

SCITECH Nepal

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Publisher's Note

Through this journal the college family first extends a warm and hearty welcome to our dear readers on the auspicious occasion of the first **nec** anniversary day. Along with its aspiration of building an attractive image through its quality education and, above all, through some substantial contribution to the country, **nec** has now opened up a new forum, viz. **SCITECH Nepal**, a biannual journal, for all those who are interested in the practical dimension of science and technology. The main function of the journal is to provide an interactive medium for informed and lively discussion on matters that energize and initiate the scientific mind.

Scientific mind and technical hand should march together to construct a better world for mankind. Practical applications of the field should be the key motivation of our modern technologists and scientists. Our ambition is to hand on the journal for readership and encourage to illuminate the practical dimension of modern technology. Even in its burgeoning state the journal seems to flash a jubilant smile. Now, we feel the need of affirmation and constant encouragement of our readers for its life and continuity. Your contributions, suggestions and time to time comments as readers are equally significant to lead the periodical to its desired direction.

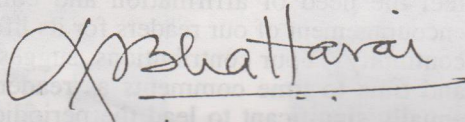
We acknowledge with thanks the contributions made by the authors and the advertisers to this issue and request all concerned to contribute articles on the subjects of their own expertise. Let us venture to make this a technical periodical of international standard with national relevance and await until the next issue that, we hope, will essentially be a momentous one!

Message from the Chairman

I am pleased to bring to you the first issue of SCITECH published by nec on the auspicious occasion of the first college anniversary day. College education should strive for quality production. Our whole-hearted devotion and commitment should be directed to achieve this aspired mission. More than academic, our approach of imparting education should be technical or practically-oriented.

The sheer motivation in the students in conjunction with our steady and sincere effort can only materialize our vision. I firmly believe that this college obviously makes some headway in this direction.

Even in its inception, the journal heralds a promising future in its attempt to embody articles purely related to the practical dimension of science and engineering. I extend grateful thanks to the authors who have contributed and wish the time to time contribution and direction from all the readers. I equally welcome all the well-wishers and benefactors to participate and initiate us in such constructive activities.



Lava Raj Bhattarai
Chairman
Nepal Engineering College

July, 1995
Kupondole

Message from the Principal

Nepal Engineering college, established with the sole aim to impart quality education, has come before the readers with this first issue of SCITECH, a biannual journal on subjects related to science and engineering. We feel that along with the formulation and implementation of innovative educational strategies our dynamic and disciplined energy should be equally directed to some other creative and constructive activities. We firmly believe that nec will certainly prove itself as a milestone in this direction.

Although the first publication, the periodical essentially attempts to make a significant move forward by comprising articles entirely focused on science and technology. The advisory panel of SCITECH welcomes and is always pleased to consider for publication of articles which could further the journal's mission to illuminate the practical aspects of modern technology. For this, we request all the readers to make healthy suggestions and significant contributions from their respective areas. We hope the envisioned objective to make this a journal of international standard will be fulfilled through our initiative and drive.

Bhattarai
Deepak Bhattarai
Principal
Nepal Engineering College

July, 1995
Kupondole

nec News Brief

Seminar and Workshops

The following seminars/workshops were held at *nec*.

Seminar on "Implementation of Development Projects in Nepal", a Ph.D. proposal to be submitted by Deepak Bhattarai, on April 30, 1995

Seminars on teaching B. E. students:

- a. Mathematics I on Dec. 9, 1994
- b. Communication I on Dec 16, 1994
- c. Physics on 15, 22 May 1995
- d. Civil Engineering Material on 25th May 1995
- e. Mathematics II on June 2, 1995

Special Talk Program

Prof. Asha Ram Shakya delivered a talk program on Lord Buddha's life and his teachings on May 14, 1995.

Trainings

One month's training on *Scaffolding* for two batches were conducted from 20 May to 30 June, 1995.

Full Time Faculty Members

The following individuals joined the college as full time faculty members:

1. Mr. R. N. Paudel as lecturer in Mathematics on 25th Sept, 1994
2. Mr. N. R. Chaulagain as lecturer in English on 25th Sept., 1994
3. Mr. H. K. Shrestha as lecturer in Hydrology on 9th Oct, 1994
4. Mr. R. K. Neupane as Computer Instructor on 13th Nov. 1994
5. Er. N. P. Bhandary as Asst. lecturer in Civil Engineering on 27th Nov., 1994

6. Er. K. Bhagat as Asst. lecturer on 1st Dec., 1994
7. Er. R. C. Gautam as Asst. lecturer in Civil Engineering on 1st Dec., 1994
8. Er. S. K. Karki as Education Officer on 10th Apr., 1995

Part Time Faculty Members

The following joined the college as part time faculty members:

1. Mr. P. J. Tamrakar in Drawing in Nov. 1994.
2. Mr. P. N. Shrestha in Mathematics in Nov. 1994.
3. Mr. R. K. Yadav in English Nov. 1994.
4. Mr. B. K. Parajuli in Drawing in Oct. 1994.
5. Ms. S. Poudel, in Chemistry in Sept. 1994.
6. Ms. S. Shakya in chemistry in Sept. 1994.
7. Ms. P. Shrestha in Chemistry in Nov. 1994.
8. Mr. S. O. Bade Shrestha in Workshop Technology in Nov. 1994.
9. Mr. K. Maharjan in Workshop Technology in Sept. 1994.
10. Mr. N. B. Maharjan in Physics in March 1995.
11. Mr. S. Risal in Physics in March 1995.
12. Dr. N. H. Joshi in Physics in March 1995
13. Mrs. H. Yami in Engg. Materials in March 1995.
14. Mr. P. Dhital in Machine drawing in March 1995.
15. Mr. S. Risal in Machine Drawing in March 1995.
16. Dr. S. K. Mishra in Mathematics in April 1995.
17. Er. S. K. Shrestha in Computer on 9th April 1995.

Distinguished Visits

1. Hon'ble Minister for Education and Culture visited the college in Feb 23, 1995 and provided valuable directions.
2. Dean of Institute of Engineering visited the college on 27th Oct. 1995 and provided valuable directions to the college.

Outside Visits of Faculty

Mr. Deepak Bhattarai, Principal visited New York, USA in January, 1995.

Mr. Deepak Bhattarai, Principal visited Finland in June, 1995.

Student Activities

NESCO - "Nepal Engineering Students Council" has been formed on 21 April 1995. with Mr. Vijay Gurung as its first president.

B. E. (I) students visited the new Bagmati Bridge at Thapathali on 15th May 1995.

B. E. (I) students visited Nepal Tar-Mahadev Khola Bridge, Balaju, Kathmandu on 10th Feb. 1995.

B. E. (I) students of *nec* visited Arniko Highway Maintenance Project, Dolalghat, Kavre on 23rd May 1995.

Various Extra curricular Activities were organized in June 1995 on the occasion of first College Anniversary Day Celebration.

Farewell

Er. Manohar Rijal, Asst. Lecturer at *nec* joined Dept. of irrigation in March, 1995.



With Best Wishes
to
NEPAL ENGINEERING COLLEGE
on
The Auspicious Occasion
of
Fiurst Anniversary Day.



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Solid Waste from Industry - A Valuable Mineral Resource for Construction Industry

- Dr. Govinda Prasad Regmi*
- Tanka Prasad Gautam**

Introduction

The present research paper embraces a wide range of questions on research and development of cost effective and environmentally friendly building materials. Portland cement is reliable and easy to use. But in several cases it is not appropriate for particular type of work. On the other hand, it is expensive and inaccessible because of its shortage and high cost. It is apparent that there is a need of developing alternative binding materials and components based on locally available materials. At the same time construction industry in Nepal is facing acute problems because of the conventional materials which are increasingly becoming expensive and rare. Therefore Research Center for Applied Science and Technology (RECAST) has been giving priority to R&D works on the cost effective and technically reliable building materials for few years.

Among the various sources of indigenous construction materials, industrial wastes can also be considered. Rational application of industrial wastes in the construction industry should be instrumental in preserving degradation of

environment and production of cost effective, durable construction materials and products. Recently, principally wastes are in the state of solid and liquid generating from the industries producing paper, sugar, carpet, rubber, rice mill and so forth. It is estimated that there are about 500 cottages to intermediate industries where rice husk is used as fuel on large quantities. By virtue of combusting rice husk in furnaces, considerable amount of rice husk ash (RHA) has been accumulated on disposal area of industries.

The main constituent of RHA is silica in amorphous and crystallic state which is hydraulic active mineral and reacts with lime in normal temperature and creates cementing property. Obviously, optimum combination of RHA and lime is a hydraulic binding material that can be substituted or complemented for more expensive Portland cement. The optimum amount of lime and RHA is found by experiment. Moreover, RHA is an excellent mineral resource for production of no-fire light weight aggregate, autoclaving and normal hardening cellular light weight concrete, lime silicate brick, soil stabilization and microfiller to cement mortar and concrete.

* Dr. Regmi is engaged in RECAST, T.U., Kirtipur.

** Mr. Gautam is a Ph.D. student on study leave from IoE, T.U.



Fig 1. A Typical disposal area of RHA.

It is estimated that every year about ten thousand tons of RHA from various industries get accumulated on disposal areas. Their practical utilization has not been found so long. Realizing the imperative need, efforts are being made by RECAST to explore the possibilities of converting RHA into valuable mineral resources to the construction industry.

Scope and Details of Present Investigation

The construction industry in Nepal has not been popular in using RHA in spite of the many advantages it offers. The major factor of not using RHA is the variation in its quality from different sources and inadequate research works carried out in this field. The present paper makes an effort to prove that the wastes from one activity is supplementary to the construction industry. In order to achieve cost effective and technically reliable building materials from RHA, the present study was undertaken to combine the different techniques for optimal design of lime and cement based materials.

I Lime based materials :

1. Study of lime/RHA to the extent of 10/20 to 70/30 percent by weight;
2. Study of lime/RHA mortar;
3. Study of light weight cellular concrete from RHA;
4. Study of no. fire light weight aggregate from RHA;
5. Adontation of accelerating curing techniques (autoclaving, heat treatment) of components from RHA.

II Cement based materials :

1. Mortar and concrete with RHA as partial replacement of cement and sand to the extent of 40 percent by weight;
2. Use of accelerating and mortar reducing admixtures to mortar and concrete based on RHA.

Materials used for laboratory experiment

Cement: Ordinary Portland cement produced by Hetauda Cement Factory conforming to NS 49-2041. The properties of the cement are given in table 1.

Table 1. Physical properties and chemical composition of used cement.

Physical Properties	Chemical Composition
Specific gravity. 3.10	CaO - 61.27%
Fineness. (Blain) 3260 cm ² /gm.	SiO ₂ - 22.28%
Setting time :	Al ₂ O ₃ - 4.78%
Initial setting - 160 min.	MgO - 3.53%
Final setting - 225 min.	SO ₃ - 2.07%
Normal consistency - 27.3%	Na ₂ O - 0.38%
	K ₂ O - 0.93%
	LOI - 1.48%
	IR - 0.58%

Lime: The hydrated pulverised lime manufactured by Agricultural Lime Industries, Kathmandu conforming to NS - 09-036 was used. The properties of lime are given in Table 2.

Table: 2 Physical properties and chemical composition of used lime

Physical Properties	Chemical Properties, %
Color - white	CaO - 78.01
State of aggregation - powdery and soft.	SiO ₂ - 6.12
Hydrochloric acid test - gel formed is not quite thick.	MgO - 2.0
Specific gravity - 2.35	Al ₂ O ₃ - 0.85
Normal consistency - 38.40%	Fe ₂ O ₃ - 0.88
Setting time:	SO ₃ - 0.33
Initial - 18 hr. 20 min	Na ₂ O - 0.29
Final - 32hr. 40 min	K ₂ O - 0.25
	LOI - 11.20

Fine and course aggregates: Bagmati river sand having fineness modulus of 2.54 and crushed quartzite of 20 - 10mm size coarse aggregate were used in the study.

Rice husk ash (RHA):

The research work was carried out on RHA available from:

- Balkhu carpet dyeing factory, Kathmandu.
- Bhrikuti pulp and paper Factory, Gaidakot, Nawalparasi,

c. Shankar rice and chiura udhyog, Manigram, Rupandehi

d. Kalika rice and chiura udhyog, Butwal.

The collection stations were selected according to combusting technologies used by industries. Collected RHA from disposal areas of above mentioned industries were oven dried and ballmilled for 45 minutes to obtain fine powder. The physical and chemical properties of RHA from different sources are given in Table 3 and 4.

Table 3. Chemical composition of RHA, %

S.N	Sources	ISO ₂	Al ₂ O ₃	Fe ₂ O ₃	CoO	MgO	SO ₃	Na ₂ O	K ₂ O	LOI
1.	Balkhu Carpet Dying Factory (RHA from disposal area)	77.30	1.78	1.24	0.68	0.82	0.25	0.28	0.95	10.66
2.	(RHA from furnace)	86.80	0.95	1.14	0.95	0.69	0.31	0.21	1.03	3 11
3.	Bhrikuti Pulp and Paper Factory, Gaidakot	85.40	1.03	1.61	1.41	0.68	0.15	0.15	1.51	7 82
4.	Shankar Rice and Chiura Udhyog, Rupandehi	80.13	1.70	0.72	1.68	1.00	0.09	0.20	1.84	12.94
5.	Kalika Rice and Chiura Udhyog	77.80	1.38	0.68	1.93	1.04	0.20	0.17	0.78	11.17

Table 4. Physical properties of RHA.

1. Specific gravity - 2.58
2. Fineness:
 - Residue retained on 150 mk sieve %, 1.16
 - Residue retained on 75mk sieve, %, 10.26
3. Bulk density - 840 kg/m³
4. Lime reactivity - 44 - 67 kg/cm²
5. Lime absorption 48 - 69mg/gm

Chemical admixtures were purchased from the local market and ordinary tap water available from the RECAST reservoir was used for the testing.

Experimental Results :

1. RHA with Lime :

The tests were carried out to identify suitability of the RHA for use as pozzuolana which include chemical analysis, lime reactivity, absorption of lime, setting times, fineness and pore distribution, compressive strength and behavior of materials in aggressive (acidic) medium. The hydraulic property of RHA was identified by absorption of lime. The absorption of lime by RHA in contact with saturated calcium hydroxide solution (PH=12.45) was determined by titration. The absorption values of different RHA during 28 days made in the vicinity of 48-69mg/gm.

The initial and final setting times were carried out with the help of vicat's

apparatus. The normal consistency pastes of RHA/lime and RHA/cement were prepared to identify setting times, and results from setting times test have been reported on fig.2 and 3. From the given results, the combination of 20 percent lime and 80% RHA shows the minimum value of setting process. At the same time, an effort was made to regulate setting times by using accelerating admixtures and the results satisfy statement of the question on setting times.

Compressive strength was tested on cylindrical specimens of 50x50 mm for lime/RHA and cement/RHA pastes, 70.5mm cube specimens for lime/RHA and cement/RHA mortars and 100mm cube specimens for cement/RHA concrete. All specimens were casted on a standard vibrating table and cured under water kept in a room temperature and tested after 7,28,90 and 360 days in saturated condition. Typical crushing strength results are presented in Tables 5, 6 and 7.

