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THE LIMELIGHT

VOL VII, 2016
AN ESGB PUBLICATION

ENGINEERING STUDENTS' GROUP OF BHAKTAPUR
IOE, PULCHOWK CAMPUS

ENGINEERING STUDENTS' GROUP OF BHAKTAPUR

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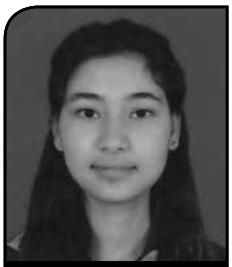
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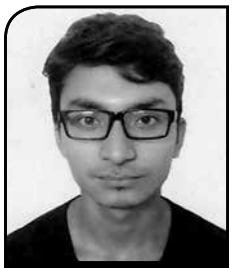
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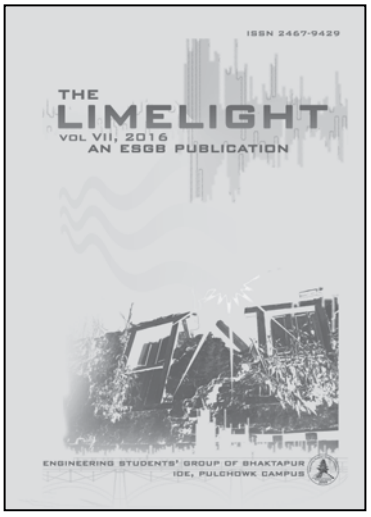

THE LIMELIGHT
PULCHOWK CAMPUS 2005

Editorial

072, wish it was just a bad dream we could forget. The joyous moment of new year celebration couldn't even last for a week. Nature stroke and it stroke harder. It has been a year of disaster, a year of misery. Along with the disaster, there comes a real life lesson about the safety of our structures, our lives more specifically our society.

Along with massive disastrous earthquake, it was also the year of severe energy crisis. Indian blockade followed by political instability after the promulgation of new constitution clearly exposed the huge dependency of our country on foreign nations in energy sector. Based on foreign energy sources, development may be possible but sustainable development is almost impossible till energy sector is locally based and independent to imported resources.

It clearly exposed the zero alertness and precautions to such disasters. One question arises for sure… Whom to blame? It's easy to point our finger to any one of them and keep self on safe side but we shouldn't forget the bitter fact that remaining four fingers are directing to self. Obviously, we can criticize government for zero alertness but it's the duty of each citizen to behave responsibly. Realizing this fact, this time we come up with the new edition of "The Limelight" focusing the technical aspect of earthquake and energy crisis of Nepal.

Despite of obscured obstacles, we are back with the new issue of "The Limelight" and we have tried our best to meet the expectations of the readers. We would like to thank everyone who has directly and indirectly helped us. We would like to express our heartiest gratitude to all our sponsors and well-wishers.

Finally we'd like to mention that we are always expecting your precious comments, creative criticisms, and suggestions for betterment of this journal and to enhance its significance to serve our society.

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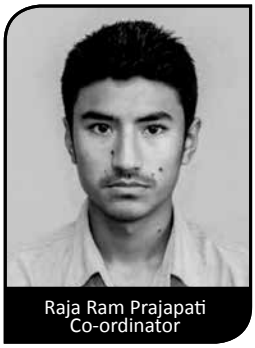
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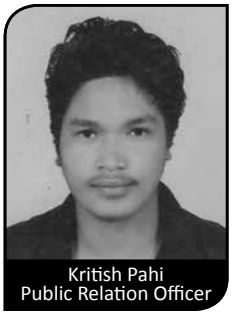
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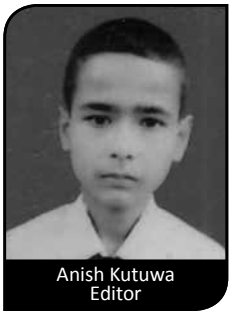
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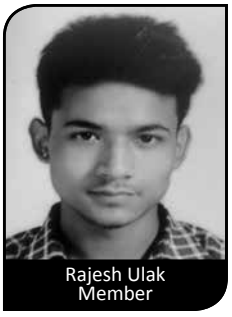
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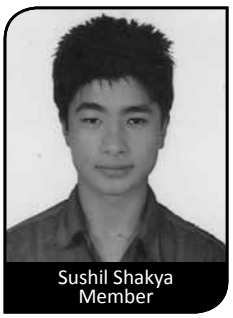
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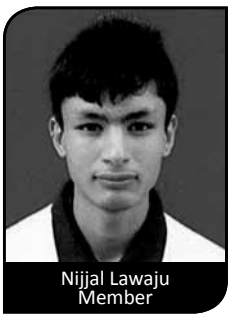
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Date: 15th May 2016

Message from the Dean

I am gratified to know that the 'Engineering Students' Group of Bhaktapur' studying at Central Campus Pulchowk is bringing out 7th issue of their technical journal "**The Limelight 2016**".

The Institute of Engineering (IOE) being the centre of excellence for engineering education in Nepal; it has greater role to achieve its goal and provide excellent manpower to the nation. This can be possible only by setting a mission of quality engineering education in the frontier engineering areas relevant primarily to the nation thereby enhancing national development process. I believe this publication will be one of such steps to achieve the national development goal.

The most important aspect we could derive from this stupendous effort is that it brings out the various technical and analytical skills of the promising engineers. I also applaud the coordination and efforts behind the team to bring out this issue. I congratulate all the contributors and the editorial board for bringing out such a beautiful journal and glad to welcome students with more interest in bringing the article with more bright concepts and innovative ideas in the next issue. I wish them to experience victory in all of their future endeavors.

Prof. Dr. Tri Ratna Bajracharya

Dean

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Pulchowk, Lalitpur

Date: 17th May, 2016

Note from the Campus Chief

It gives me immense pleasure to know that Engineering Students' Group of Bhaktapur is going to publish technical journal "**The Limelight 2016**" which aims to disseminate technical knowledge in the field of engineering. Such technical journals help to upgrade the knowledge and skills of the students in the related field. For the development of nation, technical manpower with proper skill is very much needed. Engineering Students' Group of Bhaktapur of Pulchowk Campus, may play vital role to guide engineering students in the proper direction. Therefore, articles published in journal "The Limelight 2016" will help to broaden the technical knowledge in the field of engineering. I wish the success of the journal and hope more innovative ideas in the future.

