)	Transcultural scientific knowledge
Non-empirical, non-ordinary knowledge	Local symbolic systems	International mass culture

Adapted after Giarelli (1996)

Figure 3. Classifications of Knowledge Systems

If we agree on a classification of knowledge systems as shown in the Figure 3 (originally proposed by Giarelli, 1999), then it is easy to see that Indigenous Knowledge includes the non-empirical, non-ordinary knowledge such as local symbolic systems. As this component of IK system is unverifiable by the rationality approach, the indigenous people tend to suppress it while interacting with the rational researchers. It has been observed in the field that the interviewer quite often receives the answers in the format that the indigenous interviewee perceives s/he would like to hear. The locals themselves downgrade the matters pertaining to faith and beliefs in front of researchers thinking that this would present a 'modern point of view' and help them to gain respect. This division of psyche is the first step towards an alienation of the indigenous mind.

FRAMEWORK FOR ENHANCING THE USE OF IK

The framework is a modified version of the same proposed earlier by Evelyn Mathias.

What to do	How to do it	Status	Needed
Record and document Indigenous Knowledge	Field Studies Literature Studies Workshops	Most of the anthropological studies contain descriptive information.	In-depth researches which record and analyze IK, presented in a user-friendly fashion. Local people are involved as partners.
Validate Indigenous Knowledge	Assessments of local people, Field Testing Laboratory tests On-Station Research	Limited effort except in the research of medicinal Plants	Field Testing and On-station research in addition to studies on economic aspects of IK
Test field methodologies for recording and using IK	Methodological studies Research and projects that record and use IK Learning from development projects that have made use of IK in the past	Limited. Projects with participatory approaches often apply IK. But there are only a few projects that integrate recording and use.	Studies on how applied projects can assess and make use of IK Encouragement and funds for documenting and analyzing the experiences.
Make Information Available	In the form of documents, audio-visuals and artifacts Through conferences, networking, databases, print, mass media, museums etc.	IK has traditionally been part of museum exhibits. Over the last ten years the amount of information on IK stored in documents, videos etc. has also increased. Networks such as Honey Bee have been established. News-letters such as IK&DM cater the IK News. CIKARD's Homepage and database on traditional ecological knowledge have been established.	Improved regional networking in the South is required. Establishment of databases on various aspects of IK and improving their accessibility is needed.
Raise awareness of the value of IK • local people • individuals and field level organizations • teachers, scientists and other academics • policy makers, development planners	Projects Workshops Video Cross visits Integrate IK module in training Develop easy to read manuals Information materials Videos Conferences Information on the role of IK for development Short case studies Demonstrate the effectiveness of selected IKs.	Limited, though increasing. The inclusion of IK module in regular training is still exception not the rule. Information of IK is not suitably packaged for policy makers and development planners.	Projects where outsiders help communities to record, document and use their own IK. Consultation with local people to determine how IK could best benefit them. Cross-visits between participants in IK projects. Integration of IK modules in the training courses. Packaging of IK for policy makers and development planners.
Provide Guidelines on how IK can be used • Policy makers and government officials • Development planners	Brief policy papers Guidelines on measures that can enhance the use of IK Guidelines on how development projects can build on IK.	A small numbers of policy papers are available such as the World Bank's guidelines for working with indigenous peoples. There is a framework for integrating IK into development, but it has not yet been put into a suitable format for the planners.	Country specific guidelines formulated in collaboration with governments. Guidelines packaged for development professionals.

Contd.

What to do	How to do it	Status	Needed
Provide tools and methods for the recording and use of IK in development projects.	Simple manuals for field level workers, case studies, and other publications.	Manuals for participatory approaches are available. A general manual for the recording and use of IK for the benefit of field level workers is in preparation, while a field level manual for laptop use is being prepared by CIKARD. Case studies are available in not very friendly format.	Manuals adapted to different audiences and purposes. Manuals on different topics. Case studies demonstrating the application of IK.
Train government and non-governmental organization field personal in tools and methods.	Short training courses.	Limited availability.	Courses on methods for the recording and use of indigenous knowledge.

Adapted from Dr Evelyn Mathias's paper in Indigenous Knowledge & Development Monitor, 3(2): 17-18.

REASONS FOR IK RESEARCH: TOWARDS CONCLUSION

Indigenous Knowledge systems often present themselves as an alternative sources of information in a complimentary fashion, for understanding the reality. To this extent, an IK researcher is no more different than others coming to gather, categorize, classify, test and *patent* the indigenous knowledge reserves. Indeed, there has been a steady exploitation of indigenous products such as indigenous herbal resources by transnational pharmaceutical companies, indigenous agro-products by international market giants with the complete disregard to their intellectual rights.

But what is more important that Indigenous Knowledge necessarily present alternatives to development (as opposed to development alternatives). There is also an inherent link between whys of IK research and the questions of power. It is important to conduct researches in IK *in order* to, as Paulo Freire has put it, 'to give a sense of affirmation and to provide conditions for (....them) to display an active voice and presence' (Freire as summarized by Giroux, 1985:xxi). 'Truth', as we know now has many versions. Which version an IK researcher hears depends on the prevailing equations of dominance. It is imperative thus to diagnose the advocacies on objectivity and unbiasness. The methodologies adopted in IK research should be then designed for 'conscientization', collective action and critical reflection struggling for meaning and struggling over power relations. Information flow in an IK research, for instance, should be a two way process.

To this end, Indigenous Knowledge systems are to be studied. To this end again, it is necessary but not sufficient to know the similarities and differences between indigenous knowledge and 'scientific' knowledge systems.

REFERENCES

Adunga, Girma (1996), "The Dynamicism of Knowledge Systems vs. Sustainable Development", Indigenous Knowledge & Development Monitor 4(2):31-32.

Agrawal, Arun (1995), "Indigenous and Scientific Knowledge: Some Critical Comments, Indigenous Knowledge & Development Monitor, 3(3): 3-5.

Dirks, N., G. Eley and S. Ortner (1995), "Introduction" in N. Dirks, G. Eley and S. Ortner (eds.), *Culture-Power-History, A Reader in Contemporary Social Theory*, Princeton, Princeton University Press.

Giarelli, Guido (1996), "Broadening the debate: The Tharaka Participatory Action Research Project", Indigenous Knowledge & Development Monitor, 4(2): 19-22.

Giroux, Henry A. (1985), "Introduction" In Paulo Freire (ed.), *The Politics of Education: Culture, Power, and Liberation*, London, Macmillan, pp. xi-xxv.

Howes, M. (1979), "The Uses of Indigenous Technical Knowledge in Development", IDS Bulletin, 10(2): 12-23.

Kulka, T. (1977), "How Far Does Anything go? Comments on Fayerbend's Epistemological Anarchism", Philosophy of the Social Sciences, 7:277-287.

Lamers, J.P.A., P. R. Feil and A. Buerkert (1995), "Spatial Crop Growth Variability in Western Niger: the Knowledge of Farmers and Researchers", Indigenous Knowledge & Development Monitor, 3(3): 17-19.

Lawas, Corazon M. and Henk A. Luning (1996), "Farmers' Knowledge and GIS", Indigenous Knowledge & Development Monitor, 4(1): 8-11.

Levi-Strauss, C. (1962), *Totemism*, Boston, Beacon Press.

Levi-Strauss, C. (1966), *The Savage Mind*, Chicago, Chicago University Press.

Mandoza, Maria Corazon Y. (1999), "Terracing With the Aid of Gravity Flow", Indigenous Knowledge & Development Monitor, 7(3):

Pickering, A. (Ed., 1992,) *Science as Practice and Culture*, Chicago, Chicago University, Press.

Showers, Dr. Kate B. (1997), "Comments on Article by Arun Agrawal", Indigenous Knowledge & Development Monitor, 4(1): 13-14.

Any failure will tell you success is nothing but luck.

- Unknown

❋ ❋ ❋

No one can make you fell inferior without your consent.

- Eleanor Roosevelt

❋ ❋ ❋

In the midst of difficulty lies opportunity.

- Albert Einstein

❋ ❋ ❋

TRICKS AND TOOLS TO TACKLE, "TEACHER-TAUGHT" TUSSLE

*S.V. Sahasrabudhe**

ABSTRACT

In teaching certain courses like Graphics or Instrumental Drawing to the engineering and architecture students, there is a need to modify the conventional approach to teaching by taking into account the special needs and requirements of these courses. The paper deals with the common difficulties that the student often encounters in such courses and outlines some simple techniques by which these problems can be overcome.

INTRODUCTION

The teaching is the process by which the knowledge is transferred to other in academic institutions. The effectiveness of the transfer of knowledge depends upon the teaching process adopted by the teacher on one side and the capacity of understanding it by the student on the other. In order to make teaching interesting and attractive teacher has to adopt different techniques for teaching. Each different subject needs different techniques for teaching so that the student finds the subject attractive and understands the contents easily and clearly. The medium of teaching instruction plays an important roll in the process of explaining and expressing the subject matter by the teacher as well as grasping the subject by the student.

There are some subjects where medium of instruction required is different in the professional institution. As an example Instrumental drawing or Graphics is the subject, which is to be taught is different from the other subjects of the professional courses. This is one of the core subjects mainly for architectural course. This is the subject student finds it difficult to understand and grasp. It is observed that about 37% of the students, in general, are poor or weak in these subject. Further more about 27% of the students manage to overcome the cutoff line and clear the examination. Only about 10%students, most unlucky, remains below the cutoff lines and are listed as failed. The main reason for this is that they do not understand the subject or get very little practice for the subject. As an academician one must find out the reason or the root cause regarding the poor performance in this major subject of the professional course. Is it the fault of the teacher? Is it due to the teaching process or the approach by the teacher? Is it because the student has inadequate backup knowledge and training required for understanding the subject during their earlier education? All such questions are posed by most of the institutions. Therefore, an attempt has been made, in this article, to identify the problem and how the improvement or improvements could be made in the teaching process mainly for the subject of Graphics or Instrumental Drawing.

* Professor, Nepal Engineering College

TUSSLE

The subject of graphics or instrumental drawing is taught by a teacher with the help of black board and chalk for teaching in all institutions. A teacher, as per his/her command in freehand drawing, explains and expresses this subject by drawing the problem on the black board by freehand technique. The freehand drawings are not geometrically accurate but at the same time the teacher expects and presumes that all the freehand figures drawn on the board are supposed to be geometrically accurate. The teacher explains, further on, the problem in freehand with the presumption that the figures are geometrically correct.

A fresh student is trying to understand the freehand drawing drawn on the board and start to inter- link it with the definitions, one has in their memory. The majority of the students are confused and with-in their heart are not ready to accept what the teacher has to say and explain out of the figures drawn on the board. This type of confusing communication gives jolt or shock to the thinking process of the fresh entrant in the professional institutions. This is because the freehand figure drawn by the teacher is geometrically as well as technically incorrect, deceptive and false. The tussle is generated in the mind of student. They are puzzled because of the freehand drawing is misleading. This perception difference between SAYING by the teacher and SEEING by the student is one of the basic and major causes of not grasping the subject of graphic and instrumental drawing by majority of students.

Illustrative Examples

Example 1 – A teacher says, "This is a regular pentagon of 200 mm each side". He draws the pentagonal figure on the black board. The skill of freehand drawing can never be as accurate as is drawn with geometrical instruments. The figure drawn on the board is perceived by the student only as a figure having five sides but not as a regular pentagon. The sides are not straight, the length of each side is different, and the internal angle between two adjacent sides is not equal or not 108°.

Example 2 – A teacher says, "This is the elevation of a regular cylinder and axis is marked with dotted line. This is the plan of a cylinder and it is divided in eight equal parts". After seeing this figure, the student does not find the lines of the edges and the axis parallel, the plan of the cylinder is not a true circle, and the eight divisions are also not equal. This entire thing and observations made by the student regarding the figure he sees and the explanation given by the teacher confuses the student.

This SAYING and SEEING generates tussle in the student's mind predominantly in the class of instrumental drawing or graphics. A student is compiled to, temporarily, accept the inaccurate figure as a correct figure as they have to perform the same exercise with geometrical instruments themselves on the drawing sheet in the drawing studio after the lecture is over.

The teacher presumes that the students are following what they say and expects them to ignore the illusions present in the freehand figure student sees on the board. This is mainly because each student has to follow the explained steps to execute on the drawing board with proper instruments. A teacher has to keep keen watch over the working and progress of each and every student in the drawing hall.

The teacher is fully conscious and aware about the tussle being developed in the mind of a student because of the disparity of saying and seeing. This teacher and taught tussle is one of the major reasons for the poor performance of most of the students in this subject. Teacher for better understanding and teaching of the subject must tackle this tussle. A teacher may adopt any of the following recommended tricks or tools in their teaching techniques mainly for graphic and instrumental drawings.

TECHNIQUES

There are various standard teaching techniques available to the teacher in every educational institution. Any teacher can adopt and apply them for imparting knowledge to the students. Improvements and innovations in the techniques are accepted any time.

The teaching techniques are –

1. Teaching on black board.
2. Teaching on wall with charts.
3. Teaching on screen by using slide projector.
4. Teaching on screen by using filmstrips.
5. Teaching with scaled model.
6. Teaching on monitor through computer.

The advantages and disadvantages of the above teaching techniques are presented in Table 1.