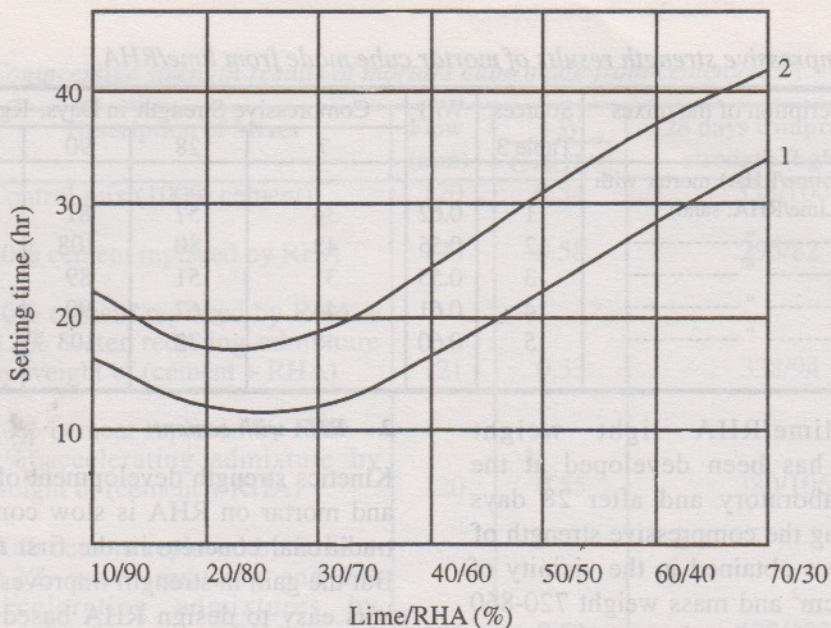


Fig. 2 Initial and final setting times of Lime/RHA paste with different combinations.

1. Initial Setting, 2. Final Setting

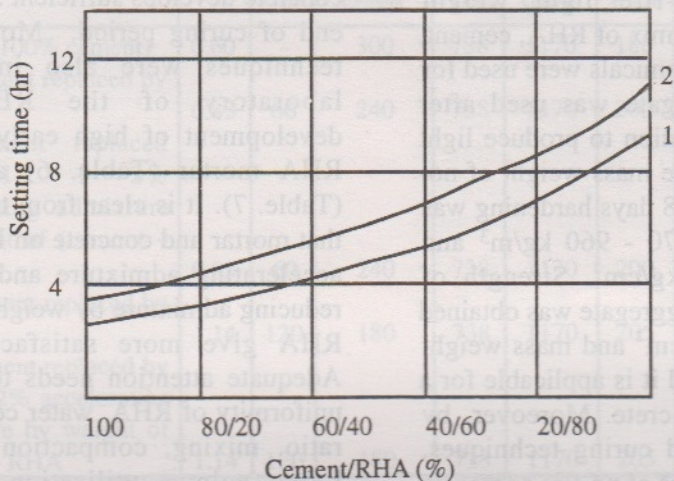


Fig. 3 Initial and final setting times of Cement/RHA paste with different combinations.

1. Initial Setting 2. Final Setting

Table 5. Compressive strength results of mortar cube made from lime/RHA.

S.N.	Description of the mixes	Sources Table 3.	W/B	Compressive Strength in Days, Kg/cm ²			
				7	28	90	360
1.	1/5 (Lime/RHA) mortar with 1:3 (Lime/RHA: sand)	1	0.62	34	57	81	160
2.	----- " -----	2	0.55	42	80	108	175
3.	----- " -----	3	0.55	31	51	89	181
4.	----- " -----	4	0.61	44	62	90	165
5.	----- " -----	5	0.60	48	72	103	169

Cellular lime/RHA light weight component has been developed at the RECAST laboratory and after 28 days normal curing the compressive strength of products were obtained in the vicinity of 32....48 kg/cm² and mass weight 720-860 kg/m³. By using chemical admixtures or heat treatment, there can be significantly improvement in physico-mechanical properties of cellular components.

RHA is an excellent raw materials for production of no-fire light weight aggregate. A proper mix of RHA, cement, lime, gypsum and chemicals were used for this, and the aggregate was used after water-stream granulation to produce light weight concrete. The mass weight of no-fire aggregate after 28 days hardening was in the vicinity of 770 - 960 kg/m³ and strength 38 - 62 kg/cm². Strength of concrete on no-fire aggregate was obtained within 75 - 265 kg/cm² and mass weight 960 - 1675kg/m³ and it is applicable for a structural grade concrete. Moreover, by adopting accelerated curing techniques, strength and properties of no-fire aggregate and concrete based on it were significantly improved.

Autoclaving process was the most effective method to improve physico-mechanical properties of lime/RHA and cement/RHA based components.

2. RHA with cement:

Kinetics strength development of concrete and mortar on RHA is slow compared to traditional concrete in the first few days. But the gain in strength improves later and it is easy to design RHA based concrete which will have the same strength as the control mix adopting replacement of 20 to 30% cement. The initial development of lower strength at early age does not make any difficulty in construction as RHA concrete develops sufficient strength at the end of curing period. Moreover, some techniques were also introduced at laboratory of the RECAST for development of high early strength on RHA mortar (Table. 6) and concrete (Table. 7). It is clear from tables 6 and 7 that mortar and concrete on RHA with 2% accelerating admixture and 0.2% water reducing admixture by weight of cement + RHA give more satisfactory results. Adequate attention needs to be paid on uniformity of RHA, water cement + RHA ratio, mixing, compaction and curing. Large volume utilization of RHA in structural grade concrete technically and economically feasible as it gives good workability, increases strength and durability and improves the overall long term performance of concrete and mortar.

Table. 6: Compressive strength results of mortars cube made from cement/RHA.

S.N.	Description of Mixes	Flow (mm)	W	28 days compressive strength (kg/cm ²)
			C+RHA	
1.	Control mix (100% cement)	120	0.54	358/100
2.	30% cement replaced by RHA	120	0.58	295/82
3.	30% cement replaced by RHA + 0.2% water reducing admixture by weight of (cement + RHA)	121	0.53	338/94
4.	30% cement replaced by RHA + 2% accelerating admixture by weight of (cement + RHA)	120	0.55	380/106
5.	30% cement replaced by RHA + 0.2% water reducing and 2% accelerating admixtures by weight of (cement + RHA)	122	0.52	435/122

Table .7: Compressive strength results of RHA concrete cube at 28 days curing.

S.N.	Description of mixes	W/C	Materials for 1 m ³ mix (Kg/m ³)					Mass Weight (Kg/m ³)	Comp. Strength Kg/cm ²
			RHA	Cement	Sand	Gravel	Water		
1.	Control (100% cement)	0.60	-	300	738	1170	180	2325	192/100
2.	20% cement replaced by RHA	0.83	60	240	738	1170	200	2330	186/97
3.	20% cement replaced by RHA + 2% accelerating admixture by weight of (cement + RHA)	0.83	60	240	738	1170	200	2324	221/115
4.	40% cement replaced by RHA	1.14	120	180	738	1170	205	2282	149/78
5.	40% cement replaced by RHA + 2% accelerating admixture by weight of cement + RHA	1.14	120	180	738	1170	205	2305	194/100

An important characteristic of cement/RHA materials is their superior stability in acidic environment. Cylindrical specimens made from cement /RHA paste containing 10 to 30% of RHA by weight were submerged continuously for a period of

180 days in solution of 5% HCl. In the 5% solution the control specimens were registered 18.5% weight loss but for specimens with RHA the loss of weight was only 8.4 to 12.3%.



Fig. 4. Testing specimens on durability in 5% solution of HCl

Conclusion

Rice husk ash (RHA) from boilers and furnaces is a valuable mineral resource or production of lime base components (lime puzzolana binding materials, cellular light weight concrete, autoclave hardening product, no-fire light weight aggregate, soil stabilization) and mineral admixtures

to cement concrete and mortar in reverse of cement and sand, to improve rheological and physico-mechanical properties and consequently durable and low cost concrete. Experiments show that materials from RHA are highly resistant in aggressive (acidic) medium. □

PHOTOVOLTAIC HOME

- Nanda Bahadur Maharjan*

Introduction

Here the Photovoltaic Home means a home with photovoltaic panels fitted on the roof of the home for the conversion of solar energy into electrical energy to use in the same home. The photovoltaic cell converts sun light directly into electrical energy. The electricity thus obtained is in the form of direct current which is used to charge a rechargeable battery for the storage of energy. The D.C. current from the battery is fed into the inverter which changes D.C into A.C. The A.C current is stepped up or down to the required voltage by a transformer. Finally, the electrical instrument is joined on the terminal of the transformer.

Here the discussion on the following topics are done -

- a. Sun, the extremely large source of energy.
- b. Brief theory of photovoltaic cells
- c. Photovoltaic energy as clean energy over petroleum and biomass energy.
- d. Photovoltaic home cost estimate for 5 member family.
- e. Some photovoltaic homes in Japan.

a. Sun, the extremely large source of energy

Sun is the source of energy. The energy received on the Earth from the sun is about 1340 Wm^{-2} (1). The total energy radiated by the sun is 3.92×10^{26} watts(1).

The total energy received by the earth from the sun is about 1.7×10^{17} watts (radius of earth $R = 6.4 \times 10^6 \text{m}$). So the solar energy falling on the earth is only tens of billionth part of the energy that the sun is emitting. Yet this energy just for an hour is equal to the amount of energy consumed in a year in the world. Total global consumption of energy is about 1×10^{10} kw (2). Hence the total solar energy on the earth is approximately 17,000 times the global consumption. If we use this solar energy by some means the energy problem of the earth could be solved.

The vast amount of energy from the sun is due to the fusion of hydrogen into helium. In the fission process the energy is released when a heavy nucleus is split into two lighter nuclei. The total amount of energy released by one kilogram of uranium fissioned is about 2×10^7 kwhr. The fusion case is the reverse of fission in which lighter nuclei are fused together to form the heavier nucleus. When 4 atoms of hydrogen is fused to form a helium nucleus, the mass of helium nucleus is less than the total mass of individual hydrogen atom from which it is formed. The loss of mass is converted into energy ($E = m.c^2$) (3). The Sun is composed of about 90% hydrogen, 8% helium and only 2% of the heavier elements. The temperature of photosphere is about 6000°C , while the temperature of the interior is 13000000°C .

* Mr. Maharjan is Lecturer in T.U., Central Dept. of Physics.

At this temperature thermonuclear reaction occurs in which hydrogen is converted into helium. One kilogram of hydrogen when converted into helium produces approximately 9×10^{13} watts(2).

To produce 3.92×10^{26} watts by the sun, 4.3×10^{12} kg of hydrogen will have to be converted into helium every second. The mass of the sun is 2×10^{30} kg so the time required to convert the whole hydrogen of the sun into helium is 14000,000,000 years. So the energy from the sun will be received on earth for tens of billion of years again. This vast amount of energy is in front of us to use it. Now it is our work to utilize these solar energy for the development of mankind. Scientists found one way of converting solar energy into electrical energy which can be used at our will by the use of photovoltaic cells.

b. Brief theory of photovoltaic cells

Pure silicon and germanium are called intrinsic semiconductor. Silicon is found in large quantities. So it is widely used in semiconductor devices. When some impurities are doped with pure silicon, it is called extrinsic semiconductor. The pentavalent atoms like Arsenic, Antimony and Phosphorous called donor atoms when added to the molten silicon the number of free electrons in it increases. Such silicon is called N-type semiconductor. Similarly, if one of the trivalent impurities like Aluminium Boron and Gallium are doped in the pure silicon, the number of holes in it increases. Such semiconductor is called P-type semiconductor. The N-type or P-type semiconductor can be manufactured in any shape. The widely used photovoltaic

cell semiconductor is manufactured in 10cm x 10 cm crosssectional area ingot by electromagnetic casting. The typical electromagnetically cast ingot is shown in fig. 1.

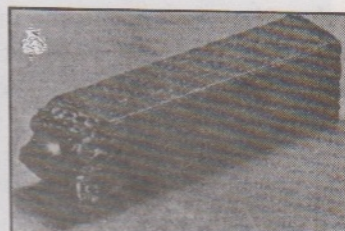


Fig. 1 Electromagnetically Cast Ingot

The N-type silicon is cut 0.1mm thick while P-type semiconductor is cut to 0.3mm thick. The cutting machine is shown in fig. 2.

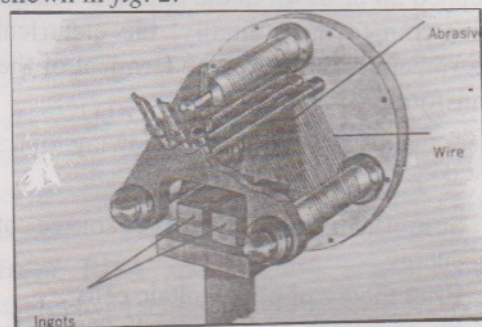


Fig.2 Multi wire saw for Ingot cutting

Both of them are joined together to form a P-N junction of 0.4mm thickness. This is then called a diode.

This diode is called a photovoltaic cell or solar cell. One of the types of photovoltaic cells manufactured by Showa Shell Sekiyu K.K., Japan, whose dimensions are 100 mm x 100 mm x 0.4 mm is shown in fig.3. This cell produces 3A current and 0.5V potential difference (1.5 watts) when it is illuminated by bright sun light.

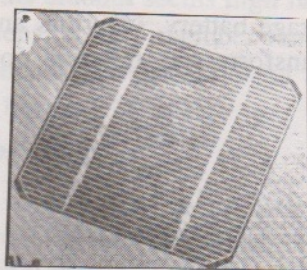


Fig.3 Single Photovoltaic Cell

When a photovoltaic cell is exposed with the N-type semiconductor towards the sun the photon coming from the sun strikes electrons of the N-type semiconductor. The electron absorbs the photon and it becomes free to move. If a conductor is joined into the N-type and P-type semiconductor, the free electrons move from N to P via the conductor. The movement of electrons from one place to the next is said to be the generation of current. *fig. 4.*

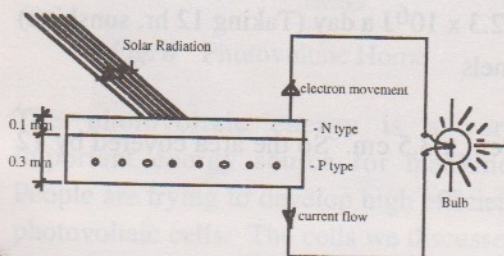


Fig.4 Principle of Photovoltaic Cell

The photovoltaic cells can be connected in series and parallel to produce the required amount of the current and voltage.

A high efficiency power module GL136 of Showa Shell Sekiyu K.K. Japan has 36 photovoltaic cells in series which gives 53 watts 3.05A and 17.4 v. *fig 5.* This is called a photovoltaic module. Such module

can be installed on roof to produce required electrical energy.

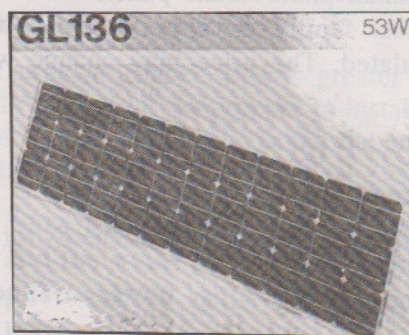


Fig. 5 Photovoltaic Module

c. Photovoltaic energy as clean energy over petroleum and biomass energy and lasts for extremely long time

In these days we talk about the bad effect of air pollution around the world. The air pollution in Mexico due to petroleum product in 1994 compelled people to carry the oxygen cylinders to breath the fresh air. Combustion of fossil fuels is accompanied by production of gasses such as carbon dioxide and nitrogen dioxide. These gases have a harmful effects on the earth atmosphere. People are very much in trouble due to air pollution caused by combustion of petroleum products and biomasses.

Solar energy does not involve such a gas production and is very clean. So solar energy can be considered as a clean energy.