Finally, I would like to congratulate members of Engineering Students' Group of Bhaktapur for their hard work in publishing the journal.

Prof. Gokarna Bdr. Motra, Ph. D.,
Campus Chief,
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Pulchowk, Lalitpur,

ENGINEERING STUDENTS' GROUP OF BHAKTAPUR

CENTRAL CAMPUS PULCHOWK, IOE

Lalitpur, Nepal

Ref. No: ..... **Date: 2073 / 02 / 09**

Subject: Message from the President

First of all, I would like to congratulate the current Limelight team in releasing our publication "The Limelight 2016, Vol. VII" after such a long gap of almost 4 years on behalf of all ESGB members. Their tireless efforts, regardless of busy schedule, have made possible to bring out another volume of "The Limelight" and maintain ESGB's pride in the campus.

I'd like to take this opportunity to thank all the material contributors of this journal for providing thought provoking research articles in their respective fields, hereby increasing the value of the journal. Also, I'd like to thank all the senior alumni of ESGB for their experience sharing, advice and guidance through various obstacles faced during publishing this journal. I'd also like to acknowledge the sponsors for their financial assistance, without which this publication would not have been possible.

With time, ESGB has evolved its scope. What started out just as a group to procure college bus, it now carries out various activities such as software training programs, blood donation programs, hiking, picnics, football etc apart from publishing "The Limelight". Organizing programs after earthquake such as free medical camps, stationery distribution to unprivileged children, public toilet construction etc, ESGB has tried to fulfil its responsibility towards the society. ESGB aims to unlock the potential (other than academic) of its members, something which the college frankly doesn't always provide. As the president, it is my absolute pleasure to lead such an enthusiastic group of talented and devoted people.

Finally, I sincerely hope that the future ESGB members would continue such fruitful traditions, and utilize to the fullest the platform that is ESGB for their own personal development, social networking as well as to maintain the ethos of the group.

Shirish Hachhethu
President
13th ESGB Committee

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Quality Control in Construction of Road and Bridge

Prof. GBS Tamrakar
Department of Civil Engineering, Central Campus, IOE T.U.

Abstract: *Quality of works is not found in most of the road and bridge construction in Nepal. In most cases quality constructions are not achieved due to different causes. The major causes in Nepalese context are such as untrained technical staff handling the construction works, due to negligence and not seriously taking care in the construction works, no briefing to the execution team about the work before execution of any activities, lack of the nationality feeling by Construction Industry partners etc. Therefore it is essential to know how to achieve the quality of construction works by the persons involved in the construction industries and is the main objective of this article.*

As per the nature, type of works and elements of road to be constructed various activities can be broadly divided into several works as follows.

I. Earthwork
- Site clearance
- Earthwork in filling for embankment
- Excavation for cutting
- Excavation for borrow pit
- Excavation for structural foundation
- Disposal of surplus earth

II. Drainage Works
- Side drains
- Culverts
- Sub-surface drain
- Causeways
- Minor bridges
- Other water management structures

III. Structural Works
- Earth retaining structure
- Gully control works
- Landslide stabilization works
- River training works
- Bridge protection works
- Anchor wall

IV. Pavement Works
- Sub-grade preparation
- Sub - base course
- Base course
- Wearing course

V. Miscellaneous Works
- Road furniture
- Traffic sign/signal/marking etc.
- Bio-engineering works

As per the nature, type of works and bridge to be constructed various activities can be divided into following works.

Bridge construction
- Foundation
- Abutment/Piers
- Bearings
- Girders/Cross Girders
- Deck slab
- Foot paths / railings

Bridge Protection works
- Abutment / pier protection works
- Upstream and downstream bank protection works

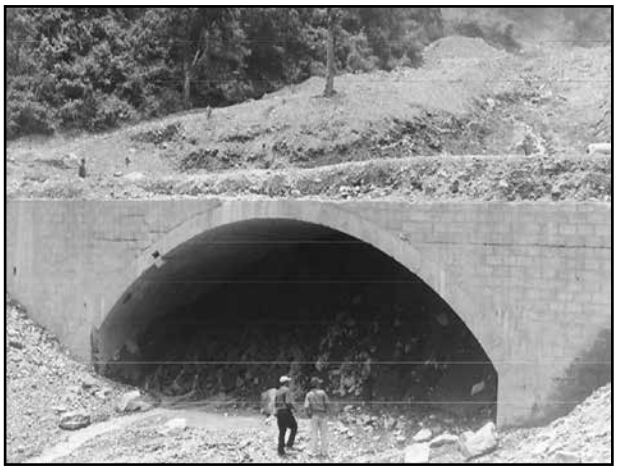
For all the activities for road and bridge construction following steps are to be clearly mentioned and elaborate
- Material requirement
- Tools, equipment and plant requirement
- Construction steps in sequence
- Steps for quality control
- Precaution to be taken while executing the particular activities

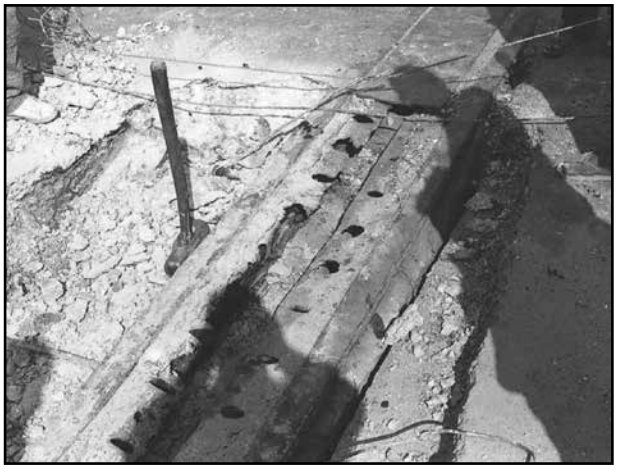
Procedure for the Quality Control of the Construction Materials
1) Checking of manufacture's test certificates of the products for cement, Gabion and reinforcement steel bars.
2) Random sampling of the materials from different sources and conduct tests.
3) Compare the test results with the specification requirement.
4) Approve or reject the source of materials according to the test results.
5) Strictly maintain the source of materials for the construction once approved.
6) In case the source has to be changed repeat the above mentioned procedure steps from (1 to 4).