Table 1. Various Teaching Techniques Available

Techniques	Advantages	Disadvantages
Blackboard: a) Based on Freehand. b) Back ground Graph. c) Special Instruments. d) Translucent Charts.	a) Step by step explainton. b) Adaptive to instant changes. c) Easy correction. d) Impressive. e) Flexible.	a) Geometrically incorrect. b) Freehand skill dependent of teacher. c) Slow and time consuming. d) Class control is difficult. e) Class face back of teacher.
Charts Pinup Board: a) Opaque Charts. b) On white Board. c) On Black board.	a) Geometrically correct. b) Fast & Quick to Glance. c) Impressive & Attractive. d) Easy for Explanation.	a) Poor visibility for last bench. b) No Instant Change is Possible. c) Labour intensive. d) Stock & Store is difficult.
Overhead Projector: a) Transparency on White Board. b) Transparency on Black board.	a) Geometrically Accurate. b) Impressive. c) Fast & Time Saving. d) Use of overlay is possible. e) Better Class control.	a) Expensive. b) Not flexible. c) Retards Thinking Process. d) Intense preparation necessary. e) Stock & Storage is difficult.
Video & filmstrips.	Same as above.	Same as above.
Computers.	Same as above.	Same as above.

SELECTION OF TEACHING TECHNIQUES

The selection of a teaching technique is governed by the approach a teacher intends to adopt. It is also dependent on the complex character and nature of the topic to be taught. The criteria for the teaching technique selection depends upon their advantages and disadvantages, merits and demerits, type and nature of the topic to be taught, the backup knowledge of the student, funds and facilities available at hand for the teacher as-well-as in the institution. Above all the teacher has to take initiative, interest and apply innovative ideas in handling both teaching techniques and topics to be taught so as to impart knowledge clearly, correctly and carefully to the students.

Some simple improvements and tricks or tips are suggested below to improve the teaching of the subject like Instrumental Drawing or Graphics.

TOOLS AND TRICKS

1. Marking scaled graph to give guidance to teacher to draw various figures more correctly in freehand on the black board. The type of graph to be marked on the black board is square grid, angular grid, in both direction and radiating lines. This is because some of the teaching topics may require them.

2. The purpose and use of the special big size geometrical instruments to be used on black board. The figures or drawings drawn by such big instruments will be more accurate and correct in all respect and are easy for the student to understand properly. The efforts, by the teacher, in this manner will reduce the tussle, developed due to faulty freehand drawing used for the explanation on the black board, between teacher and taught.

3. The use of overhead projector for teaching instrumental drawing is very advantageous because of it built-in advantages. The teacher can actually draw on the OHP transparency, with proper geometrical instruments and with use of various colour pens as per the need of the problem. It can be projected on a white screen for further explanation in the class. In this the problem is enlarged on the screen for better viewing by the entire class. The teacher can use a pointer on the over head projector to explain the various details of it.

4. Alternatively the problem which is well drafted and drawn with geometrical instruments along with light constructional lines and final answer with bold lines on the transparent film having black back ground with white lines. Such special type of transparencey is to be projected directly on the black board, instade of on the white screen, for further explanation and solving the problem by using the common white chalk. This techniques of teaching will help to reduce the confussion created while understanding the problem. This technique is more simple to follow in the class. The students will belive and understand the exercise as they see what they have heard from the teacher. This technique can also easily be adopted for the slid projector.

5. The large scale/size charts well drafted on an opaque paper or translucent film are to be prepared for each problem to be used for teaching the subject matter by the teacher. They are to be well drafted having all the constructional lines and final answer with bold lines. Such charts are mounted on white board and are to be hang

over the wall in the classroom at the time of explanation or teaching purpose. The teacher can use the washable /dry wipe/ erasable marker over them while teaching. A teacher has to prepare and keep ample stock of the problem to be taught during the course of study. The new problems are to be added every year or semester so as to reduce the possibility of monotony.

6. Alternatively the problem is drawn on translucent plastic film, by using special drawing instruments, as refereed in item No. 2 above, with all constructional and final bold lines having black background with white lines. Such charts are to be hanged on the black board in the classroom. The teacher has to use chalk or white marker for further explanation.

CONCLUSION

Geometrical accuracy when used to explain various problems in the subject of Instrumental Drawing or Graphics is bound to help tackling the teacher taught tussle. This change in teaching technique will improve the understanding of the subject matter by the student, and ultimately the institute will be producing good professionals to serve the society. The teacher's initiative is the backbone behind all such efforts.

I divide mankind into three classes - the few who make things happen, the many who watch things happen and the overwhelming majority who have no idea of what happens.

- Nicholas M. Butler

❋ ❋ ❋

Meetings do not bring out the best in us. They are designed for, and are popular with the people who would rather do anything except actually go ahead and do it. They are a haven for compulsive talkers, impulsive talkers and repulsive talkers.

- A.C. Chevens

❋ ❋ ❋

An archaeologist is the best husband. The older you get, the more interested he is in you.

- Agatha Christie
(Married to an archaeologist)

❋ ❋ ❋

RAINWATER HARVESTING FOR DEVELOPING COUNTRIES

*R.P. de Silva**

ABSTRACT

Rainwater harvesting or the collection of rainwater for future use is proving to be very important especially in the areas where other sources of water cannot meet the demand. Unfortunately, the number of such areas are increasing throughout the world and shortage of water has become a serious problem in highly populated third world countries. This paper reviews some of the currently available literature on rainwater harvesting throwing light on the important aspects. Also taking locations in the dry zone of Sri Lanka as examples the paper demonstrates that attempting to tap the groundwater may be an altogether futile exercise whereas harvesting the surface components of rainfall will result in significantly increased yields.

Keywords : *Rainwater harvesting, dry zone, Sri Lanka, water quality.*

INTRODUCTION – WHAT IS RAINWATER HARVESTING?

The severity of the water problem is increasing each day as increase of population results in more thirsty mouths to quench and also the human encroachment of the environment results in decreased rains and contamination of whatever water sources we have. In this context, it has become top priority among many governments (especially those in the poor developing world) to look for alternate sources of water. Rainwater harvesting, defined as the collection of rain water into a suitable container, or into the soil profile (as infiltration) or into reservoirs for future needs is a very promising alternative because it;

- Provides more self sufficiency with your water supply
- Offsets the need for pumping groundwater
- Produces good quality water (in most areas) with zero hardness and low in minerals
- Reduces erosion and flooding typically created by runoff.
- Reduces silting and contamination of waterways from runoff.
- Saves time and energy (especially for women) which otherwise would have needed to fetch from distant sources.
- Requires less soap (because of zero hardness) and also reduces mineral deposits in pipes and water heaters

This short paper reviews and discusses the important aspects of rainwater harvesting as applicable in the poor developing countries of the third world.

HISTORY OF RAINWATER HARVESTING

Much of the early history of rainwater harvesting has it's origins in Europe, where the location of towns, industrial and commercial centres was determined by physico-

* Senior Lecturer, Department of Agricultural & Plantation Engineering, Open University, Nawala, Nugegoda 10250, Sri Lanka

geographical factors, the principal factor of course being the availability of water for domestic and commercial use and later for industrial consumption (United Nations Environment Program, 1983).

However, extensive rainwater harvesting apparatus existed 4000 years ago in the Negev desert. In ancient Rome, residences were built with individual cisterns and paved courtyards to capture rainwater to augment water from the city's aqueducts. Buddhist monastic cells in the hills in India had an intricate series of gutters and cisterns cut into the rock to provide domestic water on an year-round basis (Hofkes, 1983).

Rainwater was harvested into reservoirs (known as tanks) in ancient Sri Lanka hundreds of years ago. It is reported that there are about 25,000 such tanks in the dry zone of Sri Lanka, where it was attempted to trap every drop of water running off and during these times the harvested rainwater was used very successfully for irrigation. Sri Lanka was known as the 'granary of the east' which speaks volumes of the successful irrigation system (Basnayake, 1997).

WHY HARVEST RAINWATER?

All water we use for all our activities originate from the rainfall except for tiny quantities known as *connate water, magmatic water, plutonic water* and *metamorphic water* which have geological origins (Todd, 1980). These waters may eventually join the hydrological cycle.

Out of the amount of total water available on the earth only about 0.6% are available as fresh water and 50% of this freshwater are below a depth of 800 m. Therefore, the actual amount of freshwater available for man is about 0.3% of the total amount of water on earth (Wilson, 1974; Todd, 1980).

However, the non-equal distribution of this groundwater poses serious problems to many people living in the dry areas of the third world such as the dry zone of Sri Lanka. Therefore, the governments have built dams across many rivers in order to divert water to these dry areas. However, despite all these attempts still there are large areas where people are without water for their very basic needs.

At this point it is relevant to look at the components of the hydrological cycle to understand how one can obtain water in the most suitable and appropriate manner in a given locality. Since we need some actual data for this purpose, the author has chosen three locations in the dry zone of Sri Lanka where these data is available. Table 1 summarises the climatic, soil and vegetation data/parameters of each location.

Now it is possible to input these data into a simple water balance to compute the magnitudes of different components of the hydrological cycle at each location. Details of the water balance are found in de Silva (1996). Table 2 shows these magnitudes of different components as estimated from this water balance model.

It is seen from Table 2 that most of the water we receive as rain is evapo-transpired back to the atmosphere as actual evapotranspiration and as interception. An amount between 20 – 30% are available as runoff which can be put to a better use. Actually, in some locations (e.g. Angunakolapellessa) only about 9% of rain reach the water table and as

Table 1. Details of study locations in the dry zone

Location	Mean Annual Rain[1] (mm/y)	Mean Annual Pan Evaporation[1] (mm/y)	Vegetation	Top soil	Root zone depth (m)	Field Capacity (%)	Permanent Wilting Point (%)
Embilipitiya	1397	1729[2]	Shrub jungle	Loamy Sand	0.69	21.4	15.7
Angunakola-pellessa	1041	1868	Shrub jungle	Sandy Clay Loam	0.95	20.2	12.0
Maha Illuppallama	1305	1579	Jungle	Loamy Sand	1.17	20.9	11.0

[1] 6 year mean value except for Angunakolapellessa where the mean value is the 17 year one.
[2] Pan evaporation values are from the climate station at Sevanagala (i.e., the nearest agro-climatic station).

Table 2. Magnitudes of different components of the hydrological cycle at 3 study locations

Location	Rain (mm/y)	Interception (mm/y)	Runoff (mm/y)	Actual evapotranspiration (mm/y)	Recharge (mm/y)
Embilipitiya	1397	134 *(10%)*	275 *(20%)*	657 *(47%)*	331 *(24%)*
Angunakola-pellessa	1041	139 *(13%)*	229 *(22%)*	589 *(57%)*	90 *(09%)*
Maha Illuppallama	1305	177 *(14%)*	257 *(20%)*	678 *(52%)*	193 *(15%)*

Note : The values inside the brackets are the magnitude of the particular component as a percentage of the rain.

Table 3. Magnitudes of different components of the hydrological cycle at Angunakola-pellessa for different years

Location	Rain (mm/y)	Interception (mm/y)	Runoff (mm/y)	Actual evapotranspiration (mm/y)	Recharge (mm/y)
1976	1020	128 *(13%)*	242 *(24%)*	489 *(48%)*	129 *(13%)*
1977	1182	150 *(13%)*	269 *(23%)*	650 *(55%)*	140 *(12%)*
1978	993	142 *(14%)*	197 *(20%)*	581 *(59%)*	78 *(08%)*
1979	1124	162 *(14%)*	247 *(22%)*	662 *(59%)*	45 *(04%)*
1980	1137	135 *(12%)*	260 *(23%)*	641 *(56%)*	106 *(09%)*
1981	830	120 *(19%)*	161 *(19%)*	508 *(61%)*	45 *(05%)*

much as 25% of rain is available as runoff and. Table 3, which shows the estimates of different parameters of the hydrological cycle at Angunakolapellessa emphasises this point very clearly. It must also be noted that a fair amount of the interception will also be available for harvesting and therefore the actual amount of water possible to be harvested is likely to be 30-40% of annual rain.

Therefore, digging wells to tap the groundwater resource, especially at Angunakolapellessa seem a futile exercise because only smaller amounts of rain reach the water table. The more sensible option is to collect the rainwater into a suitable container, a reservoir or to the soil profile i.e., to harvest the rainwater.

THE TECHNIQUES OF RAINWATER HARVESTING

Harvesting rainfall is either done by collecting the runoff from a house roof or by collecting it from a ground catchment. A rainwater harvesting system usually comprises 6 components (Texas Water Development Board,1997), namely;

1. Catchment Area/Roof, the surface upon which the rain falls;
2. Gutters and Downspouts, the transport channels from catchment surface to storage;
3. Leaf Screens and roof-washers, the systems that remove contaminants and debris;
4. Cisterns or Storage Tanks, where collected rain-water is stored;
5. Conveying, the delivery system for the treated rainwater, either by gravity or pump; and
6. Water Treatment, filters and equipment, and additives to settle, filter, and disinfect.

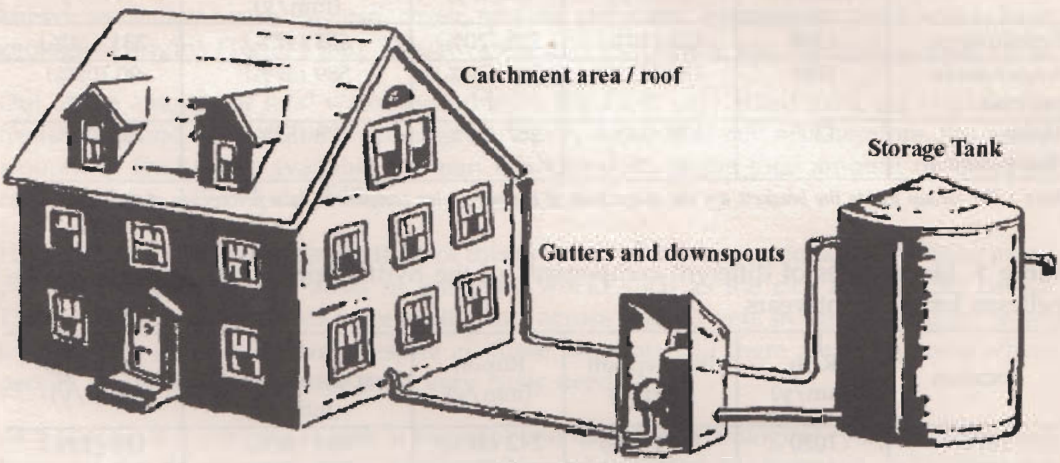


Fig. 1. Diagram showing different components of a roof rainwater harvesting system (after Texas Water Development Board, 1997)

THE AMOUNT OF WATER HARVESTED

The amount of rainfall that can be collected is determined approximately as the product of a runoff coefficient (Table 4) and the area of physical rainfall catchment.