Petroleum product has the life period of 43 years, coal 174 years, natural gas 56 years, and uranium 66 years (2). However, solar energy will last for 1.4×10^{10} years.

d. Photo voltaic home, cost estimate for a 5 member family

To install photovoltaic panels for a five member family the approximate cost is calculated. The price may change with

time. Here only the cost of photovoltaic panels, the storage battery, invertors and the step up transformer installation cost are estimated :

Assumptions:

A five member family needs energy for the following items for a day -

	power	Time	Total Energy needed
1. Cooking meals	- 1 kw	3 hr.	3 kwhr = 1.08×10^7 J
2. Lightning 5 rooms	- 0.1 kw	5 hr.	2.5 kwhr = 9×10^6 J
3. Water pump	- 0.5kw	0.5 hr.	0.25 kwhr = 9×10^5 J
4. Fans, computer			
Television, radio	- 0.1kw	3 hr.	0.3 kwhr = 1.08×10^6 J
5. Freeze	- 0.04kw	24 hr.	0.96 kwhr = 3.5×10^6 J
6. Geysers	- 2kw	0.5 hr.	1 kwhr = 3.6×10^6 J
Total energy needed			7 kwhr. = 2.8×10^7J

A photovoltaic panel produces 53 watts (GL136) = 2.3×10^6 J a day (Taking 12 hr. sunshine)

$$\text{No of panels required} = \frac{2.8 \times 10^7}{2.3 \times 10^6} = 12 \text{ panels}$$

The size of 1 panel is approximately 129 cm x 33 cm x 3.5 cm. So the area covered by 12 panel on the roof is = 5m²

Weight of each panel is 6.2 kg

Total weight on roof by panels = 74 kg

Total cost estimation

	Each (NRs)	Total (NRs.)
1. Cost of panels (12)	= 15,000	180,000
2. Storage battery (18)	= 1,000	18,000
3. Invertor (1)	= 10,000	10,000
4. Transformer (1)	= 10,000	10,000
5. Cables (1)	= 5,000	5,000
6. Installation cost	= 12,000	12,000
Total		235,000

This amount seems high in the context of Nepal for a 5 member family. But if we calculate electrical bill for about 15 years, it becomes cheaper.

Installation

It was found meteorologically that the angle of inclination of the photovoltaic panel should be equal to the latitude of that place which is called the *tilt angle*. The twelve panels are kept on roof in series with tilt angle equal to about 30° in Kathmandu. *fig 6*.

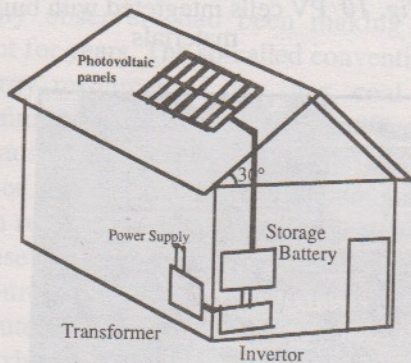


Fig. 6 Photovoltaic Home

The photovoltaic energy is a very important energy source for mankind. People are trying to develop high efficient photovoltaic cells. The cells we discussed above are only of 12% efficient. There are many homes in Japan completely powered by photovoltaic energy. In many countries the target is to use solar energy by photovoltaic cells. In my opinion, there will be 95% photovoltaic homes in the world during 21th century. There will be very few hydro electricity, very few generators which are run by petroleum product. The cars, bus, train etc. will be run by photovoltaic energy. If we

displayed 8×10^{10} m² area by photovoltaic panel it would create sufficient energy for the whole world. This area is 1/6250th part of the total area of world.

The area of the deserts is greater than 8×10^{10} m². So if we propose to install the photovoltaic cells in the desert the energy for the whole world can be solved.

e. Some photovoltaic homes in Japan and the water pumping in Nepal by photovoltaic cells (Sundarighat, Kirtipur)

There are many photovoltaic homes in Japan. Some of the photovoltaic homes are shown (2) below :

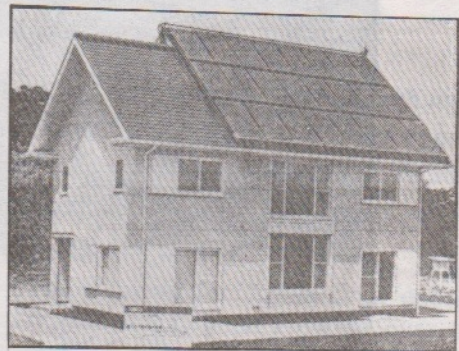


Fig. 7. A private photovoltaic home



Fig. 8. High inclination PV-Home

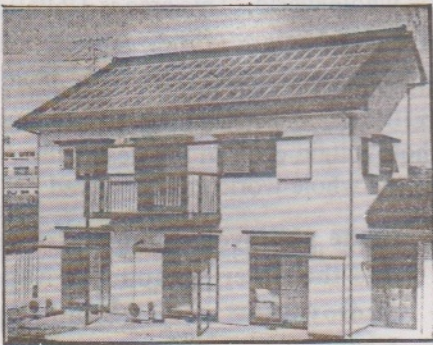


Fig. 9. Private PV-Home

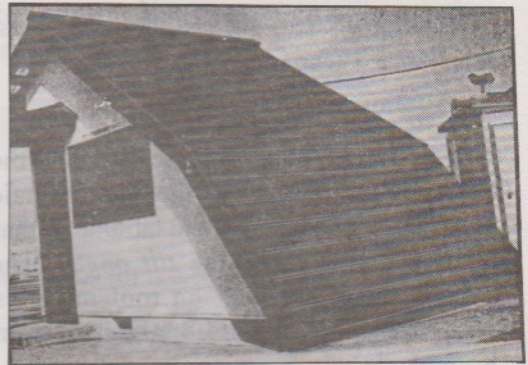


Fig. 10 PV cells integrated with building materials



Fig. 11. Photovoltaic Water Pumping at Sundarighat, Kirtipur, Kathmandu (Nepal)

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RENEWABLE ENERGY - A DIVERSE SOLUTION

- Tri Ratna Bajracharya*

Introduction

Only after the first oil crisis of the early seventies, the significance of energy for sustained growth and importance in physical quality of life of human beings came to the forefront of national, regional and global policy planning exercises. Basically, the oil importing developing countries of the world have been facing multifaceted problems due to the oil crisis. Many observers had been making this point for years. The so-called conventional energy resources of oil, gas, coal and uranium are finite and will, therefore, be exhausted at some time in the future. Major debate goes on as to the amount of each resource available, the projected rate of use and, therefore, the time when the resources will be exhausted. No one disputes, however, that the resources will be exhausted. Now, the energy crisis has become further complex due to a variety of adverse ecological and environmental impacts associated with the excessive use of fossil fuels.

If these consumable resources are to be exhausted in the future, where shall we find our energy? Aside from technologies not yet proven such as fusion, the answer must lie in renewable energy sources such as geothermal energy and solar energy, including its various forms: wind, wave, offshore thermal energy conversion, biomass conversion as well as the more direct forms of thermal and photovoltaic conversion.

The use of renewable energy sources could not only meaningfully supplement the generation of power through conventional energy sources but also provide a viable option in a wide range of applications. As the new and renewable energy sources are locally available, they provide clean energy and help preserve the environment and ecology. Their development and utilization will change the complexion of rural areas, improve the quality of life and provide dependable power supply to rural and urban people.

Energy problems of developing Countries

There are some characteristics which make the main and rather similar energy problems of the developing countries drastically different from those of the developed countries.

1. The demand for commercial energy resources has been growing over the last 25 years, twice as fast as in developed countries.
2. Among the commercial energy sources, developing countries use proportionally more petroleum than developed countries.
3. The per capita consumption of commercial energy in developing countries is much lower than in the developed countries, and has to increase substantially if some basic development goals are to be achieved.

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4. Developing countries use very large amount of non commercial and animate energy.
5. Energy investments for the coming years have been forecast to require a larger share of gross capital formation in developing countries than in developed countries.
6. Developing countries have different basic conditions regarding costs of capital and labour, distributions of skills, and patterns of social organization than developed countries.

These characteristics make it necessary for developing countries to seek approaches and solutions to their energy problems that have to be different from those of the developed countries. In this respect, the expected gradual economic development of these countries will permit the optimization of their overall energy planning including *built in conservation* and substitution measures as well as the utilization of renewable energy resources.

Status of Renewable Energy / Technology in Nepal

Nepal is endowed with various renewable sources of energy. Among them hydropower is one of the richest and most useful one.

Micro Hydro

The hydropower stations for the generation of only mechanical energy and as well as electrical energy up to a capacity of 100KW come under micro-hydro in Nepal. The HMG has delicensed the installation of hydropower plant up to 1000 KW. The total existing capacity of all micro-hydro turbines in Nepal is about 7 MW. The

progress in MicroHydro development was quite significant during the eighties when government provided some funds as subsidy for rural electrification.

Solar

The geographical location of Nepal is favorable for the utilization of solar energy. It is traditionally used for drying crops, clothes, fuel wood, crop, residues, etc. The technological intervention started only in the sixties with the production of domestic solar water heaters. At present, the demand for solar water heaters is steadily growing.

The active solar collector, photo voltaic in remote communications, solar photo voltaic based rural electrification have been carried out by Nepal Electricity Authority in three different locations whose total installed peak power is 130KW. The other main users of pv systems are Nepal Telecommunication Corporation, Civil Aviation of Nepal and Agricultural Development Bank of Nepal has installed five solar pv sets for water pumping for irrigation purposes.

Wind

The northern mountainous belt of Nepal is best for wind energy. But in the lack of data wind energy in Nepal is still not popular. Efforts should be made in this regard to identify favorable sites to harness wind energy and to collect and maintain reliable data.

Biomass

Biomass is a renewable source of energy conversion of biomass to oil, natural gas or any other liquid or gaseous fuel which can substitute the role of oil as a source of

energy and as a feed stock for chemical, and petrochemical industries would provide us an alternative and infinite source which can replace the role played by oil as a convenient source of energy and of chemical feed stocks. Plenty of biomass can be made available by proper planning and management. The thrust was so far on the production of biomass as a source of wood, food and fibre from crops. With the advancement of biotechnology newer plants and tree species will be developed which can be grown in an multistoried lands, in factories or laboratories or in arid and semi-arid zones. The yield of biomass per hectare can be increased by using plant growth hormones and by employing genetic engineering and other techniques. The concept of petrocrops, fuel farming and biomass fuel conversion industries has to be developed further.

Plenty of biomass is available as rural, urban and industrial waste. Municipal waste containing organic materials can be incinerated to generate power. Human waste (nightsoil) can be converted into biogas. Cattle dung and agrowastes are also being used as raw materials in biogas digesters. Waste treatment has become one of the stringent requirements of the industries. Some industries generate toxic wastes which have to be treated chemically before subjecting the waste to aerobic or anaerobic treatments.

Biomass Briquetting

Biomass densification which is also known as briquetting of sawdust and other agro residues has been practiced for many years in several countries. Biomass briquetting improves the handling

characteristics of loose biomass for transport, storage and their combustion. This technology can help in expanding the use of biomass for energy uses such as for the industries that are dependent on wood coal and lignite, and also can help in improving the fuel situation in rural areas. Briquetting technology is yet to get a strong foothold in many developing countries because of the technical constraints involved and the lack of knowledge to adapt the same to suit local conditions. Many operational problems associated with this technology and quality of raw materials are crucial in determining its success for commercialization. In addition to its commercial aspect, the importance of this technology is leading to the destruction of forests.

Compressed rice husk briquettes entered into Nepalese market during 1980^s when Nepcoal Ltd., Butwal, started to produce rice husk briquettes. This system used a pyrolyzation process. Soon after, another factory was installed in Dharan. However, both were closed down due to technical difficulties and low demand for their products. In 1980/89, a factory at Chitwan was established using extrusion technology which do not used to pyrolyse the husk. Since then, four similar factories have been established these factories use either rice husks or saw dust as briquetting material. Dissemination of this technology has met with mixed success in Nepal.

Biogas

Biogas production technology is based on the phenomenon of biological decomposition of organic materials in the

absence of air. It reconciles two apparently conflicting objectives of getting from cattle dung and agricultural residues -

- a. Cheaper and better fuel for cooking, lighting and running engines, and
- b. Good quality manner to supplement and optimize the use of chemical fertilizers. Besides, many social and environmental benefits are also derived from biogas production.

Nepal, having the sufficient cattle population, offers a tremendous potential for the development of biogas. Over 13,000 biogas have already been set up. Biogas program has been seriously taken for promotion by the Government.

Geothermal Energy

Geothermal energy is the energy coming out of the molten interior of the earth towards the surface. The average rate at which this heat emerges is about 0.05 w/m² while the radial temperature gradient which causes this heat flow is about 0.03°C per metre. Thus, on an average, the temperature of the earth increases by 30°C per kilometre as one moves inwards. Because of non homogenetics in the earth's crust, there are numerous local hot spots just below the surface where the temperature is in fact much higher than the average value expected. Ground water comes into contact with the hot rocks in some of these locations and, as a result, either dry steam or wet steam and water are formed. A well drilled to these locations causes the dry or wet steam to emerge at the surface where its energy can be utilized either for generating electricity or for space heating.

In Nepal, geothermal resources over 50 hot springs in the form of hot water have been found. However, no firm estimates of their potential are available. By further studies, it may be possible to use the energy of hot springs.

Energy Policy

Energy policy of Nepal covered only hydropower and forestry sectors until the sixth five year plan. In the seventh plan the government started to attach due importance to the development of alternative energy sources. Government provided subsidies to those who installed micro-hydro turbines and biogas plants. Photo voltaic stationaries were set up at three places. Improved cooking stoves were distributed to promote them.

The energy policy has to be covered the following areas:

- a. Ensure management and sustainability of the present energy resources.
- b. Encourage and develop hydropower resources.
- c. Diversify the accessibility to socially viable areas.
- d. Encourage research and development of renewable energy sources.
- e. Encourage efficiency in energy production, transmission and consumption.

Energy Conservation

One of the major problems associated with energy conservation is the lack of capital investment on energy conservation measures. A project on energy conservation and boiler tuning program is going to be carried out by Ministry of Industry. Energy audits which were carried

out in the selected industrial plants proved the great potential for energy conservation in Nepal. The energy conservation policy should be developed with the following initiatives:

- a. Promote efficient energy use practices in all sectors of the economy.
- b. Encourage the use of energy efficient equipment though provision of fiscal incentives.
- c. Ensure adherence to energy efficiency standards.
- d. Substitute, wherever possible, local energy reserves for imported ones.

Energy Education

The benefits of new energy technologies and conservation techniques are widely appreciated by the people through the information dissemination and awareness on the energy demand scenario of a

country. In Nepal , renewable energy technologies and conservation measures have not made much headway in terms of development, adaptation and utilization due to poor information campaigns. The school curriculum in Nepal does not address energy education at all. Though elementary of energy conversion is taught in the engineering institutions, there is no institution involved in a formal training program in energy.

Conclusion

The energy demand management, development and mass level utilization of renewable energy technologies are the important remedial strategies for the developing countries. For the basic issues concerning the availability and sustainability of energy resources, energy education at all the levels is viewed as the only solution. □

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Best Wishes
to
NEPAL ENGINEERING
COLLEGE
on
the Auspicious Occasion
of
the First Anniversary 1995

Krishna Construction Co. (P.) Ltd.
Deep, Pokhara, Nepal

Land Evaluation for Irrigation Development in Nepal

- Sital K. Karki*

Objective

To concentrate irrigation on the most beneficial land and choose the best alternative.

Scope

Nepal has been suffered from either choosing wrong alternative or irrigating land of less priority or less suitability. So effort is made to develop a methodology through land evaluation. Various factors affecting the suitability of land are recommended to consider for data.

Limitation

General guidelines, the process and the physical factors discussed here need further discussions by a multi-disciplinary team.

Introduction

In this article, a possible process of land evaluation is proposed so that the land evaluation can be helpful to evaluate the land in both agricultural and engineering purposes. In irrigation suitability, more factors are recommended to be considered. Recommendation is made for guidance during land evaluation for irrigation development specially for the appraisal level. It provides an overview on the possible uses of land evaluation for optimal irrigation plans.

Principles of Land Evaluation

The major governing principles of land evaluation for irrigation are discussed as

Prediction : Prediction here is to predict the future soil-water-crop interactions expected after the land is irrigated. This may require further research work besides careful field/lab. studies of observable soil characteristics, qualities and other attributes. So certain suggestions can also be made along with the prediction of the problems.

Economic Correlation: It is to relate all the physical factors with economic value in terms of return and loss. The set of determining factors varies with time and place.

Permanent and Changeable Factors: It is to recognize that certain factors change and certain do not after irrigation. The change can be beneficial/harmful to one/another.