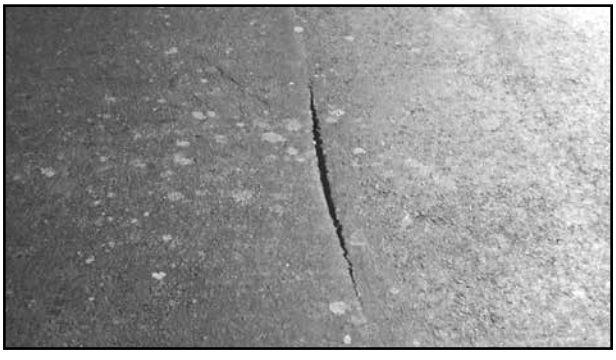
Road, Pavement and Bridge damages due to the Poor Quality of Construction Material and Poor Workmanship in Nepal (Some Photographs)

Definition of Quality by different persons

- Degree of Goodness
- Conformance to requirements or standard specification
- Zero defects
- Fitness for use
- Consistent conformance to expectation
- Doing the right things
- It is the totality of all characteristics of a product or service or as specified, required and expected







In general quality assurance system covers

- Quality control system and procedure
- Quality assurance plan
- Program of tests
- General procedures for acceptance
- Laboratory arrangements and related facilities

These are required for the selection and control of the quality of materials and workmanship.

Major problems seen not achieving quality of construction works in Nepal

* Negligence in construction industrial partners (contactors, consultant and employer).
* Inadequate technical skills.
* Very weak in research or even not at all.
* Not listening seriously the instructions.
* May be insufficient salaries.

What should be done for the quality of work?

Prepare the Quality Assurance plan consisting at least the followings:

- Project Organization Chart.
- Job description and responsibility of different key personnel
- Working procedures of different item of works
- Flow diagrams presenting clear steps for achieving the required quality standards.
- Various Standard test formats and a register for keeping lab/field test records
- Test frequency of different item of works as per BOQ

The contractor will prepare the Quality Assurance Plan (QAP) and submit to the Engineer for his approval. Any activities of the construction works will be then executed very strictly as per the approved QAP document.

JOB Description

(Sample only)

Geotech/Quality Assurance Engineer (QAE)

Location	: Site address
Responsible to	: Contractor's Representative
Responsible for	: Quality Control
Functional Relationship	: To co-ordinate with Employer and Engineer's Representative for quality control
Principal Functions	: To carry out various testing, mix designs etc.
Specific Activities	: To control the quality of construction
Personal Qualification	: Master in Civil Engineering
Timing and Duration	: ……. Months

WORKING PROCEDURES FOR QUALITY WORKS

(For example)

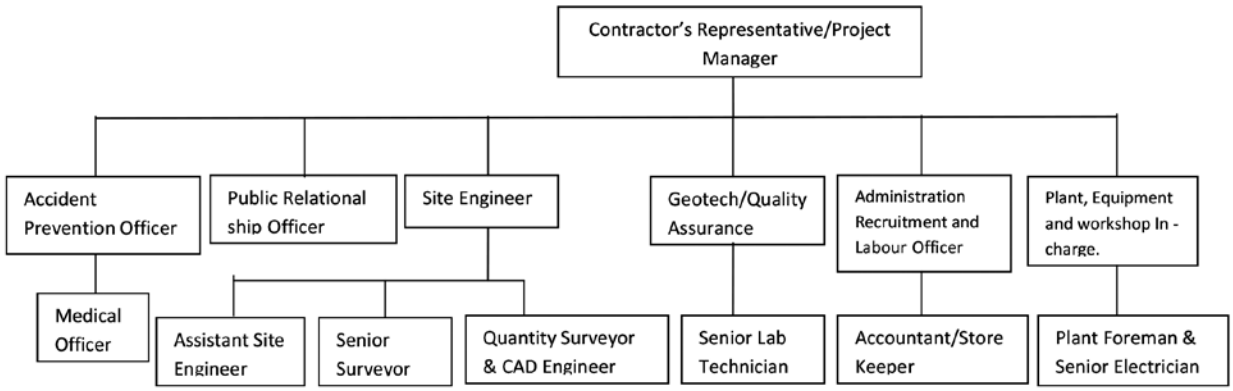
Earthwork in filling for embankment

* Preparation and approval of the plans showing proposed method of work, selection of material, methods of compaction.
* Testing of filling materials and its approval from engineer.
* Construction of successive layers parallel to final road level.
* Compaction of each layer to achieve specified dry density.
* Final checking of sub grade level, dry density and formation slopes.
* Approval of completed section.

Concreting Works:

* Testing and approval of concrete ingredients of specified grade.
* Transportation of materials from crushing plant to batching plant.
* Checking, centering, shuttering and placing reinforcement and taking approval from Employer/ Engineer.
* Production of the concrete by batching plant or mixture as per mix design.
* Pouring of concrete.
* Making working cubes for testing density and compressive strength.
* Curing for 7 days.
* Approval of completed section.

Project Organization Chart



Stone Masonry Work

- Prepare the drawings for the structure and make approval.
- Layout of the structure at the site.
- Approval of the materials to be used (Sand, Cement, Stones, Backfill material etc.).
- Foundation excavation as per the approved drawing.
- Construction of the structure as per specification
- Sampling of mortar for cube testing.
- Curing at least 7 days.
- Proper curing of the section.
- Backfilling in layers with suitable approved material with required compaction.
- Compressive strength testing of mortar cubes for 3 and 7 days.
- Approval of the completed section.

Material Quality Control:

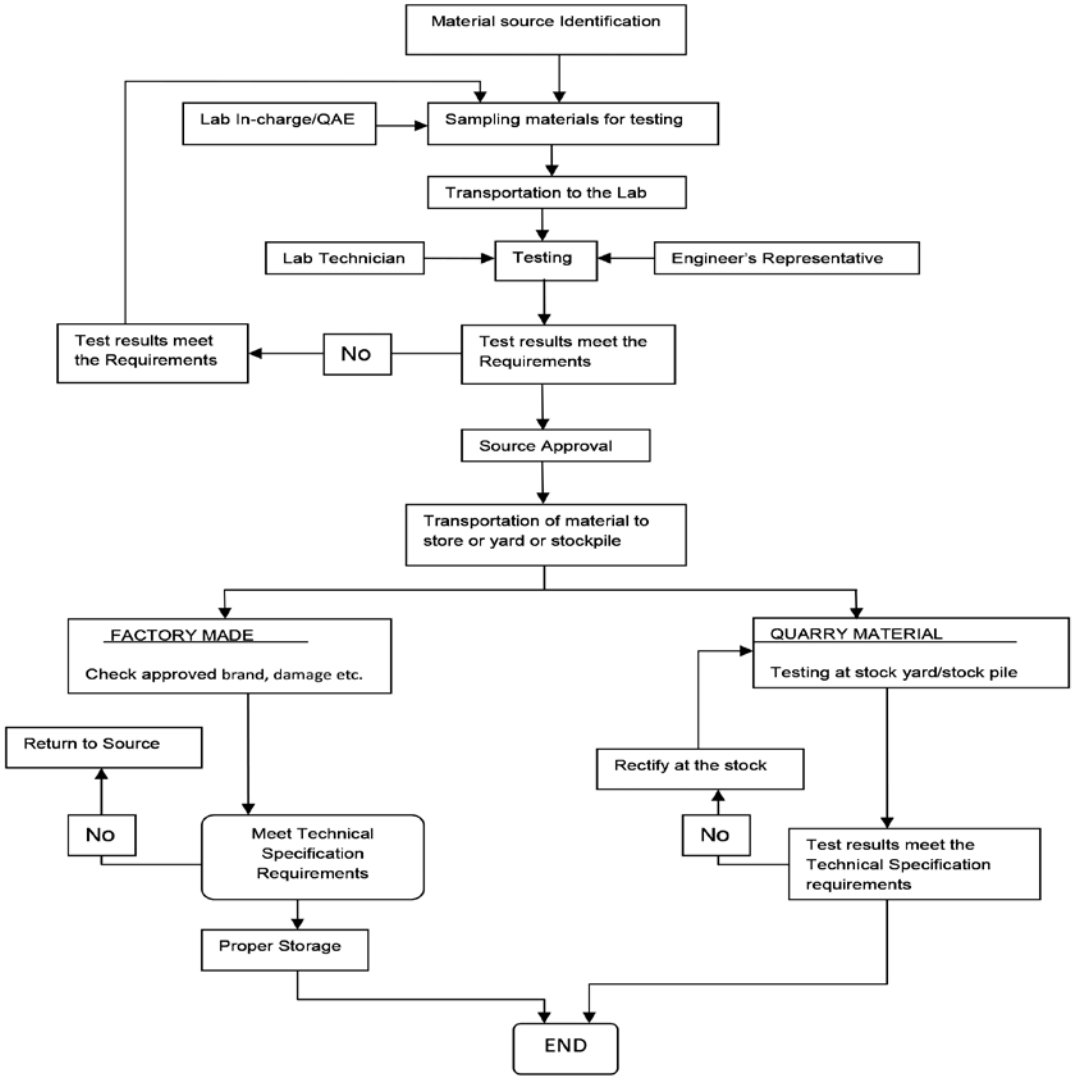
List of Test Formats

Usual list of the formats are as given below for the construction of the road with Otta Seal surfacing, the variation in the number of list may have to be produced depending upon the items of activities in the construction.

- Foot paths / railings
- Gradation of sand for concrete works
- Gradation of sand for masonry works
- Gradation of coarse aggregate for concrete works (M 10/40)
- Gradation of coarse aggregate for concrete works (M 20/20)
- Gradation of gravel sub-base
- Gradation of coarse crusher run material for sub base
- Gradation of aggregate for Otta seal
- Gradation of fine aggregate for Otta seal
- Aggregate crushing value
- Aggregate impact value
- Los Angeles abrasion value
- Water absorption and specific gravity
- California bearing ratio

QUALITY CONTROL FLOW CHART

(For example)



- Determination of moisture content
- Flakiness and elongation index
- Field density
- Compressive Strength of mortar
- Compressive Strength of concrete
- Compaction
- Atterberg's limit
- Penetration and softening point of bitumen
- Spray rate of bitumen and aggregate
- Zinc coating etc

Concrete Mix Design	
Type of Material :	Date of Sample
Source of Material :	Date of Test
Sample Location :	Test Standard

Type of Work :		Lab Ref. No. :	
Sample No. :		Concrete Grade :	
Cement Content :		Mix Ratio	
S.no.	Activities	Formula	Quantity Kg/m3
1	Weight of cement (X)	X	350.00
2	Water cement ratio (Y)	Y	0.50
3	Weight of water (W) = X * Y	W = X*Y	175.00
4	Weight of coarse and fine aggregates	A = D – (X + Y)	1925.00
5	Weight sand (Fine aggregate)	B = A * S	770.00
6	Weight of coarse aggregate	C = A - B	1155.00
7	Ratio	X : B : C : W	350 : 770 : 1925 : 175
8	Mix Ratio	X/X : C/X : B/X : W/X	1 : 2.2 : 3.3 : 0.5
Quantities of ingredients for 3 cube moulds of size 150*150*150mm (Volume = 0.012 m3)			
	Materials	Formula	Quantity for three cubes (Kg)
1	Cement	X * 0.012	4.200
2	Sand (Fine aggregate)	B * 0.012	9.240
3	Coarse aggregate	C * 0.012	13.860
4	Water	W * 0.012	2.100
5	Slump	S1	S2
Comments:			
_____ _____ _____ Tested by Checked by Contractor Q.A Engineer		_____ _____ Witness and checked by Engineer/Employer	Approved by

Quality Assurance Plan - Recapitulative Test Schedule and Testing Program (Samples only)
Earthwork in filling for embankment

Description of Works	**Test Description**	**Frequency of Test**	**Specification Requirement**	**Code/Standard**
Earth works	1. Atterberg's limit	Every 1500 m3 and each new source	LL < 75 & PI < 40	IS 2720 part 5
a) Fill Material	2. Modified proctor density	Every 1500 m3 and each new source	As obtained of material used	IS 2720 part 8
	3. Californoa Bearing Ratio (CBR)	Every 1500 m3 and each new source	> 4 %	IS 2720 part 16
	4. Moisture content	Every 250 m3 of material	90 % - 105 % of OMC	IS 2720 part 2
	5. Field density	500 m2 of each layer with min. 3 test per section	> 95 %	IS 2720 part 28/29