More accurate and technical methods of determining the water that can be harvested is found in Pacey & Cullis (1986), Texas Water Development Board (1997), Gould & Nissen-Petersen (1999) and also from different sources of information available on the Internet which are too numerous to mention here.

Table 4. Runoff Coefficients (After Pacey & Cullis, 1986)

Type of Catchment	Coefficients
Roof catchments	
• tiles	0.8 - 0.9
• corrugated metal sheet	0.7 - 0.9
Ground surface coverings	
• Concrete	0.6 - 0.8
• plastic sheeting (gravel covered)	0.7 - 0.8
• butyl rubber	0.8 - 0.9
• brick pavement	0.5 - 0.6
Treated ground catchments	
• compacted and smoothed soil	0.3 - 0.5
• clay/cow dung threshing floors	0.5 - 0.6
• silicone treated soil	0.5 - 0.8
• soil treated with sodium salts	0.4 - 0.7
• soil treated with paraffin wax	0.6 - 0.9
Untreated ground catchments	
• soil on slopes <10%	0.0 - 0.3
• rocky natural catchments	0.2 - 0.5

THE QUALITY OF WATER HARVESTED

In general, the quality of harvested rainwater is comparatively better in most places on earth, except in the areas where air pollution has taken place due to industrialisation and urbanisation. Let us now look at some of the documented cases of water quality of rainwater harvesting.

Table 5 shows the summary of experimentally determined water quality data for the Kandy area in 1997/98 for harvested rainwater and also for other types of water. As seen in Table 5, the harvested rainwater is not suitable for drinking without boiling. However, for all other requirements, the quality is satisfactory. Ileperuma (1999) also report of harvested water quality data in 18 meteorological stations throughout Sri Lanka. From this study, he has found that at least in some locations (eg. Anuradhapura and Hambantota), the pH of rainwater is below the level of demarcation for pH of acid rain (5.6). Silva (1999) also report of rainwater with pH as less as 4.8 in certain parts in Sri Lanka. Heijnen & Mansur (1999) also report of some water quality measurements in the southern Sri Lanka. They have found the pH to be between 6.9 to 7.5 in the 3 areas of their study.

It is usual to divert the rainwater of the first few minutes of rain away from the cistern or the storage tank as this rain is likely to consist of dust, bird droppings etc. There a few contraptions developed to divert this first flush away from the water storage tank and one such contraption is described in Pacey & Cullis (1986).

Caution is needed if rainwater is harvested from a roof where lead based paint is applied on it. This water is unlikely to be suitable for drinking because of the high concentrations of lead. Another point to keep in mind is that prolong drinking of harvested rainwater could result in deficiencies of certain minerals (i.e, one must not use distilled water as

Table 5. Water quality parameters of harvested rainwater compared to other types of water [Summarised from the work of Padmasiri (1999)]

	Conductivity (µS/cum at 25°C)	Colour (Pt col scale)	Turbidity (FTU)	pH	Total coliform (per 100 ml at 35°C)	Feacal coliform (per 100 ml at 44°C)
Distilled water	<5	0	0	6.5		
Drinking water	5-1500	0-30	0-20	6.5-8.5	10	0
Harvested rainwater	50-2000	5-110	5015	6.0-7.5	4-1000	0-180
Bore hole					00	00
Dug well					<400	<250

drinking water as it will be deficient in essential minerals which the water obtained from wells normally contain).

CONCLUDING DISCUSSION

Rainwater harvesting or collecting rainwater for future use is not a new concept, but has been used in the past. Nevertheless, the abundant availability of surface water and groundwater coupled with development of technology to easily tap these sources (with the industrial revolution) led the man to somewhat forget rainwater harvesting. However, with increasing population and dwindling surface and groundwater sources along with their contamination has resulted in putting emphasis on rainwater harvesting.

Rainwater harvesting is likely to be especially attractive in certain dry areas where surface water and groundwater sources are not capable of meeting the demand. Also as in Bangladesh, where most of the groundwater is contaminated with arsenic, harvesting rainwater provides a viable, low cost and simple method which does not require advanced technological inputs to meet the demand for water. The same can be said of Nepal, where at least in certain areas close to Kathmandu, the groundwater is contaminated and is not suitable for most purposes.

However, there appears to be some mistaken notions about using harvested rainwater (such as rainwater not suitable for washing, rainwater is always heavily acidic etc) and government agencies working in the water sector must dispel these myths about harvested rainwater. Also, it is necessary that they take appropriate and quick action to make the technology available to the most deserving sectors of the society who are often faced with both the water problem and also with non accessibility to relevant information.

The quality of harvested rainwater appear to be good according to the literature cited, but, as stated already needs to be boiled if used for drinking purposes and for all other purposes may be used without requiring any other treatment (except perhaps of filtering).

While water harvesting is regarded as an appropriate and cheap mechanism for the improvement of access to water in the, people should be wary of the environmental costs associated with the technology. For example, water harvesting can cause serious land degradation by concentrating livestock at water points, causing overgrazing and soil erosion (Mafuta, 1999). Similarly water points can serve as breeding grounds for mosquitoes, resulting in high incidences of malaria and other water borne diseases.

REFERENCES

Basnayake, H. T., (1997). Hydraulic Civilisation in Ancient Sri Lanka (in Sinhala language), MD Gunasena & Company, 217, Olcott Mawatha, Colombo 11. Sri Lanka

De Silva, R. P., (1996). Estimating Groundwater Recharge with Limited Resources, with Special Emphasis on Spatial Variability: A Study in the Dry Zone of Sri Lanka. Unpublished PhD Thesis, Silsoe College, Cranfield University, UK.

Gould, J. & Nissen-Petersen, E., (1999). Rainwater Catchment Systems for Domestic Supply, Intermediate Technology Publications, UK.

Heijnen, H & Mansur, U., (1998). Rain Water Harvesting in the Community Water Supply and Sanitation Project. Proceedings of a Symposium on Rainwater Harvesting for Water Security, Lanka Rainwater Harvesting Forum, 05, Lionel Edirisinghe Mawatha, Colombo 5, Sri Lanka, Vol I & II, 53-59

Hofkes, E. H., (1983). Small Community Water Supplies, International Reference Centre for Community Water Supply and Sanitation. PO Box 93190, 2509 AD, The Hague, Netherlands.

Ileperuma, O. A., (1998). Acid Rain Monitoring and Total Chemical Analysis of Rain Water. Proceedings of a Symposium on Rainwater Harvesting for Water Security, Lanka Rainwater Harvesting Forum, 05, Lionel Edirisinghe Mawatha, Colombo 5, Sri Lanka, Vol I & II, 24 - 26.

Mafuta, C., (1999). Water harvesting: appropriate technology for the Zambezi Basin?, SARDC IMERCSA Newsletter, Zambia

Pacey, Arnold & Cullis, Adrian, (1986). Rainwater Harvesting – The Collection of Rainfall and Runoff in Rural Areas, Intermediate Technology Publications, UK.

Padmasiri, J. P., (1998). Constraints in Rain Water Harvesting with Respect to Water Quality. Proceedings of a Symposium on Rainwater Harvesting for Water Security, Lanka Rainwater Harvesting Forum, 05, Lionel Edirisinghe Mawatha, Colombo 5, Sri Lanka, Vol I & II, 22-23

Silva, E. I. L., (1998). Rainwater Quality and Buffer Intensities of Surface Water in Sri Lanka. Proceedings of a Symposium on Rainwater Harvesting for Water Security, Lanka Rainwater Harvesting Forum, 05, Lionel Edirisinghe Mawatha, Colombo 5, Sri Lanka, Vol I & II, 47-50

Texas Water Development Board, (1997). Texas Guide to Rainwater Harvesting, Austin, Texas, USA, Second Edition

Todd D. K., (1980). Groundwater Hydrology, John Wiley, New York.

United Nations Environment program (1983). Rain and Stormwater Harvesting in Rural Areas, Tycooly International Publishing Limited, 6, Crofton Terrace, Dun Laoghaire, Co. Dublin, Ireland.

Wilson, EM (1974). Engineering Hydrology, Macmillan Press Ltd, London.

READY RECKONER TO CALCULATE SOLAR HEAT GAIN TO BUILDING ENVELOPE

*S. Sahu**

ABSTRACT

Solar radiation incidence causes substantial cooling loads on building envelope in summer time and involves complex calculations for its assessment. Therefore, architects resort to qualitative judgment while designing buildings. In fact, building envelope needs to be optimized in terms of shape and size, fenestration and orientation etc. for minimum heat gain or heat loss, which may prove to be least energy consuming and comfortable at the same time. Keeping this important aspect in view, to facilitate the architect, a new dimension has been brought out in the form of surface area to floor area ratio (SA/FA), to be considered as the major determinant for designing thermally efficient building envelope. In this paper, a Ready Reckoner is presented to assess solar heat gain to various design options at the initial design stage. It is simple to use and least time consuming. It will help the architects to contribute towards minimizing cooling loads in the air-conditioned buildings and optimize thermal comfort in unconditioned buildings.

INTRODUCTION

Design of buildings to minimize the use of energy is a field, where research is drastically neglected. The buildings in urban area are major consumers of energy produced. i.e. to the tune of 20% of the total energy output in India while in advanced country like U.S. this figure goes beyond 40%. In order to reduce energy consumption in buildings, the architects can contribute effectively through the design of a building in scientific manner. Although, physicists have brought out enormous data on solar radiation, U-values, Thermal Performance Indices (TPI) for the use of architects but they are on individual building components and materials, which cannot be used directly on integrated building envelope, since it is composed of four walls and a roof. Hence, architects find it cumbersome to use, as it involves lot of calculations to convert it into a form, which would be readily usable for the design of integrated building envelope.

The factors that affect thermal performance of the buildings are stated to be orientation, fenestration, shape and size and U-values of the building envelope. Despite immense amount of data available with research agencies, there is no guideline provided to the effect of shape and size on thermal performance of the buildings. Similarly, there is no quantitative data available on these factors, which could be used directly for the design of integrated building envelope. Thus, the architects have been designing their buildings using qualitative judgment without knowing the quantitative end results in heat gain and leave the actual computations of solar heat gain to the air-conditioning engineers. No conscious effort is made on the part of the architect or the air-conditioning engineer to reduce the cooling loads through architectural design of buildings by controlling the shape and size of the building envelope.

* Professor, Nepal Engineering College

READY RECKONER

In order to overcome this handicap, a Ready Reckoner has been developed which has been worked out considering all the factors affecting thermal performance of buildings, for the use of architects and engineers to exercise the right option in quantitative terms at the initial design stage itself. In this Ready Reckoner a new concept has been developed in the form of surface area to floor area ratio SA/FA, which has never been taken into consideration, in this form before. This concept is based upon the fact that minimum surface area of a building exposed to direct solar radiation contributes to maximum thermal comfort indoors in unconditioned buildings and minimum cooling load on air conditioned buildings in hot weather.

The Ready Reckoner provides the information in tabular form, which can be used by designers conveniently. Since the plan shape and size of the building have a direct bearing on the thermal performance, the surface area to floor area ratio of the configuration needs to be established before a thermally efficient option is finalized. The building envelope having minimum SA to FA ratio is going to provide the most energy efficient building envelope.

APPLICATION

After having made the choice of the form and size of the configuration, the solar heat gain is to be read for the top floor (which has been considered to be equivalent to the single storey situation where the heat gains are found to be of highest order) for windowless building from Table 1. For fenestration percentage read the heat gains from Table 2 & 3 in desired orientation, as indicated below stepwise. The solar heat gains are expressed in terms of floor area enclosed within the envelope (per m^2), as the architects follow this mode of expression for all purposes in the building design.

Steps in Claculation

Step 1. Read the solar heat gain for the requisite size and aspect ratio (length to width ratio) for the windowless building from Table 1.

Step 2. Read the multiplying factors of solar heat gain for 1% fenestration in rectangular configuration of varying aspect ratios from Tables 2 & 3, under the required amount of shading from direct solar radiation in the corresponding orientation, and multiply it with total percentage of fenestration.

Step 3. Add 1 and 2 and deduct the heat gain for the desired number of storeys from the sum of the above two steps to get the heat gain for multistoried building under consideration, the deductions to be made for desired number of storeys, as indicated in Table 4.

Step 4. In the above Tables the topmost floor is considered as single storeyed building and the counting is done in the reverse order of numbering for the purpose of deductions in heat load according to the number of storeys as mentioned in step 3 above.

The resulting heat load will be the total solar heat gain to the building envelope under consideration.

Example 1

There is a three storeyed building of 20m x 100m, longer side aligned E/W i.e. facing North/South having symmetrical windows 2.5m high on 100m walls above 0.5 m cill level. Calculate the solar heat gain to the building envelope.