Arability-irrigability Analysis: Such analysis identifies the arable area with economically beneficial productivity and selection of area to be served e.g. eliminate those-costly to serve, cause problems to environment to an unacceptable level etc.[9]

Level of Evaluation

This includes appraisal, feasibility, advanced planning, special studies, post construction. It is essential to define the level, e.g. appraisal level.

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Planning Level in Nepal

National, river basin/watershed, project, farm level e.g. river basin which includes agricultural, hydropower, flood control, catchment protection, reclamation work. Thus river basin level planning involves choosing of alternatives for multi objective decision that can be referred to linear/non-linear programming.[11]

Method and Need of Irrigation

The suitable method varies with land, climate, crop etc[13]. It is important to define the method for land evaluation like the surface-gravity-perennial method. Fitting rainfed crop farming into an annual rainfall distribution known as crop calendar can locate the period and amount of water deficit[12]. A crop calendar or a crop itself can be changed with irrigation. Conventionally, the amount of water is calculated by estimating evapo-transpiration of defined crop at defined land at defined location considering various efficiencies, then subtracting from the dependable precipitation/ effective rainfall.[13]. So it needs climatological records and soil plant properties.

Objectives of Land Evaluation

- To concentrate irrigation facility to most productive land.
- To assess and accommodate problems created if any by irrigation.
- To mitigate the risk of failure of structures due to improper site.
- To mitigate the risk to environment.
- To choose an optimal irrigation plan (benefit - loss : not only financial).

Successful Irrigation

FAO(1968)[16]states " irrigation projects are complex agricultural development which requires the distribution of controlled quantities of water to suitable area of land, together with a large number of essentially complementary inputs to allow or increase crop production." The irrigation is further associated with why, where, what crop, what source of water, how distributed, how much, how applied. So planning of irrigation is said to involve: *Definiation of objective, selection of criteria, collection informations, evaluation alternatives and selection of optimal plan.*

The national level objective of Nepal is to provide higher nutrition to people to increase income from export and to save imports AF suggests: *integrated river basin development* and international agreements and water codes as factors involved. The first one is made the scope here the objectives of which to subordinate national objectives. The second one involves mostly Nepal-India that is outside the scope of this article.

Appraisal in River Basin

Various appraisals:

Water needs appraisal, future prospective, economical-financial, project layout, alternative design, EIA reconnaissance and additional studies appraisals.

Recommended Guiding consideration

"Soil and water management is a very complicated task to be done in a planned way not be trouble shooting"[19].

"Preparation of soil & water plans involves... potential hydro power,

recreation, water quality, bank protection, erosion etc." [20]

"Soil & land capability inputs.. will usually form a part of broadly based study at the pre-feasibility level. Time, area and

purposes decide intensiveness. The pedological aspect only considered when it decides much, otherwise looked for critical things.." [17] :

Aim & Level : Source inventory, project location prefeasibility.

Soil Study Intensity : Variable, Usually < one/ha.

Time Proportion : API = 60%, literature = 20%, field = 20%.

Preferred Scale : Airphotos <= 1:60,000.

Final Mapping Units : Potential dev area/river - basin/land system/physiographic units

Soil Study : Order to association.

Vegetation : Soil/ climate related type.

Land Use : agro-ecological groups.

Multy Disciplinary Team

Hydrologist & W. R. Engineer : to investigate water source & quality.

Civil Engineer : to propose the layout of the construction.

Agro-soil scientist : to provide information about suitability of land.

Climatologist : to predict and calculate irrigation need, schedules etc.

Agronomist : to plan the cropping of irrigated land, to predict/ prevent adverse changes due to irrigation.

Economist : to correlate financial cost-benefit etc.

Process Proposal

- Form a multi disciplinary team.
- Consider a river basin.
- Fix the level of evaluation.
- Obtain suitable mapping units. LRMP [21]
- Choose method of irrigation. Consider certain alternatives.
- Go to data inventory also decide attribute to be looked.
- Decide local diagnostic criteria for ranking. Data matrix GIS modern/manual [27]
- Interpret in terms of cost-benefit for each alternative.
- Choose optimal / suggest future study etc.

About the Data Matrix

Recommended here : linear combination model [14]

1. Determine the class or description of each sub-factor e.g. soil factor, sub-factor effective depth.
2. Convert sub-factors into 0 to 10 index. 0 for worst, 10 for best.
3. Decide weight for each factor.
4. Collect sub data matrix e.g.

<u>Sub factors of soil</u>	<u>Weight</u>	<u>Index</u>	<u>Score</u>
a	ws1	y	ws1*y
b	ws2	z	ws2*z
Total = 100			sum

5. Collect score of each factor, convert it into 0 to 10 index, determine weight of each factor, add score and classify or interpret e.g.

Physical factors:	Weight	index(0-10scale)	score:
Soil	ws	x	ws*x
Topography	wt	y	wt*y
So on.....			
Total = 100			total score = sum

Note: Procedure for both engineering and agricultural factors and their weight vary. Criteria can be as decided by the team (local) or FAO S1=10. Assigning a zero is very carefully done, any land having zero value for any subfactor may not completely be suitable by improvement also e.g. depth of soil.

Phycal Factors Recommendation to consider Major Soil Rigions and Soil Data

The major agro-soil regions can be grouped as follows as extracted from the soil map [1]. Grouping from south to north:

- Terai:** Southernmost productive plain belt of Nepal:
Eastern : Je 77-1/2 a
Central : Je 77-1/2a, Je 76-2a
Other Je 75-2a
- Siwalik :** A narrow strip hills and narrow to medium Dune valleys.
Eastern : Ah 12-2bc, Rd 30-2b
Other : Rd 30-2b
- Mountains & valleys :** Mahabharat range & valleys.
Mostly all : Bd 34-2bc.
- Himalayas :** Very high altitude, cold climate. I-Bh-U-C.

Region no.	Soil	Comparable FAO[2]	Association	Inclusion
1.	Je77 Fluvial Eutric	S1	Bh Gh	Ge HhRe
	Je76		Bh Hh U	Bc Lf
2.	Rd30 Regosols Dystric	S3	Qc Yk	Z
3.	Ah12 Acrisols, Humic	S6	Bh Nh	Bd G I
4.	Bd34 Cambisols Dystric	S3	Ao Dd I	Bh Be Go
5.	I Lithosols	S3		- -

1. They are mostly found in the cultivated and productive parts of the country. Rice, sugarcane, tobacco, jute are the most common crops. Farmers used to have rice-rice two crops during monsoon. Better water management is needed for increased production in terms of irrigation, flood control and drainage. Some parts develop plow pan. Some are feasible for ground water irrigation.
2. Initially it was covered with large forests. Now except the hills they are highly cultivated. It can be characterized with low moisture holding capacity, slope made of gravels. But soil in the valleys is found productive if proper irrigation is provided.
3. It is found in Ilam/adjoining to Darjeeling, India presently used as only tea producing region of Nepal. Hills, so suitable for sprinkle irrigation. Erosion factor is severe.
4. This region includes highly fertile valleys & high Mahabharat mountains. The pressure of population has made to cultivate in the high altitude also. Topography both in terms of altitude and slope are the important factors. Erosion problem is also important to be considered.
5. This region of Himalayas needs no explanation in irrigation.

It is not worthwhile to discuss soil regions for associations, inclusions, texture and slope as provided in the soil map [1] because it needs more systematic data. However, recommendation here is not to

go for more pedological study if data is not available and not critical. Because engineering soil properties available in connection to previous studies may contain the following informations which are recommended to be (for soil suitability to be irrigated) considered:

Effective soil depth [24]

Texture of surface

Soil permeability

Water holding capacity

Coarse fragments

Rock out crops

Salinity

Salt effects

Severity in alkalinity

For appraisal level all the soil characteristics may not need intensive study but should be looked on critical one.

Drainage

Subsoil Strata Drainage Characteristics:
In terms of no. month of water logging [17] e.g. depth : \no. of month to drain out : can be classified.

Outlets for Surface Drainage: Available can be classified.

Surface Drain Requirement: What size can work.

Depth of G. W. Table:

Irrigation Return Flow: Must be considered to lake or to river what happens to water quality ?

Erosion

Erosion status should be considered. It can be considered as explained by the status of water shade condition of Nepal, FAO/HMG [26]. It is not recommended to have dynamic modeling for appraisal level; for other levels it can be applied. [10]

Climate

The major agro climate in the context of south Asia [3] is explained as:

1. No. of wet months > 5, D. MO 5-6
2. No. of wet months = 4, D. MO 6-8
3. No. of wet months = 3, D. MO 7

If compared to FAO[2] all lie lower than R3. Further comment can be made Agroecological zoning [5] can be done with soil & climate regions but it is not much interpretive even for crop suitabilities because of many reasons like topo variation which is very high in Nepal.

Humidity and Temperature : They should be considered because it is important to know whether the irrigation scheme will affect the area adversely or positively.

Rainfall and Evaporation : They are important not only to evaluate for irrigation demand but also to evaluate certain discharge factors e.g. canal loses water or gets water.

Temporal Variation of Climate : It is also important in many ways to explain irrigation suitability and suitability of certain alternative layouts.

Topography

Elevation :

Class	Elevation(m)
1	<1000
2	1000-2000 LRMP
3	2000-2600
4	2600-3000
5	3000-4000
6	>4000

Micro : It should be considered. We generally follow ridge canal to get a high command and contour canals from head

works to ridge. So micro relief comes into the picture there as well as it tells wheather certain land is suitable to be irrigated or not without an unacceptable effort.

Slope and Aspect : FAO provides classification for slope and guidelines for their potential use. But for irrigation suitability of agricultural land it is recommended to break up further [17]e.g. <1% as class 1 so on. Canal slopes are the function of terrain slope and canal condition. This information is useful for the sheme also.

Surface Grading Required : Ranks the land in terms of extra input required after irrigation to level the land.

Land Use and Cropping Patern

Land use System of Nepal : It is broadly classified [23]. Like cultivated land without irrigation (presently) "L" can be ranked best for irrigation. But for facility layout it may not be ranked best.

Cropping Pattern : Rice may be ranked best for certain place.

Farm Water Requirement : A, B, C (low, med., high)

Water Source

Quantity of water available in relation to water demand should also be considered. for example a land can not be said best suitable, say S1, without considering the availability of water to irrigate it.

Qualitly of water available is important in terms of salinity level and turbidity, for example Seti river (Pokhara) irrigation project already experienced failure due to high turbidity of very fine clay.

Geology

"The physiography of Nepal is largely a reflection of the geology. Most rock formations comprise longitudinal zones which extend with marked continuity along the length of the country. Each of these zone has distinct elevations and terrain forms which relate not only to the bed rock but also to the tectonic history of the Himalayas." [6]

The geology of Nepal has been divided into many zones. Here is an overview of the fundamental studies held by the pioneers. The three major distinct types are:

Sub-Himalayas: The Siwalik and younger deposits, this is also further divided into 3 sub classes and studied by T. Hagen [7].". The characteristics explained is north-south directed dune valleys due to ancient rivers". Most of the agricultural land of Nepal lies on this zone.

Lower Siwalik: "an alteration of brown weathered sandstone and chocolate color clays. Occurs only in narrow zone of south most of central Nepal"

Middle Siwalik: "Form great cliffs of sandstone, conspicuous by their feldspar and mica content and apparently derived from granite rock..... lower part being calcareous concretions or lenses of coal. Most of the visible deposits belong to this."

Upper Siwalik: "Conglomerate with pebble and boulders of pale schistose, quartz, purple and white quartz, dark phylites, arkose, silty brown sandstone and tourmaline.....lack metamorphic rock."

Lower-Himalayas: Mahabharat Lekh, it lies on south of high Himalayas and north of sub Himalayas. It is characterized by mountainous terrain but it posses very fertile & well cultivated lands. Again referring to pioneers of himalayan geology [7]:

"It runs parallel to the MBF and still less understood..... missing stratigraphical control... Metamorphised obeying little understood rules.....so many unknown in the geology.... eastern Nepal as studied is summarized as Upper quartzite-lower phylites-lower quartzite - mica sheets (schist and gneiss) migmite.....North-south direction X-folding is remarkable."

Higher Himalayas : not considered here for irrigation purpose.

It is important to understand MBF and MCT [6]. The point which should be noted is to irrigate Terai also. Dam and reservoir are to be developed in the siwaliks or even in the north. It is interesting to share experiences as expressed by Mr. V. S. Krishnamurthy [8] in India for similar regions.

Upper Siwalik: "Due to low order of consolidation and cementation..... and interrelation of clay and shale beds, only Earth fill Dams possible."

Lower Siwalik: "Due to sandstone beds, capable for high concrete structure but large thickness of competent sandstone is generally not available for large concrete dams."

Mr. Krishnaswamy has discussed a number of experiences from many water resources projects which make one to think about geology while discussing irrigation. The point is that whatever the

land is, if we are unable to develop irrigation plan with a reasonable cost and technology, that land can not be classified as the most suitable one. Geology is important in another way in terms of ground water pollution and landslide hazards. So it must be considered for irrigation suitability and engineering capability of land. There has been many geological investigations in connection with many projects which can be used for data matrix as explained here.

Conclusion

There are still more physical factors to be considered which vary in time and place. The criteria for ranking or classification are also not static. Intensiveness can be varied with objectives and available resources. Land suitability classification can be made slightly broader during data collection which can be collected in the same data matrix later to inform land

evaluation for engineering use. Social and economic parameters are used to evaluate the physical parameters to interpret in simple social-economic terms. Evaluation must be referred at the time of evaluation. [vink] In this way land evaluation can help to choose optimal alternative in terms of cost or benefit for long terms & wider sense of benefits.

The method proposed here is basically concentrated on surface irrigation with gravity flow perennial and dam-gravity canals. However, it can be extended for other methods of irrigation by interpreting the parameters and criteria needed. Similarly, it can be extended to other than appraisal level. Also, Engineering capability of land to support canals, dams, reservoirs and other structures can easily be interpreted considering the factors like topography, geology, landform, climate and on. □

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The Ratio of Circumference to Diameter

- Rukmanath Paudel*

In early Hindu civilization the geometrical knowledge was acquired in connection with the laying out of temples and *mandapas*. The continuous exercise of these geometrical learnings later on appeared in a book form which is called *sulvasutra*. *Sulva* or *śulba* means the cord used to measure distances and *sutra* refers to rules or formulas. The experience related to days, nights, months and seasons developed a branch of science which is called *jyotiṣa*, the astronomy. Gradually, people needed a calendar for their religious, agricultural and social purposes. The primitive astronomical knowledges were compiled to the form of *vedāṅgajyotiṣa*.

The establishment of Gupta dynasty (319 A.D.) indicated the beginning of a renaissance in Hindu culture. In Indian history, the time under the Guptas is considered to be the golden age. In those times all the branches of science were rigourously cultivated and the *śulvasutra* and *vedāṅgajyotiṣa* were replaced step-by-step by the *siddhantas*, a system of astronomical theories.

The fall of the Western Roman Empire is supposed to occur in the year 476 A.D. In the same year, Aryabhata, one of the authors of ancient Hindu mathematical textbooks, was born. The eminent book of Aryabhata was named *Aryabhatīya* after him. A few names of Hindu mathematicians prior to Aryabhata are known and their works are frequently

quoted on ancient Hindu literature, but their original contributions are not found compiled in a book form. In this respect, the position of *Āryabhatīya* of Aryabhata amongst the Hindus is somewhat analogous to that of the *Elements* of Euclid in the West some centuries ago.

The *Āryabhatīya* is a brief descriptive work which includes several rules to find the results of arithmetical and algebraical problems and mainly the method of calculation used in astronomy. Generally no justification or deductive methodology is given by the author for the rules. Here, as elsewhere in Hindu learnings, the author has concentrated on how to compile his whole work into a few stanzas to make the book more easy to orate frequently. Hindu scholars gave emphasis to recite and learn their text books by heart, and, therefore, their works are inherited to generation to generation preserving the original script and language.

There are two basic schools of thought among mathematics historians. One school assumes that all ancient Hindu mathematics are heavily influenced by the Greek mathematics, and there are basically no original Hindu mathematical developments. The other school is of the opinion that the Hindu mathematicians developed most of their theories without much Western influence. This article, instead of siding with any school, attempts to present the development and use of the

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ratio of circumference to diameter of a circle in Hindu and Greek mathematics.