Stone Masonry Work

Description of Works	Test Description	Frequency of Test	Specification Requirement	Code/Standard
Dry stone Masonry and Stonemasonry in cement sand mortar	1. Fineness	Every 200 t and part of it	> 225 m2/kg; < 10 %	IS 4031Part 2
	2. Setting time	Every 200 t and part of it	Ini. 30(Min) & Fin. 600 min (Max)	IS 4031 Part 5
	3. Normal Consistency	Every 200 t and part of it	Around 30%	IS 4301 Part 3
	4. Compressive strength	Every 200 t and part of it	16 (3d); 22 (7d); 33 (28d)	IS 4301 Part 6
	1. Water absorption and specific gravity	Three tests for every source	< 5 %; > 2.65 respectively	IS 2386 Part 3
a) cement	1.Trial mix for all sources	As required	As per mortar grade	At laboratory
b) Boulder/stone	2. Compressive strength of working cubes	Every 10 m3 of masonry	> specified mortar grade	IS 4301 Part 6
c) Trial mix	1. Gradation	Every 100 t and part of it	As per specification	IS 2386 Part 1
d) Sand	2. Mica content	At least once every source	As low as possible	Minerological count
	3. Organic impurities	At least once every source	Free	IS 2386 Part 2

Concreting Works:

Description of Works	Test Description	Frequency of Test	Specification Requirement	Code/Standard
Cement concrete	1. Mix design for all sources			
a) Concrete	2. Compressive strength of working cubes			
b) Cement	1. Fineness	Every 200 t and part of it	> 225 m2/kg; < 10 %	IS 4031Part 2
	2. Normal Consistency	Every 200 t and part of it	Ini. 30(Min) & Fin. 600 min (Max)	IS 4031 Part 5
	3. Setting time	Every 200 t and part of it	Around 30%	IS 4301 Part 3
	4. Compressive strength	Every 200 t and part of it	16 (3d); 22 (7d); 33 (28d)	IS 4301 Part 6
c) Course aggregate	1. Gradation			
	2. Los Angeles Abrasion value			
	3. Aggregate crushing Value			
	4. Alkalily reactivity			
	5. Flakiness index			
	6. Soundness in sodium sulphate			

d) Sand	1. Gradation	Every 100 t and part of it	As per specification	IS 2386 Part 1
	2. Mica content	At least once every source	As low as possible	Minerological count
	3. Organic impurities	At least once every source	Free	IS 2386 Part 2
e) Reinforcement steel	Manufacturer's test certificate with			NS 191 - 2046
	1. Mass per running meter	Every 25 to 45 t depending on dia. of steel bars	As per diameter of steel	NS 191 - 2046
	2. Tensile strength		> 485 N/mm2	NS 191 - 2046
	3. Elongation		> 14.5 %	NS 191 - 2046
	4. Bend and rebend test		No cracks; No fractures	NS 191 - 2046

Here in this article working procedure for quality works, quality control flow chart, list of test formats, a test format and test frequency are given some samples only. For success of the construction works quality assurance plan is very important to prepare in detail before execution of any activities of road and bridge works. This plan should not be prepared only for the formality for the project, which many project in Nepal, happened. This quality assurance plan should be strictly followed during the construction phase to achieve and accomplice works professionally with quality. Also sincere efforts are equally necessary during construction phase to achieve better quality of works. Hope this article will help to those technical staffs who are involved in the construction of road and bridges.

Hydropower Development: Before and After 1992

Ratna Sansar Shrestha
Water Resource Analyst, FCA

Abstract: *Hydropower Development Policy promulgated in 1992 by Government of Nepal (GoN) heralded domestic and foreign private investment in hydropower projects, which was instrumental in adding 255,647MW to the system with the investment of USD493 million in a period of 23 years. While, public sector succeeded to add only 238.6MW during the same period; thus adding a total of 489.14MW to the system by public and private sectors. As cumulative total installed capacity of projects implemented prior to it in 8 decades from 1911 through 1991 was only 239.33 MW, it manifests successful implementation of the policy with resultant mobilization of private investment.*

Only 9th five-year plan period (1997-2002) succeeded to achieve 91% of the target set for the period resulting in mismatch in the growth of demand and supply; consequently load shedding. The reasons behind the failure need an in-depth analysis and critique of the policy and improvement thereof.

Introduction

Main subsectors of power sector are generation, transmission and distribution of electricity. Hydropower development policy was promulgated for the first time in 1992 and another one was formulated in 2001, supplanting the previous one. These have opened all subsectors of power sector for private investment. However, no private sector has shown interest in investing in transmission projects to generate revenue stream from wheeling charges, while apart from Nepal Electricity Authority (NEA), only Butwal Power Co. (BPC)[1] is involved in distribution. The focus of this paper is to conduct a comparison of hydropower development before private sector (entailing private investment, both domestic and foreign) was allowed and afterwards, in terms of projects commissioned for Nepal's internal consumption without delving into export/import of electricity. This paper does not attempt to record exhaustive history of hydropower development in Nepal.

Private investment in hydropower projects ranges from investment of, *inter alia* financial resources for the creation of national infrastructure assets or its upgrade/ rehabilitation to management of public property entailing no capital investment. All of these are manifestations of public private partnerships (PPP) under which public resources are used along with private investments (either human resources only or both financial and human resources) to deliver services/commodities. Private sector taking over the management of the assets owned by the public sector, for example, under a lease agreement is a type of PPP wherein private sector doesn't invest financial resources to create assets but manages the assets during the lease period. Whereas, private investment to build hydropower plants under build, own, operate and transfer (BOOT) mechanism is a modality of PPP, which is one of the modalities recognized by hydropower development policy of Nepal. Under BOOT modality private sector not only mobilizes funds to create hydro assets by implementing the project but also manages the assets till the time of its handover to Government of Nepal (GoN).[2]

Domestic and foreign private sector have invested its own resources (as equity) and also mobilized debt from domestic and international financial intermediaries (FIs)– banks as well as nonbanking financial institutions – to create fixed assets, for the generation of electricity, and have been successfully managing them, including selling electricity in bulk to NEA. In this respect, Nepal's power sector entered the PPP age with the advent of economic liberalization after the restoration of democracy in 1990.