- Total floor area on each floor 20 x 100 = 2000 sq. m.
- Fenestration area in each wall 2.5 x 100 = 250 sq. m.
- Percentage area in each wall 250/2000 = 12.5%
- Aspect ratio of the building is 5
- Read solar heat gain from table 1 Equivalent area i.e. 1936 sq. m. under aspect ratio 5 in N-S-E-W orientation = 36.63 w/m^2 ....(A)
- Read from table 2 under 0% shading for 1% fenestration in longer opposite walls = 3.870 w/m^2
- The heat gain for 12.5% fenestration in opposite walls = 3.87 x 12.5
  = 48.375 w/m^2 ....(B)
- The total of (A) & (B) = 48.395 + 36.63
  = 85.025 w/m^2 ....(C)
- Deduct for 3 storeys from (C) (Since building is 3 storeyed) = 85.025 – 21.03
  = 63.365.82 w/m2
- Thus total solar heat gain to the entire Building will be = 63.995 x 2000 x 3
  = 383970 w
  = 384 TR

With a little familiarity with the Tables, the calculations can be done very fast.

Example 2

4000 sq. m. is the permissible covered area as per stipulated FAR on a given plot in an urban location. Find the thermally most efficient building block, which should be recommended by the architect.

For the building block having 4000 sq. m. as the total covered area, 5 options have been worked out i.e. from single to 5-storeyed, enclosing given amount of area. Total solar heat gain for each option is calculated on the basis of Table 1 as given below, placed in N-S-E-W orientation, for a square configuration.

It may be seen in the above exercise that, total heat gain is decreasing substantially with the increase in number of storeys and a five storey situation has the minimum heat gain.

S.N.	Building block	Equivalent configuration size m^2	Rate of heat gain on top floor w/m^2	Reduction factor w/m^2	Reduced rate of heat gain w/m^2	Total heat gain of the block, w
1.	Single storeyed	64 x 64	34.72	–	34.72	142213.12
2.	Double storeyed	44 x 44	36.15	15.77	20.38	39455.68
3.	Three-storeyed	36 x 36	37.17	21.03	16.14	20917.44
4.	Four-storeyed	32 x 32	37.78	23.66	14.12	14458.88
5.	Five-storeyed	28 x 28	37.87	23.66	12.34	9674.56

Therefore, it is recommended to construct five or more than five storyed building block for optimum thermal efficiency.

The available wall surface area in each of the above options is different, with different configuration sizes and if the fenestrations are provided, in the above building blocks their percentage is bound to vary in each of the solutions and the heat gains will change in value proportionately. Therefore, it is always thermally more efficient to construct a multi storeyed building block even with maximum possible fenestration.

The above illustration makes the wide range of options available to the architect, to make an appropriate choice of building envelope, as per requirement.

RECOMMENDATIONS

The comprehensive graph, which has been published in the last issue as fig.- 1, is a summery of the Tables, which provides a guideline to the practicing architects to exercise a judicious option of building sizes with full awareness of the quantities of solar heat gain involved. From the exhaustive analytical study based on the computations for a wide cross section of building envelopes of different shapes and sizes, the recommendations (published from time to time) have been made for practicing architects for the design of buildings, in their pursuit of achieving thermally comfortable options with optimal energy conservation.

Table 1. Solar Heat Gain to Incremental Configurations, without fenestration, with variable aspect ratios 1, 5 and 10 for the top floor in all the orientations

S. N.	Configuration Area in m^2	Orientation	Solar Heat Gain w/m2 for aspect ratios		
			1	5	10
1.	16 (4 x 4)	NE/SW	82.96	87.28	100.15
		N/S	82.16	86.83	99.75
		SE/NW	82.96	113.72	142.43
		E/W	82.16	112.01	140.02
2.	64 (8 x 8)	NE/SW	57.26	59.47	65.73
		N/S	56.85	59.47	65.54
		SE/NW	57.26	72.73	86.78
		E/W	56.85	71.88	85.50
3.	144 (12 x 12)	NE/SW	48.69	50.15	54.37
		N/S	40.42	50.00	54.23
		SE/NW	48.69	58.90	68.42
		E/W	48.42	58.41	67.62
4.	256 (16 x 16)	NE/SW	44.40	45.49	48.64
		N/S	44.20	45.38	48.54
		SE/NW	44.40	52.11	59.16
		E/W	44.20	51.69	58.56
5.	400 (20 x 20)	NE/SW	41.87	42.70	46.23
		N/S	41.67	42.61	45.15
		SE/NW	41.87	48.00	53.66
		E/W	41.67	47.66	53.18

Table 1. (contd.)

6.	576 (24 x 24)	NE/SW N/S SE/NW E/W	40.12 39.98 40.12 39.98	40.84 40.77 45.25 44.97	42.94 42.88 49.96 49.56
7.	784 (28 x 28)	NE/SW N/S SE/NW E/W	38.89 38.78 38.89 38.78	39.51 39.45 47.29 47.05	41.32 41.26 47.34 46.99
8.	1024 (32 x 32)	NE/SW N/S SE/NW E/W	37.97 37.87 37.97 37.87	38.52 38.46 41.82 41.61	40.09 40.04 45.36 45.06
9.	1296 (36 x 36)	NE/SW N/S SE/NW E/W	37.26 37.17 37.26 37.17	37.74 37.69 40.50 40.30	39.15 39.10 43.56 43.28
10.	1600 (40 x 40)	NE/SW N/S SE/NW E/W	36.69 36.61 36.69 36.61	37.12 37.08 39.77 39.60	38.38 38.34 42.59 42.25
11.	1936 (44 x 44)	NE/SW N/S SE/NW E/W	36.22 36.15 36.22 36.15	36.63 36.59 38.95 38.89	37.76 37.73 41.59 41.37
12.	2304 (48 x 48)	NE/SW N/S SE/NW E/W	35.83 35.76 35.83 35.76	33.87 33.87 34.20 34.16	37.24 37.21 40.75 40.55
13.	2704 (52 x 52)	NE/SW N/S SE/NW E/W	35.50 35.44 38.50 35.44	35.84 35.80 37.81 37.74	36.81 36.78 40.04 39.86
14.	3136 (56 x 56)	NE/SW N/S SE/NW E/W	35.22 35.16 35.22 35.16	35.53 35.50 37.42 37.30	36.43 36.40 39.44 39.27
15.	3600 (60 x 60)	NE/SW N/S SE/NW E/W	34.97 34.92 34.97 34.92	35.26 35.23 37.03 36.91	36.11 36.08 38.91 38.75
16.	4096 (64 x 64)	NE/SW N/S SE/NW E/W	34.76 34.72 34.76 34.72	35.03 35.00 36.69 36.58	35.82 35.80 38.45 38.30

Table 2. Multiplying factors to calculate heat gain for rectangular configurations for 1 percent fenestration in L_1 and L_2 in all orientations w/m^2, under different percentage of shading

S.No.	Orientation	Shading in percent			
		100	75	50	0
1.	N/S	0.788	1.561	2.329	3.870.
2.	NE/SW	0.859	3.217	5.576	10.294
3.	E/W	0.600	2.871	5.141	9.682
4.	SE/NW	0.565	2.378	4.000	7.647

Table 3. Multiplying factors to calculate heat gain for rectangular configurations for 1 percent fenestration in each of the four walls in all orientations w/m^2, under different percentage of shading

S.No.	Orientation	Shading in percent			
		100	75	50	0
1.	N/S	1.388	4.435	7.471	13.553
2.	NE/SW	1.412	5.659	9.671	17.918
3.	E/W	1.388	4.435	7.471	13.553
4.	SE/NW	1.412	5.659	9.671	17.918

REDUCTION FACTORS FOR NUMBER OF STOREYS

Table 4. In a multistorey building, the following reduction factors may be used with the increase in number of storeys.

S.No.	Number of Storeys	Reduction in Heat Gain
1.	Single storey	–
2.	Upto two storeys	15.77 w/m^2
3.	Upto three storeys	21.03 w/m^2
4.	Upto four storeys	23.66 w/m^2
5.	Upto five storeys	25.23 w/m^2
6.	Every five storeys thereafter	1.00 w/m^2

The secret is to become wise before you get old.

- Unknown

❋ ❋ ❋

I will speak ill of no man, and speak all the good I know of everybody.

- Ben Franklin

❋ ❋ ❋

PIN TRANSDUCER FOR GENERAL FORCE MEASUREMENT IN AGRICULTURAL MACHINERY TESTING

*SAMANS Senanayake**

ABSTRACT

A pin transducer was designed, constructed and calibrated to be used for horizontal and vertical force measurement in category II tractors. The pin had the same dimensions as that of normal three-point hitch pins and therefore it can be used in place of a normal hitch pin. The pin was made in two main parts, namely the insert and the sleeve. The insert carries four-arm strain gauge bridges that sense vertical and horizontal components of the forces in the three links. The sleeve acts as a protective cover for the strain gauges ad carries a portion of the load shared with the insert. The surface of the sleeve was made with two waves so that load on the pin was always concentrated at a point. The calibration data revealed that the cross sensitivity is very low, the maximum value being 2%.

Nomenclature

c - distance from the neutral axis to the maximum stress point (m)
e - strain
E - Young's Modulus (kN/m^2)
I - second moment of area (m^4)
K - Gauge factor
ΔV - strain gauge bridge output (V)
V - applied voltage (V)
W - load (kN)
x - distance between the two strain gauge bridges (m)

INTRODUCTION

Use of agricultural tractors has been expanding in many countries because of development programmes in the agricultural sector launched to meet the increasing demand for food. Generally farm work is very tedious and time consuming. In many countries young people are reluctant to be involved in hard work and therefore the labour available for agricultural work is becoming scarce. Because of these facts together with quality, and efficiency achievable by machines many farmers now tend to use machines in their farms though, in some instances, the cost involved is little high.

Many farm activities are carried out by attaching various implements to tractors. The preparation of land is perhaps the most difficult and important as well as widely undertaken operation by tractors in cultivation. The forces developed at the implement

* Department of Agricultural & Plantation Engineering, Open University, Nawala, Nugegoda 10250, Sri Lanka

working in the soil are transferred to the tractor though the tractor/implement interface. Accurate measurements of these forces are essential in respect of estimating tractor stability and power requirements. Furthermore, two components of these forces are of particular importance, as one component, draught or horizontal component gives the estimate of tractor power and the other, vertical component provides information on degree of penetration of the implement into the soil. In addition to these two components, non-symmetrical implements generate a side force, which influences the steerability of the tractor. Therefore measuring of these forces with reasonable accuracy is very much useful.

Implements are attached to tractors through real hitch point or three-point linkage system, operating free link or restrained link. In the case of trailed implements, by inserting a force transducer between the tractor draw bar and implement force can simply be measured. However, it is rather difficult to measure forces when implements are attached to the tractor though three point linkages. Increasing use of three point hitches, as it allows better draught and position control, has emphasized the need of more research to be carried out to establish accurate methods to measure the forces in the three links. Different methods to measure these forces exhibiting varying degrees of accuracy and complications have been conceived, constructed and tested since late 1950s. Most of the designs required special attachments to be fitted in between the tractor and the implement and some designs moved to actual hitch points backward altering the location of virtual hitch point. This can be argued as changing the parameters being measured by measuring device itself. All designs made use of electrical resistance strain gauges as they provide accurate and efficient means of determining strains.

In the case of fully mounted implements, the task becomes more cumbersome, because the hydraulic lift provided to the lower link makes the forces no longer axial. Therefore, any transducer designed for the lower ink should be capable of measuring forces separately in two mutually perpendicular planes.

In 1959, Lal designed a dynamometer to measure horizontal forces in three point linkages. In this design, the normal cross shaft of the plough was replaced by a straight shaft so that the forces in the lower links were transferred to the shaft causing bending in two perpendicular planes. The shaft, at equal distances from the ball joints, were reduced to rectangular sections and two strain gauge bridged positioned on two mutually normal flat faces measured the resultant horizontal and vertical forces acting on the shaft. To measure the forces in the upper link he used a short strain gauged dynamometer. This was supported in a frame and it measured only the horizontal component. The vertical component was transferred to the lower links that was registered by the strain gauges on the shaft in combination with lower link vertical forces. The top link dynamometer measuring horizontal force component of the top link was connected electrically to the horizontal bridge of the cross shaft to give resultant horizontal force of the implement. Readings were taken through three channels. One channel measured the vertical force and one of the other two measured resultant horizontal forces – combination of top and lower link dynamometer and third measured only the top link horizontal force. Need of a special frame to carry the dynamometers was one of the disadvantages of this design. Insertion of completely new frame between the tractor and the implement altered the real positions of forces. The cross sensitivity of the strain gauged cross shaft was another draw back observed. The friction in the hitch points contributed lowers much of the error. In order to reduce the frictional effects in lower hitch points the halls in the links were replaced by self aligning ball bearings and the top link dynamometer was supported on needle roller bearings.

Reece (1961) designed strain gauged cantilever pins, which were able to measure only the horizontal force of each link. These cantilever pins were mounted on the tractor and supported on the hall joints at the inner end of the three links. He used four strain gauges on the pin equal distances away from the neutral axis. The gauges only responded to the longitudinal component of the force on the link. The arrangement of the gauges in the bridge was such that the strains produced due to side and vertical components did not give a response in the bridge. The bridges in three links were connected so that voltage unbalance was corresponding to the sum of resistance changes in all three links, which gave the total draught force. These pins were not so good in respect of cross sensitivity. The difficulty in mounting strain gauges exactly equidistant of the neutral axis caused problems. Reece observed up to 10% cross sensitivity. The pins also suffered from high position sensitivity registering different outputs of the same load applied at different positions. Further, the calibration curves showed some hysterisis. The dynamometer was limited to be used in free link operation.

Johnson *et al.* (1979) designed and constructed a dynamometer for three point hitches to measure draught, vertical force and torque simultaneously and independently in vertical longitudinal plane. In 1981, Baker used six load cells mounted on a triangular frame to measure draught force, vertical force and moments. The design, although somewhat bulky could be used for different tractors and forces were measured with little error. The implements were shifted by about 190 mm from the original hitch point. The dynamometer designed by Chung (1983) also extended the real hitch point by 210 mm to the rear.