Gaṇitapāda, the mathematical section in *Āryabhaṭīya*, begins with the powers of ten up to the tenth place and then proceeds to give instructions for squares and cubes of integers. Then the rules of mensuration follow. The area of a circle is found correctly as the product of the circumference and half the diameter. The statement which narrates the ratio of the circumference to diameter, in *Āryabhaṭīya* is as follows

Add 4 to 100, multiply this sum by 8, and add 62,000 to this product. The result is approximately the circumference of a circle of which the diameter is 20,000.

(*Gaṇitapāda*, stanza 10)

It should be kept in mind that neither Aryabhata nor any other Hindu mathematician ever used any notation for the ratio of the circumference to diameter of a circle. In modern mathematics the Greek letter π is used as a single notation for the ratio of circumference to diameter. The definitive use of π , in this sense, is largely due to Leonhard Euler (1707-1783). Hereafter, in this article, π denotes the ratio of the circumference to diameter of a circle. Therefore, according to Aryabhata the approximation of π is

$$\pi = \frac{\text{circumference}}{\text{diameter}} = \frac{62832}{20000} = 3.1416$$

Since,

$$\frac{62832}{20000} = 3 + \frac{1}{7 + \frac{1}{16 + \frac{1}{11}}}$$

someone may take the value of π

$$3 + \frac{1}{7} = \frac{22}{7} \quad \text{or, } 3 + \frac{1}{7 + \frac{1}{16}} = \frac{355}{113}$$

Bhaskara, the leading Hindu mathematician of the twelfth century, gives the values of π as $22/7$ and $355/113$ in his arithmetical text, *Līlāvati*, and explains the rule to derive the circumference of a circle of a given radius in his work *Siddhāntaśiromaṇi* which is as follows :

Take a circle whose radius is 10000 (or greater than 10000) units and divide its circumference into 100 (or more than 100) parts. Calculate the chord of an arc-segment using the rule mentioned in the chapter trigonometry. Multiply the chord length thus obtained by the number by which the circumference was divided. Since the arc-segment here taken is very small, we may assume that there is no difference between the arc-length and the chord-length. So the product equals the circumference. Thus Aryabhata obtained the circumference 62832 units of the circle whose diameter is 20,000 units.

(Chapter Bhuvanakosa, stanza 52)

The introduction of an equivalent of the sine function in trigonometry to replace the Greek tables of chords is the most influential contribution of Hindu mathematicians. In *Āryabhaṭīya*, the sine of angles up to 90° are given for twenty-four equal intervals of $3^\circ 45'$ each. In order to represent arc-length and sine-length in terms of the same unit, the circumference of the circle was taken as $360.60 = 21600$ and the radius 3438.

The *Mathematical Syntax*, an astronomical work, was composed by Ptolemy (100 - 178) of Alexandria. This celebrated work was renamed as *Almagest* latter in Arabia. Ptolemy takes the radius of the circle 60 units and gives a table of chords of arcs from $1/2^\circ$ to 180° for every $1/2^\circ$. *Almagest* remained the essential tool of the Western astronomers for more than a thousand years. In sexagesimal numeration, Ptolemy's value of the chord of $1/2^\circ$ is $0^p 31' 25''$, which is the length of a side of a regular polygon of 720 sides inscribed in a circle of radius 60 units. We may conclude Ptolemy's approximation of π as

$$\pi = \frac{720(0^p 31' 25'')}{120} = 6(0^p 31' 25'') = 3^p 8' 30''$$

which is equivalent of about 3.1416 in decimal numeration.

This article is a short account of one of the subjects of the vast field of mathematical history. An attempt has been made to illustrate the works of two highly acclaimed mathematicians, one oriental and the other occidental, on the origin of the ratio of the circumference of a circle to its diameter. Their eminent works have survived the ravages of time. Since Aryabhata was born approximately three centuries after Ptolemy, there is a tendency

among mathematics historians to dismiss the work of the former as nothing more than an attempt to present the latter's work in a different format. But a careful observation clearly indicates the variation in the methods used by Aryabhata and Ptolemy on derivation of the value of π . The *Almagest*, the work of Ptolemy, follows the steps presented on Euclid's *Element*. It is generally accepted that, at the earliest, the Hindu mathematicians became familiar with geometry in the seventeenth century whereas Aryabhata's works date back to fifth century. Hence it is apparently improbable that Aryabhata's works were influenced by Euclidean geometry.

In order to discover the methods and logic used by Hindu mathematicians on derivation of π and various other mathematical theorems it is essential that a detailed study of their works be performed. A systematic study of ancient Hindu mathematical treatise will reveal a great deal of hidden treasure of mathematical knowledge possessed by Hindu mathematicians centuries ago and will also help us in crediting developments of various mathematical theorems to the appropriate mathematicians. $\square$

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Flood Routing and River Side Constructions

- Hari K. Shrestha *

Abstract: Natural phenomena such as rain and flood are hard to predict. But there are systematic methods that can be used to predict floods based on amount of rainfall upstream. These methods can serve as a guideline when designing or constructing any construction near a river system. A flood warning system can also be established if real time rainfall data is available.

We keep reading about many constructions in Nepal being swept away by floods every now and then. Many people take it for granted that if a construction is near a river then nothing can be done to prevent it from being wiped out completely or partially by occasional major and minor floods.

It is certainly true that natural phenomena are extremely difficult to predict with a high degree of certainty. But it is also true that we have come to an age when a reliable prediction can be made as to the nature of floods in a particular river channel. A detailed study of a river channel can reveal many things which in the beginning seem can never be known. Some of these things are the return period (cycle) of a flood and the stage and discharge in a river during a flood. A trained hydrologist with enough data about a river basin can predict both of these events with a certain degree of reliability. This article deals with a way to predict flood in a downstream river channel based on the amount of rainfall in an upstream area of a hypothetical river basin as shown in *fig.1*.

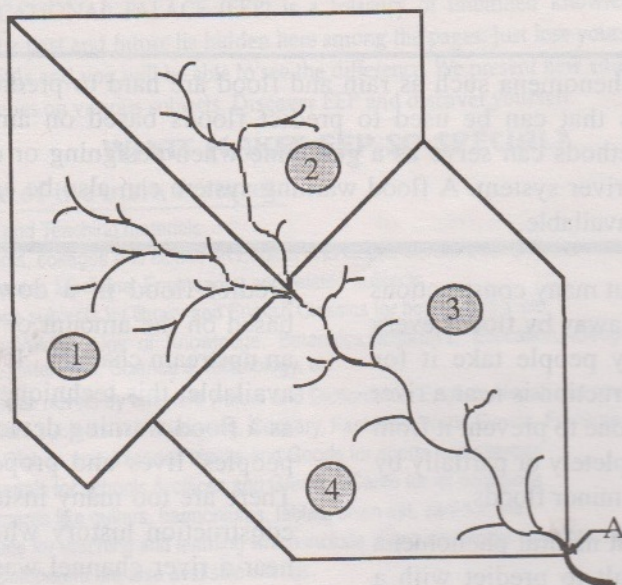
The flood routing is a straight forward and an effective way to obtain a guideline when designing or constructing any construction near a river channel. Basically, flood routing provides a way to

predict flood in a downstream channel based on the amount of excess rainfall in an upstream channel. If real time data are available, this technique can also be used as a flood warning device which can save peoples' lives and property downstream. There are too many instances in Nepalese construction history when a construction near a river channel was being destroyed or swept away by a flood. The reason for this type of accidents is the lack of appropriate planning and the designers' lack of knowledge regarding floods. Similarly, on many occasions, flash flood had swept many Nepalese. If a system of an early flood warning system can be set up using the flood routing technique, then innumerable people can be saved from disastrous death by informing them of a river channel that is about to change its flow.

The process of estimating the rate of discharge during a flood in a down stream channel based on a flood in an upstream channel is called flood routing or river routing. Once we estimate the rate of discharge from a particular river channel, we can also estimate the stage (height) of the flood by using a rating curve of the river or by finding the cross-sectional area of the channel and dividing the rate of discharge by the area.

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Figure 1. Hypothetical River Basin



The method of flood routing discussed below is a modified version of F.F. Snyder's synthetic unit hydrograph analysis method. The data needed for this method of flood routing are:

1. amount of rainfall in an upstream area,
2. total area of the river basin,
3. number of sub basins in the river basin,
4. length of river within each sub basin,
5. average watershed slope of each sub basin,
6. lag time of each sub basin,
7. C_p ,
8. time base, and
9. curve number of each sub basin.

Data on rainfall can be obtained from local meteorological stations. A rain gauge can also be installed for collecting rainfall data. The total amount of rainfall in an upstream area can be estimated by using an arithmetic mean method or the Thiessen method or the Isohyetal method.

The total area of the river basin can be obtained from topographical maps or geologic maps of the basin. The reading on a planimeter can be calibrated for a unit area, and using the same planimeter, the area of the river basin and each sub basin can be calculated.

The number of sub basins in a watershed depends on the size and shape of the basin. Analysis of a very large watershed requires dividing the watershed into several manageable sub basins. A morphologically complex watershed also demands a large number of sub basins when analyzing. A best decision on the number of sub basins comes from years of practice in this field.

The length of a river or the total length of rivers in a sub basin can be obtained from topographical maps of the sub basin.

The average watershed slope is the difference in elevation between the highest

and lowest land elevation values divided by the horizontal distance between those points. For more detailed work, the average watershed slope can be calculated by using statistical tools such as subdividing the total difference between the highest and lowest elevation value and assigning proper weight to each elevation value range based on horizontal area in that range.

The lag time (t_p) of each sub basin is the time it takes for a peak flood to travel from its origin to the river mouth. Snyder's empirical formula for calculating basin lag time (in hours) is

$$t_p = C_t(L L_c)^{0.3}$$

where, C_t = an empirical coefficient whose value is based on steepness of basin slopes.

L = length of the main stream in Km, from the outlet or the gauging station to the upstream boundary limit of the drainage basin.

L_c = distance measured along the main stream from the outlet or the gauging station to a point on the stream nearest to the centroid of the drainage basin.

The C_p is an empirical coefficient. Its value varies from 4 to 5 in SI units, and 300 to 500 in FPS units.

The time base (T) is the total time between the beginning and ending of a flood. It is generally expressed in hours. Snyder's empirical formula to calculate time base is

$$T = 3 + 3 \left(\frac{t_p}{24} \right)$$

The curve number of a basin depends on percentage areas of wooded lands, riverbed and unwooded flood plains, city and roads, lakes and wide rivers, and depressions. The Soil Conservation Service, under the U.S. Department of Agriculture, has developed a table to aid in assigning weight to curve number values for different types of areas.

The peak discharge Q_p can be calculated using the formula

$$Q_p = C_p \frac{A}{t_p}$$

where, A is the area of a basin or a sub basin under consideration.

After obtaining the data needed, a synthetic unit hydrograph can be plotted for each sub basin as shown in *fig. 2*. A unit hydrograph is a hydrograph of direct surface runoff resulting from one centimeter (or one inch) of effective rainfall (rainfall excess) falling over the drainage basin or catchment in space as well as in time for a specified or unit duration. The unit hydrograph should be plotted such that it passes through the derived points and the area under the curve represents a direct runoff of 1 cm. (or 1 inch, as the case may be).

The final plot of a flood in a downstream channel can be made by combining the synthetic unit hydrographs of each sub basin of the watershed.

The following computer program in FORTRAN 77 is used to estimate peak flood at a down stream channel of the hypothetical basin of *fig.1*. This program can be modified to suit the needs of a particular basin. Note that the program is

slightly different from the Snyder's method; in Snyder's method the curve number is not used. The table 1 is the output data generated by the program to

plot unit hydrograph of each sub basin. The table 2, also generated by the program, is the combination of flow from each sub basin. □

PROGRAM ROUTING

* This Program predicts Discharge in a Downstream Channel Based on the Amount
* of One-ince-Excess-Rainfall in the Upstream Area. Basic Data of Permanent
* Nature are Assumed since This Program Deals With a Hypothetical River Basin
* as Shown in Fig. 1.

* Real LAGT1, LAGT2, LAGT3, LAGT4
Integer TIME (80,2)
Real H(80,4)

* Print 10

Write (6,10)

10 Format (////, 2X, '*****',
+ '*****', //, 2x, 'Name of Basin : HYPOTHETICAL
+ RIVER BASIN', //, 2x, 'Total Drainage Area : 1325 Square Miles', //)

* ***** PERMANENT DATA *****

* N = Number of Sub basins

* A = Total Area of the Watershed in Square Miles.

* A1, A2,..... = Area of Sub basin # 1,2,... in Square Miles

* L1, L2,..... = Length of the River within the Sub basin # 1,2,... in Feet

* Y1, Y2,..... = Average Watershed Slope of Sub basin # 1,2,... (FT/FT)

Data N,A,A1,A2,A3,A4 / 4, 1325.,375.,350.,330.,330. /

Data L1,L2,L3,L4 / 171600.,151800., 184800.,184850. /

Data Y1,Y2,Y3,Y4 / .05, .06 .08, .10 /

* Call CURVENO (CN1,CN2,CN3,CN4)

S1 = 1000./CN1 - 10.

S2 = 1000./CN2 - 10.

S3 = 1000./CN3 - 10.

S4 = 1000./CN4 - 10.

* LAGT = Lag Time (in Hours)

LAGT 1 = $(L1^{**}0.8 * (S1 + 1.)^{**}0.7) / (1900. * Y1^{**}0.5)$

LAGT 2 = $(L2^{**}0.8 * (S2 + 1.)^{**}0.7) / (1900. * Y2^{**}0.5)$

LAGT 3 = $(L3^{**}0.8 * (S3 + 1.)^{**}0.7) / (1900. * Y3^{**}0.5)$

LAGT 4 = $(L4^{**}0.8 * (S4 + 1.)^{**}0.7) / (1900. * Y4^{**}0.5)$

* CP = 400 (From 'Hydrology for Engineers' by Linsley, Kohler, and Paulhus)

* QP1, QP2,... = Peak Discharge (CFS) in Sub basin # 1,2,...