Historical Backdrop

The first hydropower project in Nepal was commissioned on 22nd May 1911(inaugurated by late King Prithvi Bir Bikram Shah) in Pharping, about 10 km south of Kathmandu, using water from two spring sources, Satmule and Shikha Narayan,[3]with installed capacity of 500 kW. Through till 1991, the power sector was in the public domain exclusively – under the ownership of NEA, a public enterprise fully owned by the GoN, created on August 16, 1985 under the Nepal Electricity Authority Act, 1984; created through the merger of the then Department of Electricity under the then Ministry of Water Resources (now called Ministry of Energy), Nepal Electricity Corporation, Eastern Electricity Corporation and related development boards. It was established to make arrangements for supply of electricity by generating, transmitting and distributing in an efficient, reliable and convenient manner. Various projects with cumulative total installed capacity of 239,330 kilowatt (kW) were built from 1911 through 1991 under the ownership of NEA (as listed in annex 1).

As an exception to the situation obtaining at that time hydropower enthusiasts of the United Mission to Nepal (UMN), led by an electric engineer from Norway Mr. Odd Hoftun, started building hydropower plants outside the ambit of public sector and his team was instrumental/successful in the implementation of Andhi Khola Project, 5,100 kW (commissioned in June 1991).[4] Built with the financial assistance from the Norwegian government under an agreement between GoN and UMN, this project was implemented by BPC; 98.88% of its equity was owned by UMN, and NEA and Nepal Industrial Development Corporation (NIDC) holding 1.06% and

1 It was privatized in 2003 by GoN

2 BOOT is the only concession mechanism recognized by Electricity Act, 1992 and other forms of concession mechanisms like (a) build and transfer, (b) build, operate and transfer, (c) build, transfer and operate, (d) lease, operate and transfer, (e) lease, build, operate and transfer, (f) develop, operate and transfer, etc. aren't recognized. Private Financing of Construction and Operation of Infrastructure Act, 2006, however, does recognize all forms of concession mechanisms, which doesn't fall under the ambit of this paper.

3 Dixit, Ajay, 2002. *Basic Water Science* Nepal Water Conservation Foundation, p 355.

4 UMN was also instrumental in building Jhimruk project, 12,100 kW, in the similar manner as Andhi Khola.

0.06% equity respectively[5]. This project was conceived and implemented prior to formulation of policy allowing private investment in hydropower sector in 1992. Actually, the first hydropower project undertaken by this group was Tinau (1,024 kW), completed in 1972 with Norwegian government gran[6], which was handed over to Nepal Electricity Corporation (predecessor of NEA) through GoN and is in operation even today under the ownership of NEA. Thus, in 80 years since commissioning of Pharping, Nepal's total installed capacity stood at 244,430 kW; 239,330 kW (including 4.536 MW isolated & mini hydropower plants) built and owned by NEA and 5,100 kW built with Norwegian government assistance and owned by BPC.

Power Generation under New Policy

When Andhi Khola project was about to be commissioned and Jhimruk project construction was halfway through, UMN conceived of implementing of Khimti Project (60,000 kW). However, for the implementation of a project of this scale, a larger quantum of financial resources was needed, mobilization of which was beyond the capabilities of UMN and, therefore, Norwegian private investors were roped in. In order to access foreign private equity and debt from the multilaterals, and in the backdrop of the implementation of modern economic concepts of liberalization, privatization, and globalization (LPG) in Nepal, and adhering to the worldwide trend, the promoters of the Khimti Project wished to have necessary legal environment conducive for the purpose in early 1990s in Nepal. The Norwegian government provided technical assistance to help Nepal draft an appropriate policy and legislation for the purpose. Initially, it was thought that a special statute was needed just for the Khimti Project. This idea was later dropped, as it would have been too narrow—an enactment of parliament just for one project.

Subsequent to several rounds of discussion and deliberations between Nepali and Norwegian legal experts, the policy/legal framework that we have now was introduced, viz. Hydropower Development Policy (HDP) 1992, Water Resources Act 1992 and Electricity Act 1992[7]. The unveiling of these three documents was an important milestone in the history of Nepal's power sector because it heralded entrée of private investment in the power sector, thus a significant part of infrastructure sector. This is the first policy related to the power sector in Nepal, which sets out the modality that uses public resources and private investments to deliver services.

As explained above, as against the cumulative capacity of the power system built in eight decades since 1911 totaled 244,430 kW, 494,247kW hydropower was added to the system in 22 years under new policy; more than twice in 22 years compared to 8 decades. During this period (1992-2014) NEA on its own added 238,600kW to the system as detailed in Annex 2. Whereas the private sector implemented and commissioned power projects totaling 250,547kW (excluding 5,100 kW built under the auspices of UMN)—about 5% more than implemented by NEA during the same period, as detailed in Annex 3.

The electricity generated by these is sold to NEA in bulk under power purchase agreements (PPAs) executed between NEA and the respective independent power producers (IPPs).

As PPP is a modality that uses public resources and private investments to deliver services, the credit for the addition of 255,647 kW in Nepal's power system by the private sector goes to the PPP concept enshrined in the Electricity Act. Thus, the cumulative installed capacity built by private sector so far stands at 32% of the total installed capacity in a system of 787,087 kW (including 53,410 kW thermal and 100 kW solar, owned by NEA).

Private Investment

Although the sector was liberalized in 1992, it succeeded to attract private investment only in 1996 upon successful financial closure of Khimti project (first project with private investment), in January 1996, for which a PPA was signed in March 1994[8] (the first such instrument signed in Nepal). This is a turning point in the history of infrastructure development of Nepal, which succeeded to attract private investment, both domestic and foreign (FDI – foreign direct investment). The status of private investment in commissioned hydropower projects, through till mid-July 2014 is as follows:

5 Of the 98.88% equity in BPC held by UMN, 96.09% was transferred to GoN in 1996 free of cost pursuant to the agreement between GoN and UMN (thereby leaving a token 2.79% ownership with UMN). GoN divested 87 percentage points of its holding to pri vatize BPC in 2003; 75% to strategic investors, 10% to general public and 2% to BPC staff. GoN now holds 9.09% equity.

6 UMN through BPC built another project, Jhimruk (12,000kW), commissioned in August 1994 in the same manner ass Andhi Khola.

7 However, the then secretary of Ministry of Water Resources, Mr. Surya Nath Upadhyay has denied that the policy/legal framework was prepared with the Norwegian assistance in several public forums.

8 Proponent of Khimti project refused to implement the project on the basis of the PPA signed in 1994 claiming that the project is not feasible under the tariff regime and, therefore, NEA was forced to revise the tariff upwards in January 1996.