Recently, more attention has been paid to the development of pin transducers that are to be used in place of normal three point linkage pins. As these pins are subjected to bending while in operation, the strains thus produced are measured in two perpendicular planes. This method of measuring interactive forces between the tractor and the implement is more convenient than earlier methods. It does not require additional apparatus and does not alter the actual linkage geometry. The aim of this study was to design a load-sensing pin capable of sensing forces in two mutually perpendicular planes with minimum cross and position sensitivities.

PIN TRANSDUCER

The design of the pin transducer was based on the maximum draught forces experienced by implements and the tests done on three-point hitch pins. These pins can carry a load of about 50kN. In practice, these pins have never failed and it is therefore reasonable to assume that practical loads are well below this value. The maximum load a tractor can pull is limited by the traction ability of the tractor. Therefore, the maximum pull for a category II tractor weighing 6000kg was considered to be 40 kN with 70% coefficient of traction. It was also assumed that the load is equally divided between the two lower links. The pin was considered a simply supported beam carrying a concentrated load at mid span.

CONSTRUCTION OF THE PIN TRANSDUCER

The pin consisted of two main parts; namely, the insert and the sleeve as shown in figure 1. The insert, which carries eight strain gauges on four flat surfaces made on a 17mm diameter shaft, was assembled on to the sleeve with interference fit. Both the sleeve and the insert were made from EN24 steel and oil quenched at 850°C followed by tempering at 510°C to give a hardness of 82-92 Rockwell. The sleeve carries a portion of the bending moment and it acts as a protective cover for the strain gauges. The surface of the pin was made having two under cuts in order to ensure that the load applied to the pin is concentrated at a point. At the end of insert, a cavity was made in order to facilitate the connection of wires into two Wheanston Bridges. Lacquered wires were used to connect the gauges and these were brought into the cavity through small holes made at the end of each flat surface. The output and input terminals of the bridges were then connected to the socket fitted to the end cap of the pin. Wires of different colours were used for outer connections for the identification of bridges. To protect the gauges a coating of glue was applied over the gauges. The sleeve was then heated to temperature of 140°C and dropped on to the insert.

Position of Strain Gauges and Bridge Circuits

Strain gauges (EA-06-120 LZ 120 series) were positioned to sense the strains in two mutually perpendicular planes as shown in figure 2. The gauges were connected to form two four-arm bridges so that they are temperature compensation and the unbalance voltages are corresponding to strain differences in each plane. The gauges I and II were placed at the same distance and subjected to stains of equal magnitude but one in tension and other in compression. Similarly, gauges 2 and 22 were placed at equal distance sensing higher values of strains on the same plane. The unbalance voltage is given by the equation (1).

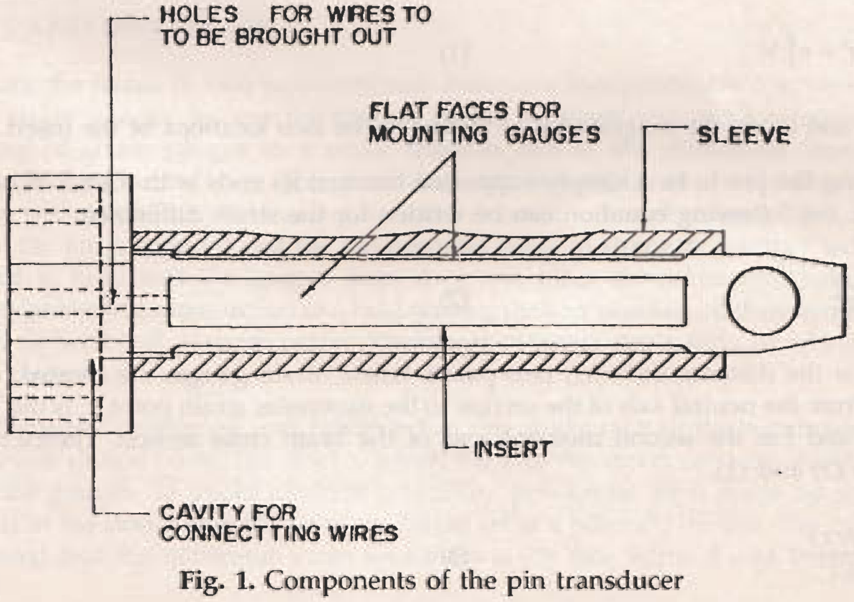


Fig. 1. Components of the pin transducer

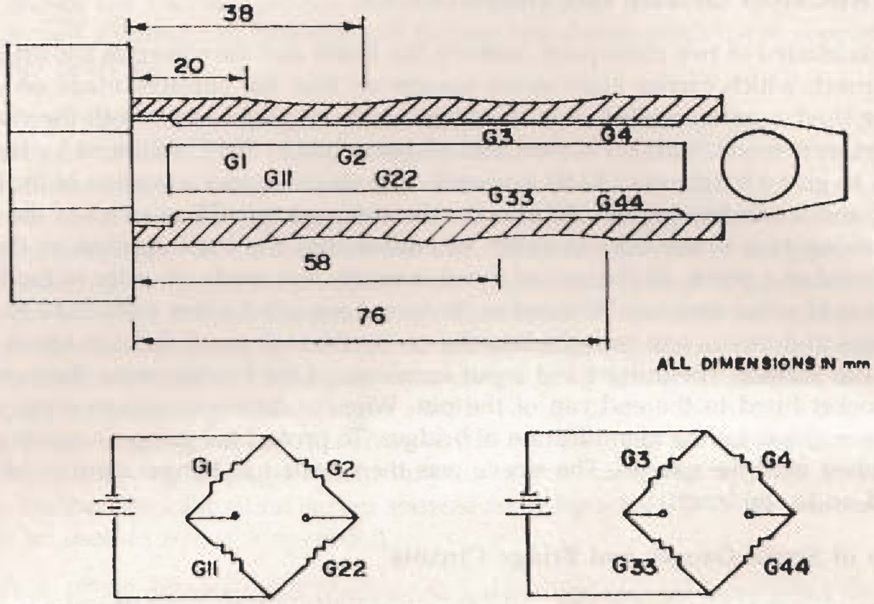


Fig. 2. Locations of strain gauges

$$\Delta V = \frac{K}{4}[e_1 - e_{11} + e_{22} - e_2]\, V$$

By taking $e_1 = e$, $e_{11} = -e$, $e_{22} = -e'$ and $e_2 = e'$

$$\Delta V = \frac{K}{2}[e' - e]\, V \qquad (1)$$

Where, e and e' are the magnitudes of strains at the two locations of the insert.

Considering the pin to be a simply supported beam at its ends with a load W acting at mid span, the following equation can be written for the strain difference.

$$e - e' = \frac{Wxc}{2EI} \qquad (2)$$

Where x is the distance between two points where strain gauges are located, c is the distance from the neutral axis of the section to the maximum strain point, E is the Young's modulus and I is the second moment area of the beam cross section. Therefore, from equations (1) and (2),

$$\Delta V = \frac{KWexV}{2EI} \qquad (3)$$

The equation (3) shows a linear relationship between the load W and the bridge out put voltage.

Bending Moments Carried by the Sleeve and the Insert

The sleeve and the insert share the bending moment. The maximum bending moment occurs at mid span of the pin and it was estimated that the bending moment carried by the insert at mid span is 390 Nm for an applied load of 20kN. Using bending theory, the strains that are likely to occur at locations where gauges are placed were calculated to make sure that sufficiently large voltage differences are obtained.

The temperature to which the sleeve should be heated for assembly should limit the amount of maximum interference and this temperature was chosen such that it did not affect the strain gauges during assembling. The temperature used was 140°C that gave an interference of 0.014mm. Under this value, it was found that the hoop stresses developed in the sleeve and the insert would not exceed the yield stress of the material.

Calibration

The pin was calibrated for a load range of 0-15kN. The bridge positioned close to the head of the pin was considered to be vertical bridge which senses the vertical component of the force and the other, horizontal bridge senses the horizontal component or the draught force. A Universal Testing Machine was used to apply load in 1kN steps. The bridge outputs were measured by using Cambell Data Logger.

The pin was supported on two mild steel blocks that provided real situation of force system. The load was applied through a similar mild steel block. The pin was set on the machine table so that line of load application is normal to the planes that carry strain gauges to get the response of vertical and horizontal bridges.

RESULTS AND DISCUSSION

To measure the forces in two perpendicular directions independently it is necessary to position strain gauges on exactly normal planes to overcome cross sensitivity. The positioning of strain gauges in a small space is one of the difficulties faced in the construction of pin transducers. The pins, which act, as transducers should also be strong enough to withstand loads. By making flat faces in order to install strain gauges, the cross section of the pin is reduced and the pin becomes weak in strength. Another factor to be considered is to protect the gauges from dust and other environmental pollutants in farms. Designing and construction of a load sensing devices meeting all these requirements is a rather difficult task. It needs perfect machining of components and careful installation of strain gauges.

The pin transducer designed and calibrated in this study met all the requirements that such a device should have. The sleeve, which fits into the insert carrying strain gauges, protects the gauges. To avoid position sensitivity provisions were made by providing under cuts in the sleeve to ensure that the forces act at a point on the pin. The calibration data showed that the maximum cross sensitivity is 2% (see figure 3 and 4 for both the bridges).

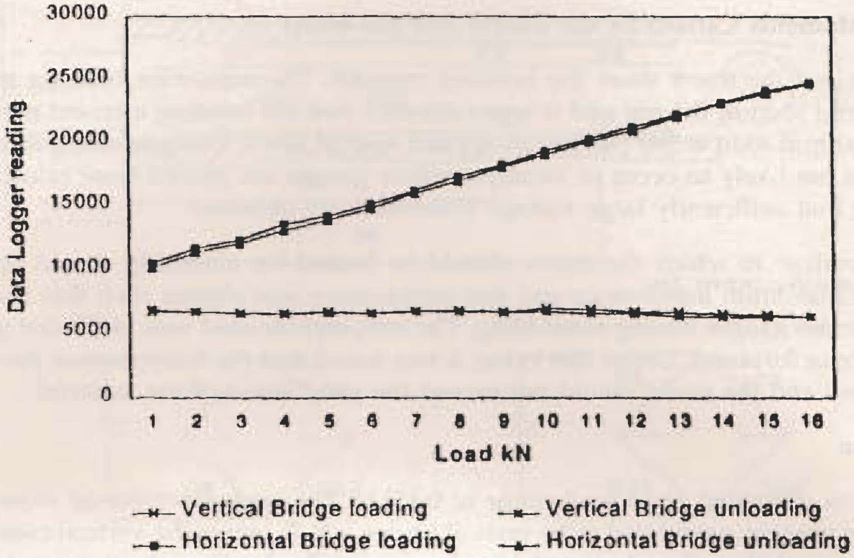
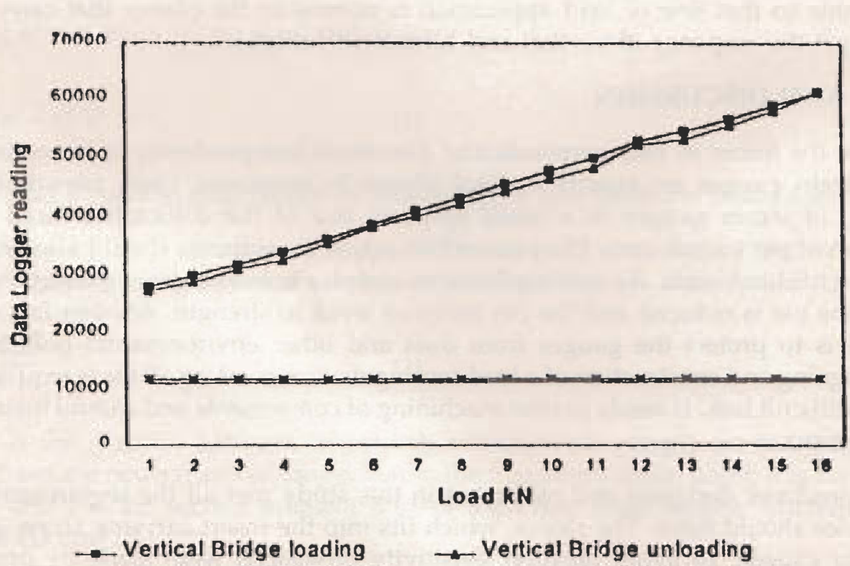


Fig. 3 and 4. Response of bridges to vertical load



CONCLUSIONS

The features introduced in the design of the pin transducer reduced the problems of force measurement in three-point links. Especially the cross sensitivity was found very small as evident from the calibration data. Positioning of strain gauges in very small flat faces on the pin was found difficult and therefore flat faces cold be made much bigger by having larger diameter insert by reducing the thickness of the sleeve. However, this can only be done by allowing a sufficient grip between the insert and the sleeve as well as well as ensuring that the stresses would not exceed allowable values.

REFERENCES

Baker. G. L., Smith, A. and Colwick, R. F. (1981), 'Three point hitch dynamometer for directional force measurement', ASAE 81-1044.

Chung, Y. G., Marley, S. J. and Buchele, W. F. (1983), 'Development of a three-point hitch dynamometer', ASAE 83-1066.

Johnson, C. E. and Voorhees, W. B. (1979), 'A force dynamometer for three point hitches', Transactions of ASAE, 22 (2): 226-228.

Lal, R. (1959), 'Measurement of forces on mounted implements', Transactions of ASAE 2(1): 109-111.

Reece, A.R. (1961), 'A three-point linkage dynamometer', Journal of Agricultural Engineering Research, 44-50.

Winning is not a sometime thing; it's an all-time thing. You don't win once in a while, you don't do things right once in a while, you do them right all the time. Winning is a habit. Unfortunately, so is losing.