QP1 = 400.*A1 /LAGT1

QP2 = 400.*A2 /LAGT2


```

QP3 = 400.*A3 /LAGT3
QP4 = 400.*A4 /LAGT4
*   T1, T2,... = Time Base (in Days) of Hydrograph of Sub basin # 1,2,...
      T1 = 3.+ LAGT1/8.
      T2 = 3.+ LAGT2/8.
      T3 = 3.+ LAGT3/8.
      T4 = 3.+ LAGT4/8.
*   TR1,TR2,... = Duration of Unit Hydrograph of Sub basin 1,2,... (Hours)
      TR1 = 0.18 * LAGT1
      TR2 = 0.18 * LAGT2
      TR3 = 0.18 * LAGT3
      TR4 = 0.18 * LAGT4
*   TPR1, TPR2,... = Adjusted Lag Time of Sub basin # 1,2,...
      TPR1 = LAGT1 + (4. - TR1)/4.
      TPR2 = LAGT2 + (4. - TR2)/4.
      TPR3 = LAGT3 + (4. - TR3)/4.
      TPR4 = LAGT4 + (4. - TR4)/4.
*   T1,T2,... = Adjusted Time Base (Days) for Sub basin #1,2...
      T1 = 3. + TPR1/8.
      T2 = 3. + TPR2/8.
      T3 = 3. + TPR3/8.
      T4 = 3. + TPR4/8.
Print 20
Write (6,20)
20  Format (1X,'SUB BASINS', 4X,' CURVE',2X'LAG TIME', 2X,'PEAK FLOW',
      +2X,'ADJUSTED LAG', 2X,'DURATION')
Print 21
Write (6,21)
21  Format (1X,3X,'NO.', 9X'NO.',5X,'(HRS)',5X,' (CFS)', 7X,'(HRS)',7X,'(HRS)')
*
Print 30,CN1,LAGT1,QP1,TPR1,T1
Write (6,30) CN1,LAGT1, QP1,TPR1,T1
30  Format(/,4X,'1',9X,F5.2,7X,F3.0,5X,F6.1,7X,F4.1,7X,F5.2,/)
Print 31, CN2, LAGT2,QP2,TPR2,T2
Write (6,31) CN2, LAGT2, QP2, TPR2,T2
31  Format (4X,'2',9X,F5.2,7X,F3.0,5X,F6.1,7X,F4.1,7X,F5.2)
Print 32, CN3,LAGT3, QP3,TPR3,T3
Write (6,32) CN3,LAGT3,QP3,TPR3,T3
Format (/ ,4X,'3',9X,F5.2,7X,F3.0,5X,F6.1,7X,F4.1,7X,F5.2)
Print 33, CN4,LAGT4, QP4,TPR4,T4
Write (6,33) CN4,LAGT4,QP4,TPR4,T4
Format (/4X,'4',9X,F5.2,7X,F3.0,5X,F6.1,7X,F4.1,7X,F5.2)
*
*****
*   From the Above Data the Synthetic Unit Hydrograph is Plotted for each Sub basin, as
*   Shown in Figure 2. The Time Width of the Hydrograph at 75% and at 50% of the Peak
*   Discharge is 65 Hours and 100 Hours Respectively; and the Width is Proportioned Each
*   Side of the Peak in a Ratio of 1:2 with the Short Time Side on the Left Side of the Synthetic
*   Unit Hydrograph (as Mentioned in 'Introduction to Hydrology' by Viessman, Knapp,

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*   Lewis, and Harbough).
*
*   The Discharge Value for Every 8 Hr's are Obtained form the Synthetic Unit Hydrograph
*   of each Sub basin, and are Stored in the Data File 'HYDRO'. The Shape of the Watershed
*   Demands That the flow form the Sub basin 1 & 2 be Added and Then be Routed from the
*   Confluence to the Outlet Point 'A' in Figure 1. The Total Flow from Point 'A' is the Sum of
*   the Routed Flow Plus the Combined Flow from Sub basin 3 & 4.
*
*   The Following Statements Combine the Flow from Sub basins 1 & 2, and Sub basins 3 & 4,
*   and Stores the New Data in File 'ROUT'
*****
*
*   ***** ROUTING BY USING MUSKINGUM METHOD *****
*
*   Open (Unit = 5, File = 'HYDRO', Status = 'Old')
*   Rewind 5
*   Open (Unit = 10, File = 'ROUT', Status = 'New')
*
*   Print 40
*   Write (6,40)
40  Format(///9X,'HYDROGRAPH OF DIFFERENT SUB BASINS : ',
*   +//,9X,'DAY',2X,'HRS',3X,'SUB1',3X,'SUB2',3X,'SUB3',3X,'SUB4',/,19X,
*   +'(CFS)',2X,'(CFS)',2X,'(CFS)',2X,'(CFS)',/)
*
*   do 600 I = 1,80
90  Read (5,*,End = 101) TIME(I,1),TIME(I,2), H(I,1), H(I,2),H(I,3) H(I,4)
*
*   ADD1A2 = Combined Flow From Sub basins 1 and 2.
*   ADD3A4 = Combined Flow From Sub basins 3 and 4.
*   ADD1A2 = H(I,1) + H(I,2)
*   ADD3A4 = H(I,3) + H(I,4)
*
*   Print 50, TIME (I,1),TIME(I,2),H(I,1),H(I,2),H(I,3),H(I,4)
*   Write (6,50) TIME(I,1),TIME(I,2),H(I,1),H(I,2),H(I,3),H(I,4)
50  Format (9X,I2,3X,I2,3X,F5.0,2X,F5.0,2X,F5.0,2X,F5.0)
*
*   The Following 'WRITE' Statement Creates New File 'ROUT' and Stores the Day,
*   Hours, Summation of Sub basins 1 & 2, and Summation of Sub basins 3 & 4 in the
*   New File.
*
*   Write (10,*) TIME(I,1),TIME(I,2),ADD1A2,ADD3A4
*   go to 90
600 Continue
*
101  Rewind 10
*
*   The Following Seven Statements Calculate CO,C1, AND C2 Needed to Route
*   the Flow ADD1A2 From the Confluence of Streams to the Point of Discharge 'A'
*   in Figure 1. The Appropriate Value of 'K' AND 'X' are Chosen so as to Make

```



```

* the Value of C0, C1, AND C2 all Positive.
* T = 8 Hours Because Data of Inflow are for Every 8 Hours.
*
K = 24
X = 0.16
T = 8.
DENOM = (K-K*X + 0.5*T)
CO = - (K*X-0.5*T)/DENOM
C1 = (K*X+0.5*T)/DENOM
C2 = (K-K*X-0.5*T)/DENOM
* Q = Final Discharge from Point 'A' in Figure 1, Which is the Sum of the
* Routed Flow Plus the Flow 'ADD3A4'
*
Read(10,*) TIME(I,1),TIME(I,2),H(I,1),H(I,2)
O = H(I,1)
Q = O + H(I,2)
*
Print 55
Write (6,55)
55 Format(/////9X,'THE ESTIMATE OF FINAL DISCHARGE AT POINT A IN',/,
+9X,'FIGURE 1, FROM ONE--INCH-EXCESS-RAINFALL, IS GIVEN
+BELOW:')
Print 60
Write (6,60)
60 Format (/19X,'DAY',2X,'HRS',4X,'DISCHARGE',/,33X,'(CFS)',/)
Print 70,TIME(I,1),TIME(I,2),Q
Write (6,70) TIME (I,1), TIME (I,2),Q
70 Format (19X,I2,3X,I2,5X,F8.2)
*
do 700 I = 2,80
Read (10,*,END = 102) TIME (I,1), TIME (I,2), H(I,1), H(I,2)
O = CO*H(I,1) + C1*H(I-1,1) + C2*O
Q = O + H(I,2)
*
Print 70,TIME (I,1), TIME (I,2),Q
Write (6,70) TIME(I,1), TIME(I,2),Q
700 Continue
* The Following Statements Keep the Value of ADD1A2 = 20.0, and
* ADD3A4 = 10.0 When it Runs out of Data in File 'ROUT', and Keep
* on Routing Until the Inflow Equals the Outflow.
*
102 ITIME1 = TIME(I-1,1)
ITIME2 = TIME(I-1,2)
KOUNT = 0
DIF = 0.001
REALIN = H(I-1,1)
ADD3A4 = H(I-A,2)
103 ITIME2 = ITIME2 + 8
if(ITIME2.GT.24) then

```



```

      ITIME 2 = 8
      ITIME 1 = ITIME1 + 1
      Endif

```

```

*      OLD = Q
      O = (CO + C1)*REALIN + C2*0
      Q = O + ADD3A4

```

```

*      Print 70,ITIME1, ITIME2,Q
      Write (6,70) ITIME1, ITIME2,Q

```

```

      if (ABS (OLD-Q).LE.DIF) go to 105
      KOUNT = KOUNT + 1
      IF (KOUNT.GT.1000) go to 105
      go to 103

```

```

105      Print 110
      Write (6,110)

```

```

110      Format (18X,'*****')
      End

```

```

*****
Subroutine CURVENO (CN1,CN2,CN3,CN4)

```

```

*      This Subroutine Computes Curve Number of Sub basins.

```

```

*      W1 , W2,... = Percentage of Wooded Areas in Sub basin # 1,2,...
*      RF1, RF2,... = Percentage of Revered and Unwooded Flood Plain in
*      Sub basins.
*      CR1,CR2,... = Percentage of City and Road Area in Sub basin # 1,2,...
*      LR1, LR2,... = Percentage of Lake and Wide River Area in Sub basin # 1,2,...
*      D1, D2,... = Percentage of Depression Area in Sub basin # 1,2,...
*      CN1,CN2,... = Curve Number of Sub basin # 1,2,...

```

```

      Data W1,W2,W3,W4 / 60.,65.,35.,45./
      Data RF1,RF2,RF3,RF4 / 25.,15.,15.,20./
      Data CR1,CR2,CR3,CR4 / 5.,5.,15.,20./
      Data LR1,LR2,LR3,LR4 / 5.,10.,10.,5./
      Data D1,D2,D3,D4 / 5.,5.,25.,10./

```

```

*      Curve Number Assigned for W, RF, CR, LR, and D are 73, 87, 90, 100, and
*      30 Respectively (from Soil Conservation Service Table).

```

```

*      CN1 = W1*0.73 + RF1*0.87 + CR1*0.90 + LR1*.0 + D1*0.30
      CN2 = W2*0.73 + RF2*0.87 + CR2*0.90 + LR2*.0 + D2*0.30
      CN3 = W3*0.73 + RF3*0.87 + CR3*0.90 + LR3*.0 + D3*0.30
      CN4 = W4*0.73 + RF4*0.87 + CR4*0.90 + LR4*.0 + D4*0.30

```

```

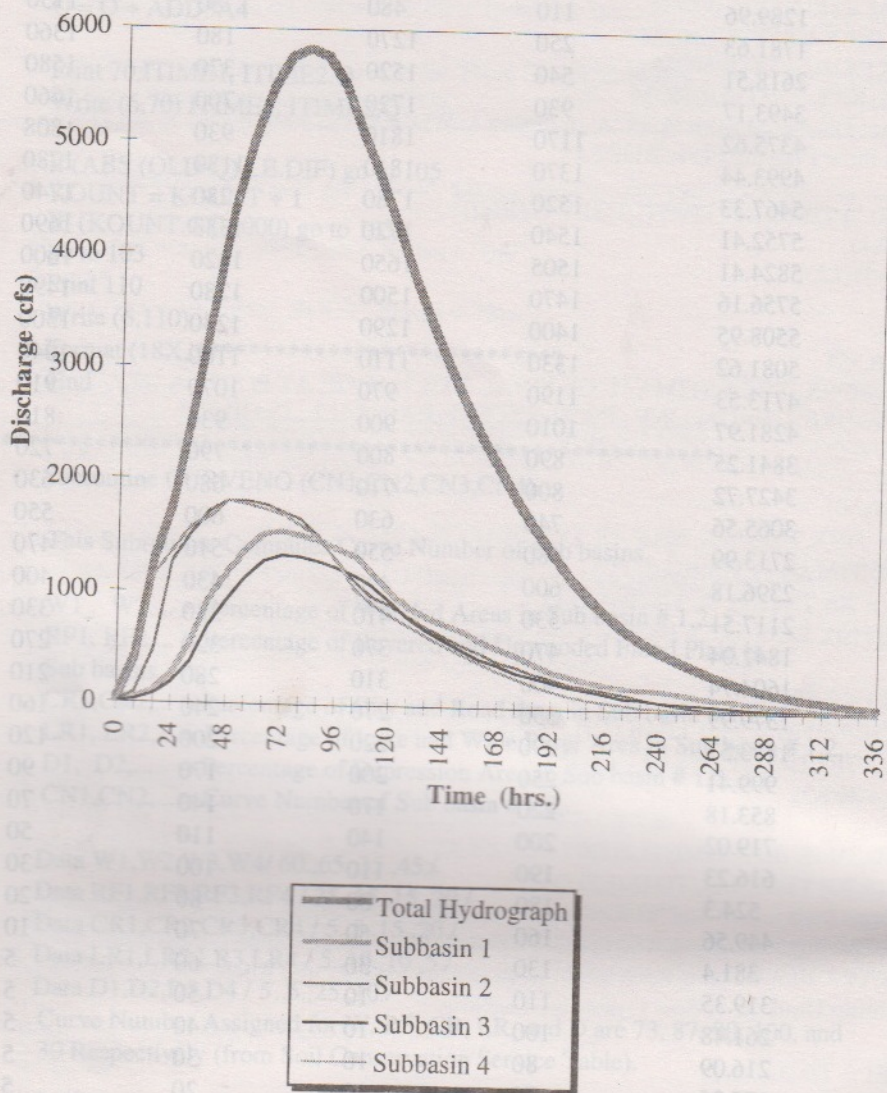
*      Return
      End

```


Table 1

HRS.	Total Hydrograph	Subbasin 1	Subbasin 2	Subbasin 3	Subbasin 4
0	30	10	10	5	5
8	410.73	40	90	20	370
16	1289.96	110	480	80	1150
24	1781.63	250	1270	180	1360
32	2618.51	540	1520	370	1580
40	3493.17	930	1720	700	1660
48	4375.62	1170	1810	930	1808
56	4993.44	1370	1810	1130	1780
64	5467.33	1520	1780	1280	1740
72	5752.41	1540	1720	1333	1690
80	5824.41	1505	1650	1320	1600
88	5756.16	1470	1500	1280	1490
96	5508.95	1400	1290	1230	1300
104	5081.62	1330	1110	1160	1040
112	4713.53	1190	970	1070	910
120	4281.97	1010	900	930	810
128	3841.25	890	800	790	720
136	3427.72	800	710	680	630
144	3065.56	740	630	600	550
152	2713.99	680	550	510	470
160	2396.18	600	490	430	400
168	2117.51	530	410	380	330
176	1842.04	470	370	320	270
184	1604.74	400	310	280	210
192	1379.99	330	270	240	160
200	1173.57	290	220	200	120
208	999.41	250	200	170	90
216	853.18	220	170	140	70
224	719.02	200	140	110	50
232	616.23	190	110	100	30
240	524.3	180	80	80	20
248	449.56	160	50	70	10
256	381.4	130	30	60	5
264	319.35	110	10	50	5
272	261.48	100	10	40	5
280	216.09	80	10	30	5
288	175.86	70	10	20	5
296	147.27	50	10	15	5
304	119.93	40	10	10	5
312	99.61	20	10	8	5
320	77.8	10	10	5	5
328	61.97	10	10	5	5
336	51.38	10	10	5	5

Fig. 2 Hydrographs of Different Subbasins and the Total Hydrograph



Earthquake Resistant Structures

- Netra P. Bhandary*

What is Earthquake ?

Earthquake simply means the movement of a portion of the earth, either horizontal or vertical, and is mainly due to the following reasons :

- Superficial movements
- Volcanic eruptions and
- Folding and faulting

Earthquakes caused by superficial movements, i.e. dynamic agencies operating upon the surface of the earth such as dashing waves causing vibrations along the sea shores, water descending along high water falls causing vibrations along the neighboring areas, snow falling down at high altitudes as an avalanche causing vibrations along the neighboring areas and working of heavy machinery and movement of locomotives causing mild vibrations in industrial areas and along the railway tracks, are feeble and very weak. They do not have much effects on life.

The molten material inside the earth's crust when heavily charged with gases and volatile constituents existing below the earth's surface is called magma. Whenever some changes i.e. pressure, temperature etc. take place, this magma no longer remains in its original position and is forced out at the surface of earth through the points of least resistance making vents. This process is called volcanic eruption.

The effect or intensity of a volcano depends upon the quantity and speed of magma coming out of the earth's crust. A few volcanic eruptions can be strong enough to have really disastrous effects causing a severe earthquake. It can have adverse effects on life and area of squares of kilometers can be covered by the molten material coming out of the earth's crust.

It still remains an uncertain geological problem to identify whether folding and faulting are caused due to earthquakes or earthquakes due to folding and faulting. But if the latter is true, such earthquakes become more disastrous and are known as tectonic earthquakes which directly or indirectly change the structural features of the earth's crust. All major earthquakes having disastrous effects are of tectonic type.

Effects of Earthquake

The effects produced by an earthquake on the structures nearby and on the feature of the earth depend directly upon its intensity. There are many scales to measure the intensity of the earthquake of which Richter Scale and Rossi Forrel Scale are widely adopted.

Richter scale is the scale from 0 to 8 indicating low intensity by a less value. A Richter scale of 8 means a very disastrous one.

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Rossi Forrel gave a scale to measure the intensity of an earthquake relative to its effects which are as follows;

Imperceptible - Recorded by sensitive seismographs only.

Feeble - Recorded by different seismographs and may be felt by a number of persons at rest.

Very Slight - Felt by several persons at rest. It is strong enough for the duration and direction to be recorded.