Status of private investment[9]

Project	Capacity in kW	Investment MUSD		
		Domestic	International	Total
Khimti Khola [a]	60,000	5.1	136.9	142
Upper Bhote Koshi [b c]	45,000	1.75	68.25	70
Syange Khola	183	0.32	0	0.32
Indrawati Khola III [d]	7,500	22.1	1.2	23.3
Chilime Khola [e]	22,000	32.9	0	32.9
Piluwa Khola [f]	3,000	4.4	0	4.4
Rairang Khola	500	1	0	1
Sun Koshi [g]	2,500	5.3	0	5.3
Chaku Khola	3,000	6	0	6
Baramchi Khola	4,200	8.4	0	8.4
Khudi Khola	3,450	8.3	0	8.3
Thoppal Khola	1,650	3.3	0	3.3
Pheme Khola	995	1.99	0	1.99
Sisne Khola	750	1.5	0	1.5
Sali Nadi	232	0.46	0	0.46
Pati Khola	996	1.99	0	1.99
Seti Khola II	979	1.96	0	1.96
Ridi Khola	2,400	4.8	0	4.8
Upper Hadi Khola	991	1.98	0	1.98
Mardi Khola	4,800	9.6	0	9.6
Mai Khola	4,500	9	0	9
Lower Piluwa Khola	990	1.98	0	1.98
Hewa Khola	4,455	8.91	0	8.91
Bijayapur-1	4,410	8.82	0	8.82
Siuri Khola	4,950	9.9	0	9.9
Lower Modi	9,900	19.8	0	19.8
Sipring Khola	9,658	19.32	0	19.32
Solar (KUKL) [h i]	680.4	0	6.14	6.14
Tadi Khola	5,000	10	0	10
Middle Chaku	1,800	3.6	0	3.6
Charnawati Khola	3,520	7.04	0	7.04
Lower Chaku	1,765	3.5	0	3.5
Ankhu Khola	8,400	16.8	0	16.8
Bhairab Kunda	3,000	6	0	6
Radhi Khola	4,400	7.41	0	7.41

9 Investment data in projects is based on information available in the public domain. For reasons of confidentiality, most private investors don't publicize project costs, in which case cost has been estimated at USD 2,000/kW.

a Total cost as mentioned in HPL website (http://www.hpl.com.np/)

b As EPC cost was $ 48 million, according to Chris R. Head (mentioned in "Financing of Private Hydropower Projects" in World Bank Discussion Paper No. 420), other soft costs, including interest during construction even if were as high as $ 20 million, the total cost could not be higher than $ 70 million

c In 2006, Panda Energy (original developer) divested 75% shareholding in BKPC, which was bought over by Nepali developer.

d Source: National Hydropower Co. Ltd.

e Source: Chilime Hydropower Co. Ltd.

f Source: Arun Valley Hydropower Development Co. Ltd.

g Source: Sanima Hydropower Ltd.

h Source: KUKL

i The cost is exclusive of cost of batteries (not used) and land used.

Chhote Khola	993	1.8	0	1.8
Mailung Khola	5,000	10	0	10
Total	**238,547.4**	**267.03**	**212.49**	**479.52**

Similarly, $13.5 million was invested by the institutional private sector (a consortium of Nepali and Norwegian investors)[10] in buying 75% shares in BPC, owner of Andhi Khola (5,100 kW) and Jhimruk (12,000 kW) projects, divested by GoN, as mentioned above. Thus, in 22 years, the private sector succeeded to mobilizeand invest $ 493.02 million ($479.52 million directly plus $ 13.5 million in buying BPC shares) into 255,647 kW hydropower projects.

Planned Development of Hydropower

Although hydropower sector was liberalized under the policy formulated in 1992, on-site activity to implement private sector projects only started in 1996 and first power project (Khimti) was commissioned in July 2000, during 9th Five-year plan. In this backdrop an evaluation of each such plan period will help to compile a score-card of the policy heralding private investment in the sector and also help gauge the success or failure of each such plan as well as to diagnose problems and suggest improvement measures.

Eighth Five Year Plan

It was in the first year of 8th Five Year Plan, for the period 1992-1997 that Hydropower Development Policy, 1992 and Electricity Act 1992 were promulgated to allow private sector entry into hydropower sector. The target set for this period was 29.7 Mega Watt (MW: thousand kilowatt) and following projects, totaling 15.2 MW, were completed:

Projects completed in 8th Plan period

	Installed Capacity kW	
Projects	**NEA**	**Private Sector**
Chatara	3,200	
Jhimruk		12,000

It should be noted that 12 MW was completed by "private" sector, but the project was started in 1989, even before enabling legal environment was put in place for private sector to build hydropower projects.

Ninth Five Year Plan

Ninth five year plan, for the period of 1997-2002, had set a target of increasing installed capacity by 293MW and following projects were successfully implemented during the period; adding about 268.7 MW to the system:

10 Nepali company Shangri-La Energy Ltd. (SEL) owns 68.95% and Norwegian company IKN Nepal AS (IKNN) owns 6.05%.

Projects completed in 9th Plan period

	Installed Capacity kW	
Projects	**NEA**	**Private Sector**
Indrawati		7,500
Kali Gandaki A	144,000	
Khimti		60,000
Modi	14,800	
Puwa	6,200	
Syange		183
Upper Bhote Koshi		36,000
Total	**165,000**	**103,683**

Nepal achieved 91% of the target during this period. This is stellar performance to date of planned development of hydropower in Nepal.

Tenth Five Year Plan

Tenth five year plan, covering the period of 2002-2007, had aimed to add 314.6 MW installed capacity. NEA was expected to complete 70 MW Middle Marshyangdi and 30 MW Chamelia projects, totaling 100 MW. The private sector was expected to complete assortment of projects totaling 214.6 MW. Compared to ninth plan the achievement of the tenth plan was very dismal as NEA failed to add a single MW11, while the private sector succeeded to add only 33.93 MW by completing following projects:

Projects completed in 10th Plan period

	Installed Capacity kW	
Projects	**NEA**	**IPPs**
Baramchi		980
Chaku		1,500
Chilime		22,000
Khudi		3,450
Piluwa		3,000
Rairang		500
Sun Koshi		2,500
Total kW		**33,930**

Only 10.78% of the target was achieved during this period.