- Vince Lambardi

❋ ❋ ❋

To get things done, choose a busy person. The other kind has no time !

- Unknown

❋ ❋ ❋

The best way to kill an idea is to take it to a meeting.

- Unknown

❋ ❋ ❋

USE OF BRICK DUST AS MINERAL ADMIXTURE IN CEMENT CONCRETE WORK

*Netra Bahadur Karki**

ABSTRACT

This study gives an overview of the physical and chemical properties of brick dust as a mineral admixture from brick and tile factories in Nepal. The reasons for using brick dust include economy and beneficial modification of certain properties of fresh and hardened concrete elements. Various properties of brick dust were studied. Experimental results indicate that brick dust can be used for partial replacement of cement in concrete work. Replacement of cement by brick dust as mineral admixture in cement concrete in about 20 percent gives almost same flexural but higher compressive strength. The concrete cube with 20% cement replaced mineral admixture prepared from brick dust (BMA) shows 15% more strength than concrete cube with Portland cement only after 90 days.

The concrete with 20% BMA also shows good resistance to chemical attack, specially the sulfate attack. They also show better pore refinement after long period. Chemical compounds and lime reactivity strength of brick dusts have been found within the range given for good pozzolanic material. The pore refinement and low heat of hydration have shown that the properties of concrete can be improved when brick dust has been used with combination of Portland cement.

Dumping of brick dust and brick bats have not only occupied the large acres of land but also create environmental problem. This problem can be reduced to a large extent by using these waste materials in cement concrete work. The mineral admixture (BMA) has good reddish colour. The mixture of Portland cement and BMA can be used as decorative cement.

INTRODUCTION

Plain and reinforced cement concrete is one of the very popular materials for construction all over the world. Nepal, rich in forests, is also experiencing great scarcity of structural wood nowadays and use of cement concrete is one of the alternative for solving the problem of shelter. Engineers, architects and builders have not always been conscious or concerned with preservation and protection of the environment or conservation of resources as they should be. Although the raw materials for cement production are available in most parts of Nepal, but the production cost is high.

Mineral admixtures like silica fume, granulated blast furnace and slag and fly ash are widely used material in developed as well as developing countries. In developing countries considerable efforts have been also directed towards the utilization of indigenous and waste materials such as palm oil fuel ash, rice husk ash, coal ash, brick dust, stone dust

* Structural Engineer, Department of Irrigation, Jawalakhel, Lalitpur, Nepal

in cement concrete.[1,2,3,4,5,6] The purpose of this study is to investigate the behaviour of concrete with brick dust as mineral admixture available in Nepal.

MINERAL ADMIXTURES IN NEPAL

Various types of local waste material which can be used as mineral admixtures are available in Nepal. Some of them are coal ash, brick dust, stone dust, rice husk ash etc. Brick dust is a waste product obtained from different brick and tile factories. There are many brick factories in Nepal. Tons of waste products like brick dust or broken pieces of bricks (brickbat) come out from these factories. So far, such materials have been used just for filling or are dumped as waste material. Similarly paddy being the major agricultural product in Terai as well as hilly regions, rice husk ash can be considered another major source of mineral admixtures. Coal ash is a by-product from coal burning brick and tile factories in Nepal. Similarly tons of' stone dust produced as waste product from stone and aggregate industries, can be another source of mineral admixtures.

RESEARCH SIGNIFICANCE

Brick dust is widely available waste product in Nepal. This paper discusses the various physical, mechanical and chemical properties of cement concrete with brick dust as the mineral admixture. It has been observed to replace cement in concrete and its use increases durability of concrete in aggressive environment.

STRUCTURAL EFFECT OF BRICK DUST AS MINERAL ADMIXTURE IN CEMENT CONCRETE

Brick dust as mineral admixture has the ability to react with lime in presence of moisture to form hydraulic products. As Portland cement liberates lime during hydration, in course of time, this liberated lime is leached out making the structure porous. Due to acidic environment CO_2 reacts with $Ca(OH)_2$ and forms calcium carbonate and water and leaches out the whitish substance.

Reaction

Portland cement + water ---> C-H-S (Glue) + $Ca(OH)_2$ (Fast Reaction)

$Ca(OH)_2 + CO_2$ ---> $CaCO_3 + H_2O$

In cement mineral admixture mixes with liberated lime that in turn reacts with mineral admixture forming further amount of hydraulic compounds, reinforcing the hydraulic properties of cement itself. The reaction is as follows:

Pozzolana + $Ca(OH)_2$ + water ---> C-H-S (Glue) (Slow Reaction)

The slow rate of reaction between mineral admixture and liberated lime coupled with the decrease in the portion of cement affects the hydraulic properties in the early age. But in the course of time the mineral admixture reaction products contribute their share to improve the rate of hydration and consequently the strength properties of the concrete.

EXPERIMENTAL STUDIES

Experimental studies have been carried out to identify the various properties of brick dust to be used as mineral admixture in concrete.

Preparation of Materials and Testing

Various materials used for the experimental studies were cement, sand, aggregate and brick dust. Brick dust was collected from one of the representative brick and tile factories in Kathmandu Valley-Harishiddhi brick and tile factory. Physical properties of brick dust in raw state such as grain size distribution, moisture content, specific gravity, bulk density were determined. In order to prepare the brick dust to be used as mineral admixture its processing was carried out by grinding it in a rotating drum with specific sizes and numbers of iron balls. The speed of rotation of the drum was kept constant (25 rpm). The required time for grinding for given weight of raw material with a given weight of iron balls was determined by sieving the grinned material through 90 pm sieve after specific number of rotation. Ground brick dust, which is hereafter called as BMA (mineral admixture prepared form brick dust), retaining about 2 percent through 90 pm sieve was adopted for experiment. This figure was adopted in order to make the fineness of brick dust near to that of cement, which is also retained through 90 pm sieve by 2.3 percent. Ordinary portland cement from Himal Cement Factory, Chovar, sand from Bagmati river conforming to zone II as per Indian standard (IS) and irregular coarse aggregates of size 20 mm were used. Physical and chemical properties of materials have been presented in Table 1 and Table 2.

Preparation of Specimens and Testing

Properties of brick dust as mineral admixture at different structural levels – paste level, mortar level and concrete level – were studied. The sizes of specimens adopted at paste level were cylinders of 15.7 mm in diameter and 10.0 mm in height. The percentage of brick dust calculated with respect to the total cementing material that was 0, 10, 20, 30, 40, 50 and 60. At this level, accelerated method of curing was carried out by putting the specimens in a chamber at 60°C temperature and 90 percent humidity. Seven specimens were tested for one result at this structural level. Compressive strength tests were carried out after 24 hrs, 3 days and 10 days.

In order to identify the properties of brick dust at mortar level, mortar cubes of 50 x 50 x 50 mm were prepared. The ratio of cementing material to sand was 1:3. The cementing material was the sum of cement and brick dust. The percentages of brick dust adopted in place of cement at this structural level were 0, 20, 30 and 50. Basis for limiting these ranges was the results obtained from paste level. Accelerated curing test was carried out at this structural level. Compressive strength tests were carried out after 24 hrs, 48 hrs, 5 days and 10 days.

Concrete cubes of 100 x 100 x 100 mm were prepared in the ratio of 1:2:4 (cementing material: sand: aggregate). The replacement of cement was 0, 20 and 30 percent by weight of total cementing material. Basis of adoption of these percentages was the results obtained form the tests in two structural levels – paste and mortar. Compressive strength tests were carried out in normal curing after 7, 14, 28, 45 and 90 days. Three specimens were prepared and tested in each result at concrete level.

Results of compressive strength test in three different levels (cement paste, mortar and concrete) are presented in Figures 1, 2 and 3.

OTHER TESTS

Various other tests were also carried out to identify the properties of paste, mortar and concrete with brick dust. These properties were normal consistency, lime reactivity, heat of hydration, pore structure by water absorption and microscopic studies and durability.

Normal Consistency

The consistency of paste and mortar was determined with the help of Vicat apparatus and flow table. In the case of paste, requirement of water was slightly more while in case of mortar and concrete it was nearly the same as for the control specimens. Results for normal consistency and setting ties of cement paste have been shown in Fig. 4 and 5.

Lime Reactivity

The lime reactivity of the brick dust was determined by lime reactivity test as per Indian Standard (IS 1767-67). It was measured in terms of compressive strength of 50 x 50 x 50 mm cubes prepared with lime, mineral admixture and standard sand (the sand conforming to Indian Standard IS 650-66). The lime used was laboratory reagent grade hydrated lime. The lime reactivity of brick dust has been found to be 2.03 MPa.

Water Absorption Test

75 x 75 x 75 mm concrete cubes were prepared for water absorption test with 0 and 20 percent BMA. The mix ratio of cementing material : sand : aggregate was 1 : 2 : 4 and w/c = 0.55. At the age of 28 days, specimens were placed in chamber at 100±5°C. After 48 hours, oven – dried specimens were cooled in silica gel and test was carried out with tap water at 24°C. Result has been shown in Fig. 6.

Microscopic Study

The microscopic study has been carried out on cement stone with 20 percent replacement of cement by BMA and control specimens. At the age of 28 days of normal curing, the specimens were cut into two pieces by diamond cutter. The cut surface was smoothen by carborendum stone and cleaned with acetone. The number of visible pores at different magnification was counted in 2 mm^2 area. The cement-stone with brick dust has lesser number of bigger as well as smaller pores. Results are shown in Table 3.

Durability

The durability of concrete was determined in terms of loss of weight and strength due to acid and sulfate solution in comparison with the control specimens. For this test, concrete cubes of 100 x 100 x 100 mm were prepared with 0 and 20 percent replacement of cement by BMA. The w/c was 0.55. All the samples were cured in normal water for 14 days, then after 3 pieces of each type of specimens were placed in 5% HCl solution, 5% Na_2SO_4 solution and normal water (control specimens). pH values and salt concentration of the solutions were checked periodically at the interval of 10 days and maintained the same by adding the acid and sulfate. At the age of 28, 45 and 90 days, specimens were removed from the solutions, cleaned and surface dried. Then they were tested on universal compression testing machine. The percentage loss and gain in strength compared to initial percentage loss in strength compared to control specimens has been plotted in Fig. 6 and 7. Other results have been shown in Table 4.

Heat of Hydration

Heat of hydration was measured in terms of rise in temperature. The results are plotted in Fig. 8. Graph shows that nearly after 14 to 15 hours from mixing of water, specimens release more heat. But in case of cement replaced by 20 percent of brick dust temperature is about 2.9°C less than the specimen without brick dust.

RESULT ANALYSIS

Results of the studies show that the compressive strength of specimen with brick dust at different structural levels (i.e. paste level, mortar level and concrete level) is increased. There is an optimal percentage of BMA for each structural level, which gives maximum compressive strength. In concrete level it has been observed that 20 & 30 percent replacement of cement by BMA gives almost or slightly higher strength in comparison to control concrete under normal curing in 45 and 90 days.

In Table 5 chemical composition of the studied BMA has been compared with Indian fly ash and fly ash conforming to ASTM C 618 for pozzolanic material. It has been found that the sum of SiO_2, Al_2O_3, Fe_2O_3 content in studied brick dust ash is less than that of Indian and ASTM C 618 class N and F. But it is greater than ASTM C 618 Class C. Loss on ignition of tile studied BMA is greater. All other constituents are in good proportion and with in limit.

Test results (Table 4) indicate that the concrete cubes immersed in HCl solution, lose their weight as compared to their initial weight and have less compressive strength than those immersed in water. Fig. 7 indicates that percentage loss of compressive strength of control concrete cubes immersed in HCl have been found to be less than that of B-20 concrete cubes in 28 clays and 45 days. This percentage loss in compressive strengths has been found as almost same in B-20 than that in control after 90 days.

Results also indicate that weights of control concrete cubes and B-20 and their compressive strengths have been found increased when they are immersed in Na_2SO_4 solution. Figure 8 shows that percentage gain in compressive strength of control cube is increased up to age of 45 days. After that percentage gain of compressive strength in control cube is reduced. But the percentage gain of compressive strength of B-20 concrete cube continues to rise even after 90 days.

CONCLUSIONS

- Brick dust as waste product from brick and tile factories in Nepal can be used as mineral admixtures in concrete. Its use in concrete can save about 20 percent of cement as binding material with same strength.
- Brick dust concrete can be produced with satisfactory slump and setting times with nearly same water cementing material ratio as in normal concrete without mineral

admixture.

- Percent replacement of cement by brick dust increases strength of concrete nearly by 15 percent at 90 days under normal curing.
- The B-20 concrete cube seems more durable than control cube specially under condition of sulfate attack.
- In mass concrete, use of brick dust as mineral admixture decreases heat of hydration, which helps to control the development of secondary stresses in the structures.

Table-1: Physical properties of brick dust, sand & aggregate

Properties	Brick dust (raw)	BMA	Sand	Riverbed Aggregate
Moisture content	3.12%	0.5%	0.00	1.08%
Specific gravity (unit)	2.557	2.65	2.62	2.70
Fineness modulus	2.13	2 %*	2.76	6.94
Bulk density (kg/m^3)				
Loose	1170.7	729	1365.54	1582.33
Compacted	1376.6	1073	1667.91	1775.10

* Percentage retained on 90 μm sieve.