Slight - Felt by several persons at motion. Disturbance to moving objects and cracks on buildings occur near the doors and windows.

Weak - Disturbances of furniture and beds, ringing of bells.

Moderate - General awakening of those asleep, stopping of wall clocks, visible disturbances to trees, people leaving their houses.

Strong - Overthrow of moving objects, fall of plaster from the walls, general panic without damage to the buildings.

Very Strong - Fall of the tall chimneys, cracks on walls of buildings.

Severe - Partial or total destruction of some buildings.

Destructive - Great disasters, disturbance in strata.

Catastrophic - Wooden structures collapse, railway tracks get twisted.

Absolute Ruin - Land faults and slips, movement and collapse of buildings.

The effects of an earthquake depend also upon the :

- Distance of the place from the point on earth's surface where the shock is experienced first (Epicenter).
- Nature of the ground i.e. medium of wave propagation.

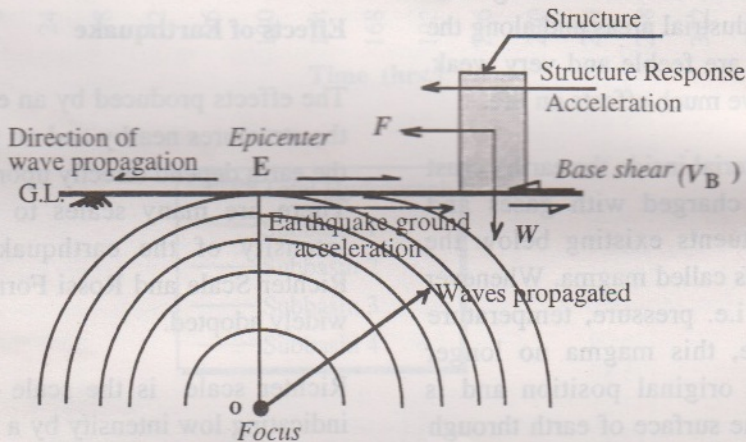


Fig. 1 (Effect of earthquake on a structure on earth's surface)

Generally, the structures at the place nearer to epicenter are more damaged than those comparatively farther from the epicenter by the same earthquake.

Earthquake waves are propagated on the surface through the material in the surface body of earth. If the material is hard and acts as one unit, the waves are well propagated and if the material is soft and elastic the waves merge in and the shock observed is less.

Earthquake induced forces are generated within the structure due to the resistance from the weight of the structure which exhibit in the form of shaking. Acceleration produced by such forces is called *structure response acceleration*. This is a complex effect of horizontal and vertical forces in which horizontal forces are mainly responsible for the collapse of structures.

Horizontal Force due to earthquake (on the structure), $F = \text{mass} \times \text{acceleration}$

$$= \frac{W}{g} \times \alpha g = \alpha W$$

Where,

W = Weight of structure

α = Acceleration coefficient
= $\frac{\text{Earthquake acceleration}}{\text{Gravitational acceleration}}$

g = Acceleration due to gravity.

Hence,

Shear produced on the base of structure by this horizontal force, F (called **Base Shear**) = αW

or, Base Shear, V_B = αW

If the intensity of an earthquake is low the effect is minor. But an earthquake with very high intensity may uproot the trees

and heavily damage many bridges, dams, tunnels, multistoried buildings, railway tracks etc.

Earthquakes in Nepal

According to IS 1893 - 1975, Nepal lies in earthquake zone V which is the most active zone mentioned in the code. According to Rossi-Forrel's scale this zone has a probability of being under the severe earthquake which means partial or total destruction of some buildings, and there is a probability of occurring 500 earthquakes of 6 Richter scale intensity in every 1000 years.

Two severe earthquakes have already been felt in Nepal within a very short period of about 55 years. One was felt on 15th January, 1934, and it affected mostly the eastern part of the Kingdom - Biratnagar (epicenter) and neighboring areas. The disastrous effect was also seen in Kathmandu; Dharahara lost its height by 25% . About 1200 lives were lost altogether in Nepal and Bihar, India. The other one was felt in August, 1988, and it again affected mainly the same part of the kingdom - Dhankuta (epicenter) and neighboring areas. Many buildings collapsed partially and completely basically because no considerations about the possibility of earthquake were taken during construction works.

An earthquake of more than 6 Richter scale intensity was also felt in Nepal in 1978 having epicenter at Darchula - far western part of Nepal. Weak or moderate shocks of the earthquake are frequently felt even these days in the western and midwestern parts of the kingdom.

Engineering Considerations Against Earthquake

Place, time and intensity of an earthquake can never be predicted. But the remedy that can be taken at the best is to provide additional factors in the design of a structure to minimize the losses to be caused by the effects of an earthquake. For this, one needs -

- to collect sufficient data, regarding the previous seismic activity in the area.
- to assess the losses which are likely to take place in future due to earthquake.
- to provide factors of safety.

Before planning and designing a structure in a seismic area (area which is frequently shocked by earthquakes) the following precautions should be taken to make structure sufficiently earthquake proof :

- Solid or firm rock bed foundation. Grillage foundation to be preferred.
- The same foundation level throughout the base of structure.
- Symmetric plan as well as the elevation so as to have simple analysis and design.
- Not much slender i.e. $h \leq 4b$ to have proportional height and breadth.

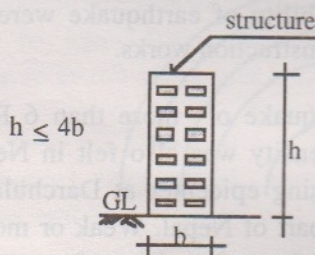


Fig. 2

- Use of rich concrete and mortar and proper placing of concrete to make no joints.
- Simultaneous erection of long walls and cross walls making no joints. Better to use vertical and horizontal reinforcing bars at the corners, and a RCC band throughout the walls instead of lintels should be provided. Shear walls must be provided.
- Masonry work with cement mortar of not less than 1:4 mix.
- Proportional doors and windows. Windows should be kept away from outer corners of a building and they should always be kept diagonally opposite to the doors. No wide windows in a building with load bearing walls should be provided.

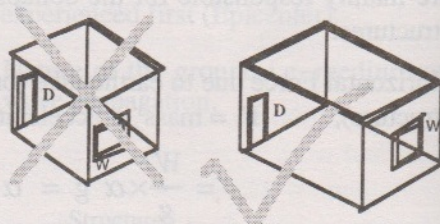


Fig. 3

- Flat RCC slabs to be provided and they should be light in case of load bearing walls.
- All the parts of the building should be tied firmly with each other. Framed structure should be preferred to the load bearing walls.
- Uniform height of the structure.
- No cantilevers and projections, parapets, domes etc. as far as practicable.
- Quality construction materials.

Earthquake Design Criteria

The design of the earthquake resistant structures should aim at providing the appropriate dynamic and structural characteristics so that acceptable response levels result under the design earthquake. An earthquake resistant structure is meant to :

- resist earthquakes of minor intensity without any damage, i.e. the structure would be expected to resist such frequent minor shocks within its elastic range.
- resist moderate earthquakes with minor structural and some non-structural damage. With proper design and construction, it is believed that structural damage due to the majority of earthquakes will be limited to repairable damage; and
- resist major catastrophic earthquakes without collapse.

Ductility, a property to undergo large strains while resisting loads, and **Strength** are the two major characteristics of a structure to be considered while designing for earthquakes. If the elastic strength of each element in a structure exceeds the greatest load imposed upon it there can be no significant structural damage provided that the structure has been designed for lateral forces several times greater than those specified in a seismic code. It must be assumed that in a severe earthquake some of the resisting elements will be loaded to their full strength. If they are brittle, they will fail throwing their share of load on to the remaining elements. If they are sufficiently ductile, they can continue to participate in resisting the lateral force nearly up to their full strength

after they yield throwing only the excess load to the remaining elements. Thus, somewhere in the line of resistance the designer must provide both strength and ductility to the structure to make it earthquake proof.

In reinforced concrete structures, ductility implies the ability to sustain significant inelastic deformations prior to collapse. A brittle material or structure is the one that fails suddenly upon attaining maximum load.

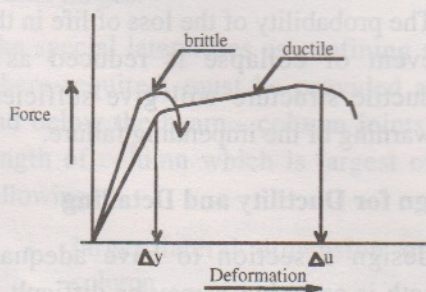


Fig. 4 (Typical Force* - Deformation** Relationship for Brittle and Ductile Behaviors)

Ductility of a structure is defined as the ratio of absolute maximum deformation to the corresponding yield deformation.

When a ductile structure is subjected to overloading, it will tend to deform inelastically and, in doing so, will redistribute the excess load to elastic parts of the structure. The significance of ductility of a structure may be better explained as :

- A structure can be expected to adopt to unexpected overloads, load reversals, impact and structural movements due

* Force may be load, moment or stress.

** Deformation may be elongation, curvature, rotation or strain.

to foundation settlement and volume changes. These are generally ignored in analysis and design but the provision of ductility to structure may counteract them.

- Limit state design assumes all the critical sections in a structure to reach their maximum capacities at design load. In order to occur this, all joints and splices must be able to withstand forces and deformations corresponding to yielding of the reinforcement.
- The probability of the loss of life in the event of collapse is reduced as a ductile structure will give sufficient warning of the impending failure.

Design for Ductility and Detailing

To design a section to have adequate strength is easy, but it may be difficult to design a section to have the desired strength as well as ductility. To have sufficient ductility in a structure or section with the desired strength attention must be paid to reinforcement detailing, bar cutoffs, splicing and joint details. Ductility in a structure can be ensured by the following design details -

- Regular structural layout, no offsets of beam to columns or offsets of columns from floor to floor.
- Restricted tensile reinforcement in beams and more compression reinforcement enclosed by stirrups to prevent from buckling.

To ensure adequate ductility, the minimum and maximum steel ratios for mild steel as well as other steels in beams are as follows

and the actual flexural steel should lie within this range.

Max. Steel :

For M-15 concrete and m.s. bars,

$$P \leq P_c + 0.011$$

For other concrete and m.s. bars,

$$P \leq P_c + 0.19 (f_{ck}/f_y)$$

For any concrete with HYSD bars,

$$P \leq P_c + 0.15 (f_{ck}/f_y)$$

Min. Steel :

For M-15 concrete and m.s. bars,

$$P > 0.0035$$

For other concrete and HYSD bars,

$$P > 0.06 (f_{ck}/f_y)$$

Where,

f_{ck} = Characteristic strength of concrete.

f_y = Characteristic strength of steel.

P_c = Actual steel ratio on the compression face.

P = Desired steel ratio on the tension face.

At least two bars of not less than 12 mm m.s. bars or 10 mm high strength deformed bars at top and bottom should be provided, each throughout the length of the member to meet the situation of reversal of sign of moments due to reversible nature of earthquake and shifting of points of contraflexure towards the center because of the increase in negative moment at one end and decrease at the other.

Both the top and bottom bars of a beam should be anchored into the column so as to develop their full strength in bond, but when beams exist on both sides of the column all longitudinal bars must be taken

continuously through the column as in figure :

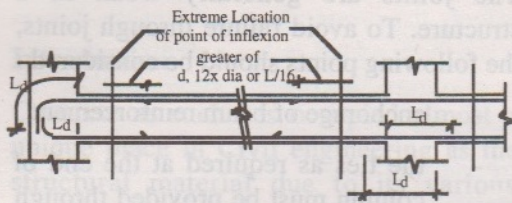


Fig. 5 (Main reinforcing bars in beam)

In case of columns, equal amounts of reinforcing steel in tension as well as compression faces increase the possible inelastic deformations confirming ductile behavior.

- Adequate shear reinforcement to ensure that shear strength exceeds flexural strength.

Vertical shear stirrups in beams should be provided to resist shear of any sign due to the reversal of load. Their spacing should not exceed $0.25d$ in a length equal to $2d$ near the supports and $0.5d$ in the remaining length.

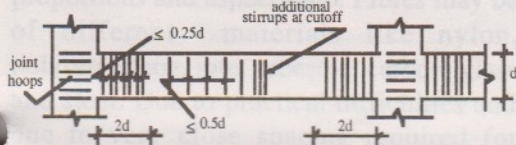


Fig. 6 (Shear stirrups in beams)

- Confinement of inelasticity to beams only (in a framed structure) and column should remain elastic. For this, sum of moment capacities of the column for the design axial loads at a beam-column joint should be greater than the moment capacities of the beams along each principal plane.

- Use of closed stirrups or spirals to confine the concrete at sections of maximum moment such as upper and lower ends of columns and within beam-column joints which do not have beams on all sides.

In seismic areas, significant shear forces may develop in columns causing them to fail in shear in case of severe earthquake. So, shear reinforcement must be provided for the applied shears at the section of plastic hinges.

The special lateral ties as confining steel, where required, must be provided above and below the beam - column joints in a length of column which is largest of the followings :

- larger lateral dimension of the column
- $1/6$ of the clear height of column
- 450 mm.

Any splice should not be located within this length and pitch of lateral ties in this length should not exceed 100 mm. In the remaining height of column the pitch of the ties should not exceed half the effective depth of column nor that specified in concrete code.

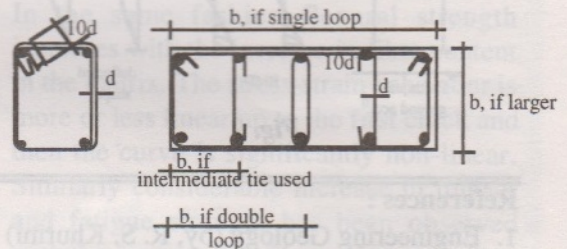


Fig. 7 (Lateral Tie - closed type)

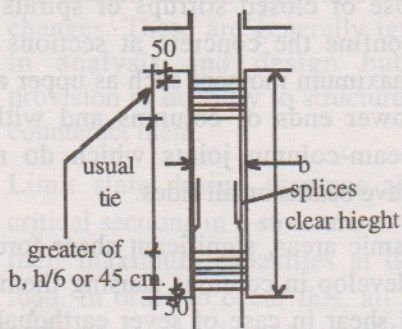


Fig. 8 (Lateral ties spacing and splices)

- Adequate splices and anchorage to prevent bond failures as shown *fig. 5*.

Splices in all bars at the same section or at the points of maximum tension must be avoided. The splices must be continued at least within two stirrups ties of 10 mm bars so that the splice does not open out and split the concrete in cover.

- Appropriate reinforcement for the reversal of stresses in beams and columns due to reversal of direction of earthquake force.

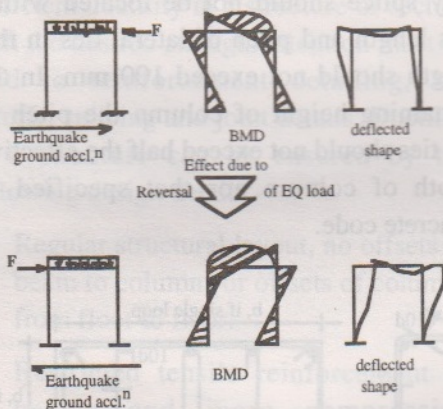


Fig. 9

- Monolithic beam-column joints.

The joints are generally weak in a structure. To avoid failure through joints, the following points should be considered :

- anchorage of beam reinforcement
- the ties as required at the end of column must be provided through the connection as well, provided that if the joint is confined by beams from all the four sides, the amount of this reinforcement will be reduced to half of this value.

A steel framed structure (building) can withstand seismic force much better than a RC framed structure. The dead weight of a steel framed structure is much less compared to a RC framed structure. As a result, the effect of horizontal seismic force between ground and first floor is less in case of a steel framed structure. The only factor which goes against it is a steel framed structure is much costly compared to a RC framed structure. □

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GENERALS OF FIBRE REINFORCED CONCRETE

- Rabi Chandra Gautam*

Introduction

Concrete as such has occupied almost a unique place in Civil engineering as the structural material due to its various advantages like high compressive strength, easiness in moulding, durability, high resistance to fire, wind, water etc. For these reasons it is even called as a universal material. However, it also possesses some deficiencies like brittleness, poor tensile and impact strength etc. Various research works have been done to overcome these deficiencies, and fibre reinforced concrete is one of the outcomes. During the last twenty years fibre reinforced concrete has drawn the attention of many research scholars and has rapidly developed through extensive research and development works.

Fibre reinforced concrete is nothing but concrete with short, discrete fibres added to it in random order with definite volume proportions and aspect ratio. Fibres may be of different materials like nylon, polypropylene, jute, asbestos, carbon, glass and steel. Due to practical difficulties and due to very close spacing required for effective arresting of crack propagation, short randomly distributed fibres are preferred to continuous, closely spaced ones. The inclusion of fibres in concrete offers a convenient practical and economical method of overcoming the difficulties such as poor tensile and impact strength, moisture susceptibility etc. can enhance engineering properties like

toughness, flexure strength, ductility, and resistance to fatigue, impact, thermal shock or spalling of concrete.

The properties influenced by the inclusion of fibre:

The compressive strength of concrete is only slightly affected by the inclusion of fibres. Since the concrete itself possesses good compressive strength it is not intended to increase it further. In case of tensile strength it is usually assumed that the fibres do not influence the tensile strength of the matrix, and only after the matrix has cracked the fibres contribute by bridging the crack. Three types of post cracking behaviour in tension is exhibited by FRC.

1. The composite fails as fibres fracture under the increased stress thrown onto them.
2. The composites carries decreased load as the fibres pull out from the cracked surfaces.
3. The composites behaves in pseudo ductile fashion with multiple cracking and carries increased tensile load

In the same fashion flexural strength increases with the increase in fibre content in the matrix. The stress-strain behaviour is more or less linear up to the first crack and then the curve is significantly non-linear. Similarly considerable increase in impact and fatigue strength has been observed with the increase in fibre volume. In fact,

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it is the behavior of the material under the dynamic load that clearly distinguishes it from plain concrete. The fibres restrain the growth of micro cracks enhancing the fatigue strength. The dynamic strength of FRC subjected to explosive charges and dropped weights is found to be 3-10 times greater than that for plain concrete.

Similarly, the shrinkage and creep of the concrete is greatly restrained with increasing fibre content. Crimped steel fibres have proved to be most effective in resisting the shrinkage and creep. However, the workability is decreased with the inclusion of fibres, and some admixtures is essential to maintain the workability.

Factors influencing the properties of fibre reinforced concrete

Volume fraction of the fibre is the quantity of fibres in terms of percentage of the volume of the matrix. The increase in volume fraction is directly related to the increase in tensile and impact strength of the concrete. However, higher volume fractions is likely to cause segregation and harshness of concrete . More recently, it has been feasible to incorporate up to 15% of fibres.

Aspect ratio is the ratio of the length of the fibre to its diameter . It is one of the important factors that influences the properties and behavior of the composite. It has been observed that higher aspect ratio than 75 reduces the tensile strength of the concrete.

Orientation of fibres is in general random and not in desired direction . But it has been observed that fibres aligned parallel to the applied load offered more tensile

strength and toughness than randomly distributed fibres.

Mixing of fibre reinforced concrete also affects the properties considerably. Fibres have to be added or sprinkled slowly with continuous mixing to avoid balling or honeycombing of fibres.

In addition other factors like modulus of elasticity of fibres in comparison to matrix, the various shapes of fibres like plane, hooked, crimped etc. and the size of the aggregate also have considerable effect on the properties of fibre reinforced concrete.

Applications of fibre reinforced concrete

The application of fibre reinforced concrete depends upon the ingenuity of the designer and the builder in taking advantage of the static and dynamic tensile strength, fatigue strength, energy absorption etc.

In applications, where continuous reinforcement is not essential to the safety and integrity of the structures e.g. pavements, overlays, shotcrete lining , FRC can be successfully used:

- The good resistance to cavitation to erosion damage of FRC can be utilized to use it in hydraulic structures like dams, spillways, stilling basins, sluice ways etc. In one study, FRC has lasted three times as long as plain concrete when exposed to water velocity of 37 m/s.
- The high flexural strength, resistance to crack propagation resulting in lower crack widths can be utilized to use it in airfield and highway pavements. The high flexural strength compared to plain concrete results in reduction in the required pavement thickness for a

given design life or an extended life for the same thickness.

- The lower shrinkage, creep and elastic shortening reduces the transmission length and prestress losses and hence FRC can be successfully used to a variety of precast applications like manhole covers, concrete pipes, machine base etc.
- The sudden punching failure can be transformed to slow ductile one by the

application of fibres, thus FRC can be used to resist shear.

- The dynamic properties can be utilized in earthquake resistant and explosive loading structures.

Nevertheless, it should be understood that FRC is still under research stage and no standards as plain concrete has been prepared. □

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MHP in Far-Western Region : Boon or Bane

*-Devendra Prasad Adhikari**

Micro Hydro Power in the far western region of the country has a different story. The rivers and rivulets in the region fall into the Mahakali river system. Numerous traditional water wheels along these rivers and rivulets have been running throughout the mountains and hills of the region since long ago. Numerous water wheels can be seen even along small rivulets in many places.

The process of micro hydro power development in the region began with the introduction of the water turbine for carrying out the agricultural processing business. It was at the beginning of 1984, Agricultural Development Bank deputed a team of technicians for site survey and identification of the potential entrepreneur for the micro hydro plant installation in the region.

In ten years' period, the number of water turbine installations for agricultural processing reached 55 in which nine units are added with electricity generating equipment. The government has provided the capital subsidy for the construction and installation of the plants on the electricity generation and distribution system. The Agricultural Development Bank made easy access to credit facilities because it had an especial package of credit for the program in that period. The bank invested about seven million rupees for the micro hydro program in that area.

These plants brought a new life into the village at the beginning. The villagers

seem happy to process their grains in the water turbine mill instead of the Ghatta. Oil extracting from the turbine-driven expeller was the main attraction in the village. It is less time consuming and crushes more oil in comparison to the Kole, a traditional equipment used for oil extracting. The plants installed in the Indian border used to get the raw materials to be processed even from the border areas.

Electrification from the micro hydro plant was even more attractive and a new advent for the villagers. Many people for whom electricity was just an imagination delighted to light electric bulbs in their home. People who used to feel under privileged as not being able to get basic infrastructures like electricity in their village were proud for having the person who took an initiative to bring electricity in the village.

The turbine owners were happy to be an introducer of a new technology in their respective villages. Many persons then inspired water turbine mill for agro processing and electrification. They got the survey work for the plant installation done by the technician. The water turbine became like hot cakes for business people in the region thinking it could bring a reliable business by processing the agricultural products in the village. The people with certain social affiliation thought that electricity generation from the water turbine could maintain their social status in their village for ever.

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The development workers were encouraged with the rate of installation of the plants each year. They advocated micro-hydro power for its likely positive impacts on the development of the village and the owners too. Many plants were inaugurated on the opportunity of very important, and long speeches were delivered by the big dignitaries. Mr. Singh Bahadur Singh, a micro hydro plant owner in the Bajhang district, remembered those days the villagers organized a procession with color to mark his heroic deeds. Mr. Rami Yier of the Kotila village in the Baitadi district was considered as the son of the village. There are many more others who were respected and even elected on the various capacities for their work on the field of micro hydro power development in the region.

As a practitioner working in the micro hydro development sector, I was very happy to know such a good pace of the development of the technology considered still developing one. I visited most of the micro hydro sites and talked with many micro hydro owners, operators and beneficiaries of the plants in six districts of the region. Some years ago, I have gone through the article published in Himal magazine regarding the bad business of micro hydro power in the Bajhang district. The writer of the article who was an outsider featured the catastrophic adverse impacts left by the technology in the district. As a student who strongly advocates the appropriateness of the technology for the rural development in the country like Nepal, I was disappointed with the article thinking it was overstated. I found the situation of the plants much worse than it was stated in that article.

Out of four plants installed in the Darchula district, two plants have added an electricity generating facility. Both two electricity generating plants have become a burden to the plant owners. Mr. Prajapati Awasti of Lali village showed the canal constructed along the fragile hill that is subjected to collapse periodically even during the dry season. Darkness returned into the Bhartaula village immediately after second years of the plant operation. Mr. Mohan Dev Pant, owner of the plant in the Bhartaula village, could not replace the rotten wooden poles used in transmission lines since then. Mr. Bahadur Chand who owns a milling plant in the Uku village in the district is almost a bankrupt. However, the villager recalled a long queue in the mill for processing the agricultural products. He abandoned the plant operation and has left the village in search of employment in India.

There are four electricity generating plants out of nine micro hydros installed in the Bajhang district. Mr. Dhirka Bahadur Singh of Bungle village is the only person in the district able to run the electricity plant in the village. Remaining other three electricity generating plants are virtually obsoleted in the Bajhang district. Mr. Singh Bahadur Singh told us that one of his female family members was seriously injured in an accident occurred inside the plant house. He expressed with a grief that the accident not only damaged the electricity generating equipment but also made her disabled to move and walk for the rest of her life.

The cases of micro hydro electricity plant in the Baitadi district are ever severe. There are two electricity generating plants

installed by Mr. Rami Yier in Kotila village and Mr. Dhan Bahadur Bohara in Vatna village in the district. The problem with Mr. Bohra is the wooden poles used in the transmission line. Most of the wooden poles fell down and the electricity supply in the village were interrupted. Mr. Rami Yier was operating his small power plant inside the unroofed power house. Most of the transmission line passes through the live trees across the village. However, his main problem is not the unroofed power house and the transmission line. He almost spent what he had earned in India for maintaining the canal that aligned across the hill of soft rocks. The canal area is slide-prone and is washed away in every rainy season.

But there are few successful micro hydro plants like that owned by Chandra Kant Badayar of Jogpura village in the Dadeldhura district. However, the plants are doing very good business; the owners feel reluctant to pay back the bank loan

thinking it could be write off because only few have paid their loan back.

There could be many reasons behind the unsuccessful operation of the plant in the region. Undeveloped socio-economic background, inaccessibility of the project location, expensive repair and maintenance services and poor feasibility studies of the project are some likely reasons for such failures. These are some examples of the unplanned development program carried out in rural areas of the country thinking that development spontaneously comes after the introduction of technologies. Definitely, the micro-hydro plants integrated agricultural processing with electricity generation could be an excellent visible development tool for the country like ours. The development planner should not only concentrate on the positive aspects of the project while designing but also take care of local factors affecting the development of the technology. □

Environmental Considerations for Road Construction Projects in Nepal

- Deepak Bhattarai*

Preamble

Indubitably, environmental degradation has posed a serious threat to the whole existence in the modern day world. Yet environmental consideration is not a new phenomenon in the field of Civil Engineering construction projects. In some construction projects where I involved previously there was a special provision made for tree-plantation, slope treatment with turfs, separate track for bullock carts as significant measures to improve environment. International consultants and their promoters tried to find a new area called "Environment" where they could have business and much sensation. These days many consultants suggest us as to how we can minimize the felling of the trees, achieve stability by planting grass on the hill slopes, cover the seeds and plants until they grow with the help of jute mesh and so on. Many voluminous books have been flocked into the third world market on subjects like environment, EIA, Vegetation application on road projects, vegetational structure. Conversely, no consultant is available to suggest us how to get rid of our solid waste at affordable cost to keep our roads clean. The environment engineers and scientists are not only getting fund but protection to disseminate and sell to the third world the imported knowledge on subjects which should instead have been dealt by local knowledgeable people or experts on areas like the type of grass required to be planted

on the road sides. In fact, the available knowledge and help including that of various -agencies are usually used to make our projects ever expensive.

Adequate attention is exactly lacking on matters more relevant to the project. Rather than raising high sounding and big issues, our first priority should be over the day to day problems confronting us. It should be admitted that the care for environment is important, more so for the road construction projects in this country. I request that this article be read and understood by Nepali Scientists and Engineers as a message to deliver their knowledge on the subjects that enhance the general environmental condition.

Introduction

Not only for the sake of using new jargon in Engineering Practice, civil engineering construction projects demand greater concern over environmental consideration. Road construction, especially in hilly area demands yet serious consideration about possible degradation of the environment of project vicinity.

Excavation, disposal, blasting, quarrying, borrow pits, tree felling including other construction process need to be considered individually and minutely so that they have minimum effect on the echo system of the area.

The designers during design stage should consider for environmentally acceptable

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road. Topmost priority should be given to the environment as the road is meant to bring prosperity to the people along with up graded environment. Designer should have the conviction that environment and development are not two divergent factors as claimed by some scientists. Rather they are one of the two wheels of the chariot called prosperity, the other wheel being development. The road could be constructed and rehabilitated with enhancement of the environment. Therefore, the road designers and construction engineers should be careful to preserve the environment and help enhance it as far as practicable.

Survey Stage

Existing Environment should be assessed during this stage on the hill road construction. Detailed study should be made about disposing excavated materials should not be disposed on hill slope. Also it should not be dumped on small rivers and gully and torrents. Also, the effect on river system should be studied while making bridges and other structures on river bed and around it.

Impact on environment by possible encroachment by people on road sides after the road is constructed should be considered care fully. The effect on pollution due to vehicular traffic should be studied and appropriate mitigational measure should be undertaken. Solid waste management on the road corridor should be studied and meaningful proposal must be developed.

Another most important aspect to be considered during the stage is the effect on environment of the borrow areas when they are filled with water. The borrow pits

might become the source of bad odor and mosquito breeding along with a source of various diseases.

Also during survey stage the effect of bio-engineering application for improving environment should be considered. Extensive bio-engineering application for the improvement of environment should be practiced.

Survey for eliminating (or minimizing to a great extent) should consist the survey of topography, hydrology and sediment regime of the drainage systems, problems and causes of erosion in the overlooking hill slopes, identification of appropriate bio-engineering measures etc. I would suggest that the area likely to be affected by the road construction should be covered. At least the right of way should be covered meticulously for its protection.

Design stage considerations

All the relevant information collected during survey stage should be processed during the design stage. Each and every design and the effect on environment during its implementation should be considered during this stage. The construction method should be assessed and analyzed by the environmental Engineers and modified at site as required. Environmental considerations should also be incorporated into the design of components like bridges, culverts, bus parks etc.

The specification should be drawn up to give environment friendly effect. For example clause like *"surplus excavated material shall not be allowed to be disposed down the hill or near the drainage system and shall be transported*

to the area specially designated by the Engineer for the purpose" should be introduced into the specification.

Tree plantation along the road strip and method to protect it until it grows should be worked out. Nature type and species of plants should be suggested. Necessary drawings and specifications should be prepared. Extensive use of bio-engineering measures and vegetation structures should be adopted during the design phases.

Environmental considerations during construction

Careful attention has to be paid to protect environment during construction. All the design requirements are to be implemented during this stage. Therefore this is the most important stage in any construction projects. Also it is so from environmental considerations.

Environment friendly method of excavation and disposal should be practiced. Similarly temporary settlement for the construction workers should be properly managed to maintain health of the worker and environment of the surrounding area. In most construction project area local flora and fauna have been found to be affected by the presence of construction workers. Fuel for cooking should always be imported from outside the project area, so also is the materials to

prepare housing to the workers. Latrines must be provided to maintain health of the workers.

Also other social evils like alcoholism and prostitution are found to be associated with the construction projects during construction phase. This has been a major cause for the degradation of social environment of the project area. All these need careful planning and management during construction phase.

Considerations during post construction phase

During this phase detail checks should be done to ensure that all the steps required to maintain and uplift the environmental standard as required by the design are implemented properly.

Regular inspection should be done to ensure that regular maintenance is being followed. Special care should be taken to check if all the plants and materials are returned out of the project area and if all the constructional debris and rubbish are properly dealt with.

Temporary settlements of the labour should be returned to its natural shape before they are abandoned. All the solid waste must be cleaned and local surroundings brought to its normal condition as it was before the construction.

Note: This article is based on a proposal prepared by the author for a road project.