Table-2: Chemical composition of cement and brick dust (in percentage)

	SiO_2	LOI	R_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Other
Cement	18.0-20.5	3.0-4.5	-	4.5-5.0	6.0-7.0	58-60	1.9-2.5	1.8-2.75	-	-	1.5-2
BMA	68.53	1.2	-	8.12	2.02	2.24	2.41	0.36	0.072	0.2	8.485

Table 3: Number of pores in cement concrete

S.N.	Number of Pores per area of 16 mm^2 in different magnification	
	6 time	12 time
Control:		
1	9	10
2	6	7
3	5	7
B-20		
1	6	6
2	3	5
3	5	8

Table 4: Results of chemical attack test

Age of Concrete (days)	Acid attack				Sulfate attack			
	Loss of strength (%)		Loss of weight (%)		Gain of strength (%)		Increase in weight (%)	
	Control	B-20	Control	B-20	Control	B-20	Control	B-20
28	42.37%	47.37%	4.07%	4.52%	0.56%	0.63%	0.08%	0.08%
45	32.82%	37.67%	3.71%	3.09%	3.57%	2.31%	0.00%	0.01%
90	39.64%	39.52%	4.49%	2.85%	2.28%	3.57%	0.28%	0.40%

Table 5: Comparison of chemical composition (%):

S. No.	Constituents	IS 3812-1981 Standard	ASTM C 618 – 91 Standard (Class)			BMA
			N	F	C	
1	$SiO_2+Al_2O_3+Fe_2O_3$ (min.%)	70.0	70.0	70.0	50.0	78.67
2	MgO (max.%)	5.0	5.0	5.0	5.0	2.41
3	SO_3 (max.%)	2.75	4.0	5.0	5.0	0.36
4	Na_2O (max.%)	1.5	1.5	1.5	1.5	0.072
5	Loss on Ignition (max.%)	12.0	10.0	12.0	6.0	1.2

Fig.1 Compressive strength of cement stone (Fcu) vs % cement replaced by BMA

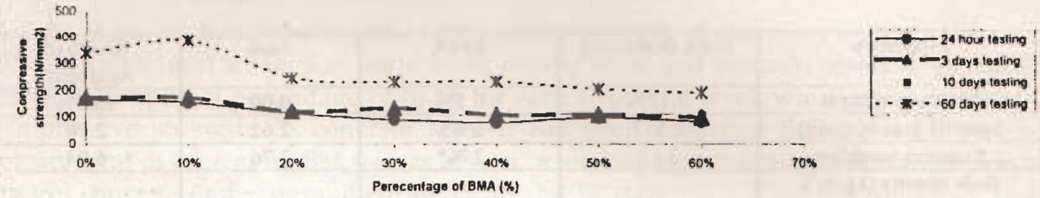


Fig.2 Compressive strength of cement mortar vs % cement replaced by BMA

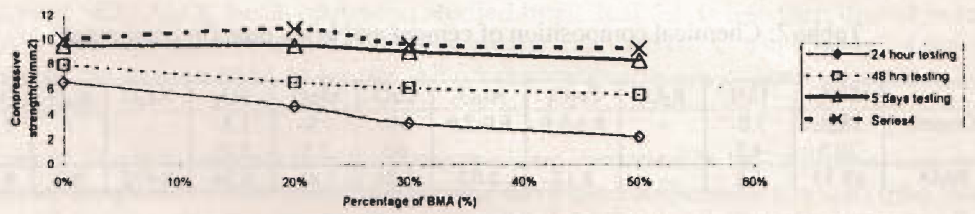


Fig. 3 Compressive strength of cement concrete vs % cement replaced by BMA

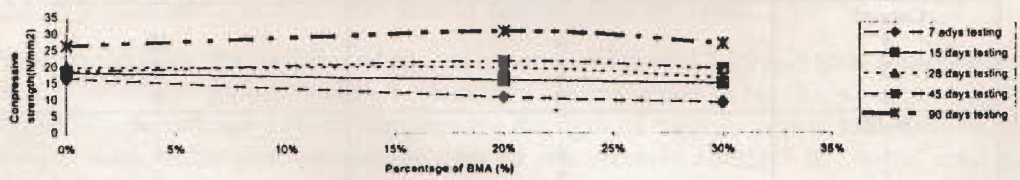


Fig. 4 Normal consistency vs percentage of BMA

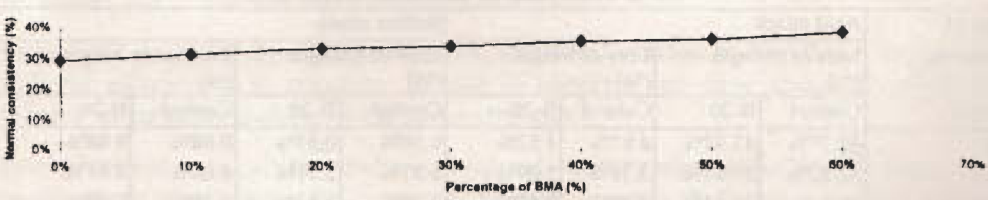


Fig. 5 Initial and final seting time vs percenatge of BMA

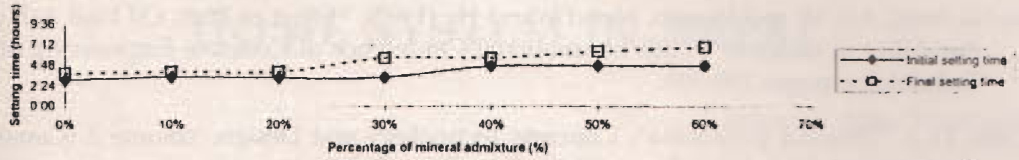


Fig.6 Graph of water absorved vs time of immersion in water at age of 28 days.

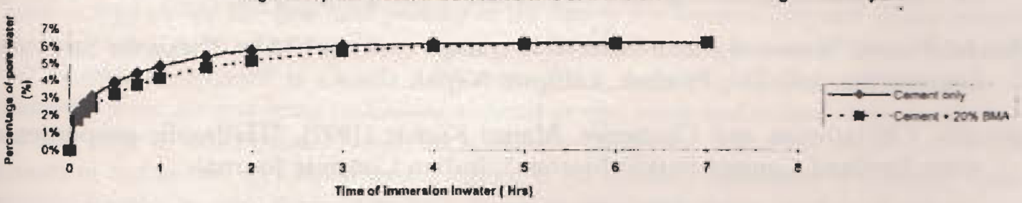


Fig. 7 Percentage loss in compressive strength of cement concrete vs Age of concrete (when concrete is in immersed in HCl solusion)

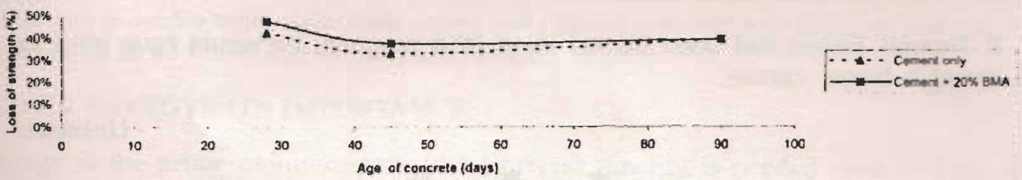


Fig. 7 Percentage increase in compressive strength vs Age of concrete (when immersed in Na2SO4 solusion)

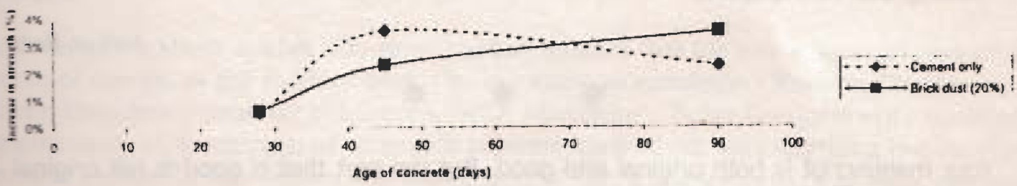
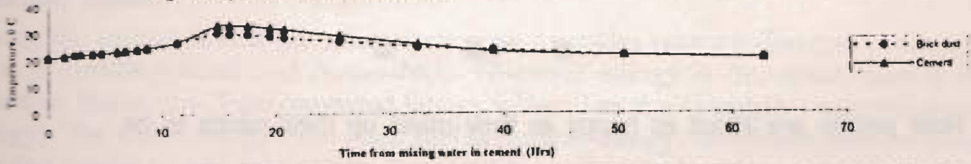


Fig. 8 Graph of Temperature variation



REFERENCES

Abdul Awal, A.S.M. and Hussin, Mohd Warid Hj. (1997), "Effect of Plam Oil Fuel Ash on durability of concrete", Fifth International Conference of Concrete Engineering and Technology, pages 299-306.

Cook, D. J., "Natural pozzolana", Concrete Technology and Design, Volume 3 (Cement Replacement Materials), Surrey University Press Publication.

Karki, Netra Bahadur, "Use of local and waste material in cement concrete" M.Sc. Thesis for Structural Engineering, IoE, TU, Pulchok, Lalitpur, Nepal.

Mandal Bharat, "Reuse of waste material in cement concrete" M.Sc. Thesis for Structural Engineering, IoE, TU, Pulchok, Lalitpur, Nepal.

Samanta, Chittaranjan and Chatterjee, Manas Kumar (1997), "Hydraulic properties of some Portland Cement-Surkhi Mortars", Indian Concrete Journal.

Zhang, Min-Hong and Malhotra, V. Mohan (1996), "High-Performance Concrete Incorporation Rice Husk Ash as a Supplementary Cementing Material", ACI Material Journal, 93-M72.

If Thomas Edison had been trained in an MBA program, he would have tried to invent a bigger candle.

- Unknown

❋ ❋ ❋

The man who reads nothing at all is better educated than the man who reads nothing but newspapers.

- Arthur Baer

❋ ❋ ❋

Your manuscript is both original and good. But the part that is good is not original and the part that is original is not good.

- Samuel Johnson

❋ ❋ ❋

Most people are about as happy as they make up their minds to be.

- Abraham Lincoln

❋ ❋ ❋

STATUS OF SOLAR HOME SYSTEM IN NEPAL

*Ishwari Man Pradhan**

ABSTRACT

The sun is the primeval source of energy on earth; it is renewable and sollution free. Harnessing of solar energy should therefore have priority in the energy development program of any country, including Nepal. As of now, Nepal's per capita consumption of energy is one of the lowest 0.3 ton of oil equivalent compared to Canada's 9.5 toe); of this, only 13 percent or 39 kgoe is in the commercial form, the rest being traditional as forest or agri waste and animal dung, indicating a very low stage of development. Nepal has no known significant deposit of foissil fuel but she abounds in hydropower (per capita second highest in the world). Exploitation of this huge hydro-potential becomes possible when India buys power on reasonable terms. As it is, it will be quite sometime before our far-flung areas have access to central grid system. For them, alternate source of energy should be provided. Various modes are being put in vogue. Of these, the PVcell which was started to power communication equipments, is now being used for lighting houses, as electricity is the ideal source of energy for lighting. PV cells are simple, very easy to use and do no damage to environment. Solar home system using them has proved to be beneficial and can well be taken up as an initial step in rural electrification.

SOLAR ENERGY : ITS IMPORTANCE

Energy is the prime requirement in the Universe. Energy is needed even to keep the "lamp of life burning" and therefore food has been the first among the four prime necessities of a creatur. Because the sun is the primordial source of energy and for that matter everything terrestrial, our forefathers have regarded the Sun as the Grandfather of the Universe.

Euphoric as the above epithet may seem, the fact remains that the sun is the most preferable source of energy, as the modern man also has come to conclude. Observes Dr. Herrman Scheer; President, Eurosolar in his book "Solar Manifesto". "Solar Energy is not a nostalgic remembrance of times past, of an earlier pastoral idyll which was anything but an idyll for most human beings. Rather the conversion of man's energy system to solar one and with it, the reintegration of humanity's energy system into the planet's, will be the decisive step towards integrating humanity into "the rhythm of nature".

Quoting the second law of thermodynamics, he discusses entropy (Energea = strength, tropos = transformation) and Negentropy. Wherever energy is converted, inescapable conversion loss occurs. Total converted Energy = Useful energy (Exergy) + wasteful energy (Anergy). The waste energy from fossil fuel & nuclear energy conversion destroys ozone layer and produces acid rain and heats up rivers used to cool nuclear reactors and thus brings irreversible disorder in the ecosystem. This is entropy, Dr. Scheer urges introduction of entropy taxation. In contrast, the loss of solar radiation conversion produces food and

* Associate Professor, Nepal Engineering College

biomass through photosynthesis, wind through changes in temperature and pressure, water through evaporation, all of which can be used to get back energy and this is Negentropy. He pleads the advanced countries to increase research budget for solar energy conversion.

This article aims to describe the status of solar photovoltaic (PV) cell in Nepal, which is used in Solar Home System.

EVOLUTION OF ENERGY CONVERSION PROCESS

The fundamentality of energy in human development can be seen from the following table:

Table 1. Historical Review of Growing Energy Demand of Man

	Daily per capita Energy Consumption, kWh per day, per capita					
Historical age	Food	Agriculture	Domestic	Industry	Transport	Total
- Cave Man (10,00,000 years ago)	3	-	-	-	-	3
- Hunting Man (1,00,00, years ago)	4	-	3	-	-	7
- Agricultural Man (5000 BC)	5	2	6	-	-	13
- Industrial Man (20th Century)	10	5	60	100	85	260
- Technologically advanced man (21st Century)	10	5	60	150	185	410

In the evolution of energy tapping from nature, the first stage was to supplement muscle power (man's own + animal's such as the bullock's, the dog's in the cold Lapland) by burning fuel wood, agriwaste (straws, leaves etc.) and animal dung. These are called the traditional methods of energy consumption, which is in vogue in backward regions. In the next stage, machines were used to get energy. Energy obtained in this way is called commercial energy. First, turbines were used, rotation being obtained from wind or water flow, Wind turbines soon gave way to steam engines and turbines (coal is the prime mover). With the invention of internal combustion engine, oil & gas began to be exploited on large scale and this was to take the Arab countries from rags to riches.

The development of electrical machinery was a big step forward, as it then became feasible to transmit energy far and wide. Electricity is ideal for lighting: it is essential for operating electric devices in control systems. Nuclear energy came up after IInd world war and is used in the form of electricity. Of the total energy consumed now a days, forty percent is in the form of electricity.

NEPAL'S ENERGY CONSUMPTION PATTERN

Regarding consumption pattern, the following observations can be made:

Per capita energy consumption has a bearing on population growth. Low energy consumption indicates low mechanization, that human hands are used to do things mostly.

Nepal's figure is one on the lowest, 0.3 ton of oil equivalent (toe) in contrast to Canada's 9.5 toe.

This is the reason why a large number of Nepalese families (in backward areas) do not have family planning and is one of the reasons of early marriage.

Country/ Continent	Energy consumption per capita 1985 (ton of oil equivalent)	Annual population growth 1985-2020 (%)
Canada	9.0	0.8
United States	7.5	0.7
Northern Europe	5.4	0.2
Australia, New Zealand	4.8	1.0
Former Soviet Union	4.7	1.0
European Union	4.0	0.1
Japan	3.0	0.7
Latin America	1.0	2.2
Asia	0.4	2.4
Africa	0.4	3.0

Table 2. Comparison of Energy Consumption, Economic and Living Conditions

	Commercial energy consumption per capita (Kg oil equival., 1990	Annual pop. rate (1990-2000)	Average life expectancy at birth (1990)	GNP per capita (US$, 1989)	Agric. production (as % of GDP)	Rural population (as % of pop.)	Population with access to safe water (as % of pop.)	Adult illiteracy (as % of pop.)
Industrial countries	4930	0.5	74.5	17,017			100	
Medium Human Development	1061	1.6	66.2	1998	13	42	85	21
China	591	1.3	70.1	350	32	67	74	27
Low Human Development	160	2.7	55.2	384	28	71	46	46
India	226	2.0	59.1	340	30	73	75	52
Least Human Development	63	3.0	51	237	40	78	46	55

From above, when we see that Nepal's per capita consumption of commercial energy is only 33 kg of oil; the plight can be imagined. And worse, of this low figure, only 85% is met from Hydel although our Hydel vaiable potential is 42133MW (second highest per capita) the rest is made up from diesel plant and purchase from India which is costing the country very dear.

The above pattern of Nepal's power energy consumption has been caused by the fact that Nepal has no workable deposit of coal, gas or oil and although she has vast resource or Hydropower, she has not beejn able tap them so far (generation capacity 600 MW, shortly).

Firstly she does not have financial resource to undertake search for oil, gas or coal or to go in for major hydel project. For cooperation with the outside, she lacks management experience on sharing hydropower with India. She has the experience of losing in the deal and is now cautious. A firm working policy has still to be formulated.

NEW WORLD ENERGY MANAGEMENT PERCEPTION & NEPALESE CONTEXT

Meanwhile, there has been a sea change in the World Energy Management perception, brought about by the 1973 oil-shock. Prior to this, oil was very popular and greatly valued. The British had monopolised Iranian oil while the USA controlled Saudi Arabian and Kuwaiti supplies. After second World War, the British lost control over Iranian crude (Iran nationalised crude production) and explored the North Sea and was able to meet a major part of her requirement from there. As the royalties on oil were based on and therefore controlled by the demand of the refineries in the industrialised countries, the oil producing countries mainly Arab, formed a cartel called OPEC in 1960. In 1973, at the height of Arab-Israel conflict, OPEC suddenly raised crude price manifold. At once, the world was reminded that oil reserve will not last long and alternate source of energy other than fossil fuel must be developed. Side by side consciousness grew about environment damage which is going on and has to be mitigated. Stress shifted to use of clean renewable source, preferably using small-decentralised system. This is particularly so for Nepal because her hydropower grid will not grow fast enough and distribution to far flung areas will not be economically feasible for quite many years. The alternate sources are identified as follows:

Photovoltaics, Solarthermics, Biomass conversion, Wind power, Mini-micro hydropower. In Nepal's present context,

1. Mini-micro hydropwer is site specific, takes comparatively long time to complete and is expensive when number of consumers are limited and also loss-incurring when load factor is low.

2. Wind power is also site specific (mapping yet to be done) design is complicated requiring control of many factors, yaw, pitch of blades, tethering etc. In India however wind power plants are widely used.

3. Biomass plants to digest animal dung and generate biogas are simple and are widely used. However they do not operate satisfactorily in hilly areas where the temperature is low. Recently landfill system to use urban west in Kathmandu valley was planned but the local people are resisting use of their land.

4. Insulation in Nepal (solar energy received per unit area) is quite good 4.5 kwh/m2 and so some solar thermic plants using flat plates are widely used as solar water heater and drier in some cases and also space heating of houses. But focussing of solar radiation to obtain high temperature has not been satisfactory. In view of the fact that more than 75% of energy use is for cooking, this could drastically cut consumption of convertional energy and save destruction of forests.

5. Solar photovoltaic cell is the simplest and has been a success story. It is described in detail below:

Education has been boosted. Also living condition has improved with relaxation and better environment (kerosene and wood lighting done away with). Below is shown how the environment has improved (study by Prof. J.N. Shrestha and Dr. D.K. Sharma).

Environmental Benefits from Photovoltaic Modules

Environmental Benefits	Savings from One 50 Watt Solar Module
Electricity saved per annum	90 kWh
Electricity save per life of solar panel	2,700kWh
Oil saved over life of solar panel	4.8 barrels
Coal saved over life of solar panel	2,700 Ib
Carbon Dioxide saving over life of Solar panel	4,000 Ib
Sulfur Dioxide saving over life of solar panel	23.3 Ib

Source: Shrestha, J.N., PV Based Rural Electrification - Is it Affordable ?

Obviously SHS in conjunction with dome3stic solar cooker would be the ideal renewable energy supply systems. Nevertheless since lighting is the foremost requirement in far flung areas the popularity of SHS is increasing. In Nepal, the covering of the entire village of Pullimarang under supervision of the Cenre for Renewable Energy (Nepal) has given SHS a big impetus. International agencies like Swedish International Development Agency is now funding its extension in Laos, Vietnam through Asian Institute of Technology for which CRE is playing the role of resource center for technical & management training in those countries.

Meanwhile research is gion on to increas conversion evviciency of solar cells and also to increase charge-holding capacity of batteries. Success in these will further increase SHS popularity.

The biggest boost will be with the advent of white LED, as this diode has the capacity to tum electricity into ligh most efficiently, requiring vastly reduce wattage and consequently much smaller batteries and also near everlasting lamps.

As the PV cells have almost unlimited life and can be sold almost with no loss to distant needy areas, it can well be seen that Solar Home System has an important role to play in initial rural elevtrification in Nepal.

A calendar is simply a reminder that our days are numbered.

- Unknown

❋ ❋ ❋

When I was a boy of fourteen, my father was so ignorant I could hardly stand to have the old man around. But when I got to be twenty-one, I was astonished at how much he had learned in seven years.

- Mark Twain

❋ ❋ ❋

THE ROLE OF LECTURES, TUTORIALS AND PRACTICALS IN TEACHING ENGINEERING COURSES

*A.S.R. Rao**

ABSTRACT

Effective instruction in engineering core courses is possible only if the teacher can clearly identify the objectives behind teaching a subject through lectures, tutorials and practical classes. This article attempts to highlight some of these objectives.

INTRODUCTION

Most engineering core courses are taught through a combination of lecture classes, tutorial assignments and laboratory and field tests. Each of these has a distinctive role in the overall scheme of teaching a particular course. It is necessary for a young teacher starting out in his teaching career to understand clearly the philosophy behind teaching through lectures, tutorials and practical classes. Otherwise, there is likely to be an overlapping of teaching material among these three components which is of course, a waste of teaching time but worse, may result in the students losing interest in the subject altogether. In the following paragraphs, an attempt has been made to highlight the objectives of teaching a course in its different facets.

ROLE OF LECTURES

In teaching any particular course, the broader aims and objectives of engineering education should always be guiding us. The state-of-the-art in engineering disciplines in already quite vast and further, it is expanding at such a pace that curriculum planners have realized that it is impossible to teach everything in a particular course in the limited time of about 45 contact hours available in a semester. Also, with technology changing so fast, teaching a student today's technology in depth may be counterproductive, if it turns out to be obsolete in future. Therefore, our basic objective in teaching an undergraduate class should be to train the mind of the student so that he can analyse any situation with the help of certain basic tools. In addition, he has to be made aware of the essentials of technology as practised at present so that he can be useful to the society in the immediate future. These two objectives could serve as guidelines in selecting the approach one should generally use in the lecture classes. In specific terms, the following points sum up the essence of the philosophy behind lecture teaching :

1. The emphasis should be on 'learning' and not on 'teaching'. Students are not to be treated as passive recipients of information. An 'active' mode of learning inculcates a spirit of enquiry and a life-long habit of learning. This can be achieved by asking questions, provoking discussions, leaving out some intermediate steps in a derivation

* Professor, Nepal Engineering College

and asking the students to complete it and most importantly, giving assignments that involve library study.

2. While the essential curriculum content should be covered, this should not be done with the narrow aim of preparing a student to face the final examination. The teacher should try to make the subject interesting by illustrating basic principles with the help of live examples with which a student can relate.

3. Broad, underlying principles of the subject must be given great weightage. To explain everything in great detail and in many cases, in a most uninteresting manner, is not the right approach. There should be a greater emphasis on exposing the limitations of the theory. Similarly, wherever possible, synthesis of approach should be highlighted. To take an example, while discussing the Laplace equation in seepage flow, one can point out how the same equation with different boundary conditions is valid for dispersion of electricity in a conducting medium or heat in a thermal medium. While dealing with shock waves, the teacher can discuss hydraulic jump in a gravity flow.

4. Teaching aids may be used extensively to save time and to make lectures more effective. Study materials may be distributed where necessary, to discourage spoon-feeding.

5. Discussing laboratory and field tests in the lecture class is a waste of lecture time. Solving design examples, too, is not a part of the lecture teaching. These are best left to the practical and tutorial classes.

6. Occasionally, during lectures, the students may be addressed by persons with research experience so that the undergraduate is exposed to the frontiers of research.

ROLE OF TUTORIALS

The role of tutorials is often misunderstood. Tutorials should serve the purpose of supplementing the knowledge gained in the lecture classes through numerical problems which illustrate the application of theory to practical problems. They are not to be treated merely as a means of assuring the student a decent score in internal evaluation in return for some mechanical application of formulas in some meaningless examples. For illustration, if a question on the permeability test asks the student to determine the diameter of a standpipe given all other data including the coefficient of permeability of the soil, it is a typical case of a stupid exercise. For, the object of the test is to determine the coefficient of permeability of the soil. A mere substitution of all given data in an equation to determine the only unknown quantity, does not constitute a legitimate question. On the other hand, if a flow net is shown below a weir and the student asked to calculate the seepage quantity, uplift pressure, exit gradient and made to investigate the effect of providing an upstream or a downstream cut-off on these quantities, this is an excellent example of a tutorial problem. Remember, every tutorial problem has to pass the litmus test of being meaningful and must test basic knowledge of a theory or use a theory to solve a real-life problem.

Tutorial classes also afford an opportunity for a student to discuss or clarify any point with the teacher without any inhibition.

ROLE OF LABORATORY CLASSES

A set of tests, performed in the laboratory in a mechanical manner, without some broad plan of action, will not be an effective aid to the learning process. When properly conducted, the laboratory work should fulfil the following objectives :

1. By observing certain phenomena in the laboratory, the student gains first-hand impression of how these actually work.
2. The student learns about the techniques of measurement, and errors in measurement of different quantities.
3. By a comparison of the measured data with the theory, the student learns to appreciate the limitations of the theory.
4. The creative ability of the student is encouraged by experimentation.
5. The student develops confidence in his abilities by doing things with his own hands.

Some innovations can be introduced to improve the effectiveness of laboratory work.

1. The laboratory instructions need not be too explicit. The student may be told the background material for a test and he must then come prepared to do the test.
2. During the test, the teacher should ask a series of questions on the test, particular techniques used, etc.
3. Instead of asking the student to write a conventional test report, the student may be asked to answer some searching questions on the test.
4. Technical report writing skills of the student could be improved by a teacher-supervised exercise.

CONCLUSIONS

1. Lectures, tutorials and laboratory work have their own distinctive roles in the teaching of a core engineering course and these need to be understood by a young teacher.
2. Students are not passive recipients of information. Learning, not teaching, is the important thing. Spoon-feeding is not the best way of learning.
3. Whenever opportunity arises, theory should be illustrated with practical applications.

Grant me the serenity to accept the things I cannot change, the courage to change the things I can and the wisdom to know the difference.

- *Unknown*

❋ ❋ ❋

Speeches are like babies - easy to conceive but hard to deliver.

- *Mark Twain*

❋ ❋ ❋

Call for Articles

Nepal Engineering College invites for its July 2002 Edition of SCITECH Nepal journal articles on topics related to Science, Engineering and Architecture from teachers, experts and field practitioners. The articles must be original and must not have been published earlier. The maximum length of papers shall be about 2500 words including references. An abstract must be sent along with the paper. The article should be sent in a computer diskette. The articles will be reviewed and only accepted articles will be published. Rejected articles will not be returned to the authors except for original illustrations. Author/s will be paid an honorarium for accepted papers.

Authors may send their papers, along with the address for correspondence to :

The Editor,
SCITECH Nepal
Nepal Engineering College
Changunarayan, Bhaktapur
G.P.O. Box 10210

The last date for the receipt of articles is June 30, 2002. For a typical format of an article, the author is advised to refer to SCITECH Vol. 6 No. 1.