First Interim Three Year Plan

A target of 105 MW was fixed for first interim 3-year plan (2007-10), of which NEA completed Middle Marshyangdi project, 70 MW. Private sector completed following projects during the period:

11 Middle Marsyangdi was completed in 2008 during the first year of 3-year Interim Plan while work on Chamelia is still going on.

Projects completed in the first 3- year Interim Plan

	Installed Capacity kW	
Projects	**NEA**	**IPPs**
Mardi		3,100
Middle Marshyangdi	70,000	
Pati		996
Pheme		995
Ridi		2,400
Sali Nadi		232
Seti II		979
Sisne		750
Thoppal		1,650
Upper Hadi Khola		991
Total kW	**70,000**	**12,093**

In this manner 82 MW was added to the system against a target of 105 MW which is a significant achievement; 78 percent. However, Middle Marshyangdi was supposed to be commissioned in the previous plan period - specifically 2004.

Second Interim Three Year Plan

A target of 281 MW was set for 2nd three-year interim plan spanning from 2010 to 2013. However, only an isolated mini hydro project 400 kW Gamgad (in Mugu district) was completed by NEA. On its part, private sector completed following projects totaling 49.863 MW:

Projects completed in the Second 3-year Interim Plan

	Installed Capacity kW	
Projects	**NEA**	**IPPs**
Bijayapur-1		4,410
Charnawati		3,520
Gamgad	400	
Hewa Khola		4,455
Lower Modi		9,900
Lower Piluwa		990
Mai Khola		4,500
Middle Chaku		1,800
Sipring		9,658
Siuri		4,950
Solar (KUKL)		680
Tadi		5,000
Total kW	**400**	**49,863**

Following projects were upgraded in this plan period by the private sector to add 6.42 MW capacity as follows:

Addition to Installed Capacity

	Existing capacity kW	Added capacity kW	Total kW
Baramchi upgrade	980	3,220	4,200
Chaku upgrade	1,500	1,500	3,000
Mardi upgrade	3,100	1,700	4,800
Total kW	**5,580**	**6,420**	**12,000**

Similarly, NEA signed Supplementary PPA for additional power of 9 MW[12] with Upper Bhote Koshi Project Company on July 8, 2012 at Rs 1.625/kWh[13], thereby adding 9 MW to the system.

Against a target of 281 MW for the 2nd Interim Plan, only 65.683 MW was added to the system – an achievement of meager 23%.

Third Interim Three Year Plan

It was targeted to add 668 MW in the system during this plan period, 2013 to 2016. However, NEA commissioned no project in the first year of 3rd Interim Three Year Plan (FY 2013/14) while following projects were commissioned by private sector in FY 2013/14:

Projects completed in first FY of Third 3-year Interim Plan

	Installed Capacity kW	
Projects	**NEA**	**Private Sector**
Ankhu Khola		8,400
Bhairab Kunda		3,000
Chhote Khola		993
Lower Chaku		1,765
Mailung Khola		5,000
Radhi Khola		4,400
Total kW		**23,558**

Conclusion

Out of 494, 274kW hydropower added to the system in 23-year period after promulgation of new policy, 250,547kW was added by private sector, which signifies that the policy has been a success. Hydropower, being an important part of infrastructure, was thought to be in the public domain till the advent of this policy. An important feather in its cap is the fact that due to introduction of this policy and related legal environment, private sector invested about US$500 million.

With an achievement of 91 percent of the target during 9th five-year plan period, it stands out as the Golden Era in terms of success of new policy and hydropower development. However, the achievements during subsequent plan periods have not been very encouraging. This calls for introspection and the policy and legal environment requires to be revised and refined.

12 Although licensed for 36 MW and armed with PPA for same installed capacity, the project company had commissioned 45 MW project in January 2001 but NEA refused to accept dispatch of additional 9 MW till SPPA was signed.
13 Source: http://www.bhotekoshi.com.np/faqs.php

Annex 1
Power projects built in 8 decades since 1911

Year	Power Plants	Capacity kW
1911	Pharping	500
1935	Sundarijal	640
1965	Panauti	2,400
1967	Phewa	1,000
1967	Trishuli	24,000
1972	Sun Koshi	10,050
1978	Tinau	1,024
1979	Gandak	15,000
1981	Baglung	200
1981	Doti	200
1981	Phidim	240
1982	Kulekhani I	60,000
1983	Jomsom	240
1984	Devighat	14,100
1985	Seti	1,500
1986	Kulekhani II	32,000
1988	Terhathum	100
1989	Khandbari	250
1989	Marsyangdi	69,000
1989	Ramechhap	150
1991	Surnaigad	200
1991	Tatopani	2,000
Isolated & mini hydropower plants		4,536
	Total kW	**239,330**

Annex 2
Hydropower projects commissioned by NEA till 2013/14 since 1992

Year	Power Projects	Capacity kW
1995/96	Chatara	3,200
1999/00	Puwa Khola	6,200
2000/01	Modi Khola	14,800
2002/03	Kali Gandaki A	144,000
2007/08	Middle Marshyangdi	70,000
2011/12	Gamgad	400
	Total kW	**238,600**

Annex 3
Hydropower projects implemented by private sector till mid-July 2014 since 1992

Year commissioned	Project	Installed capacity kW
2090/91	AndhiKhola	5,100
2094/95	Jhimruk Khola	12,000
2000/01	Khimti Khola	60,000
2000/01	Upper Bhote Koshi	45,000
2001/02	Syange Khola	183
2002/03	Indrawati Khola	7,500
2003/04	Chilime Khola	22,000
2003/04	Piluwa Khola	3,000
2003/04	Rairang Khola	500
2004/05	Sun Koshi	2,500
2004/05	Chaku Khola	3,000
2006/07	Baramchi Khola	4,200
2006/07	Khudi Khola	3,450
2008/09	Thoppal Khola	1,650
2008/09	Pheme Khola	995
2008/09	Sisne Khola	750
2008/09	Sali Nadi	232
2008/09	Pati Khola	996
2008/09	Seti Khola II	979
2009/10	Ridi Khola	2,400
2009/10	Upper Hadi Khola	991
2009/10	Mardi Khola	4,800
2010/11	Mai Khola	4,500
2010/11	Lower Piluwa Khola	990
2011/12	Hewa Khola	4,455
2011/12	Bijayapur-1	4,410
2012/13	Siuri Khola	4,950
2012/13	Lower Modi	9,900
2012/13	Sipring Khola	9,658
2012/13	Solar (KUKL)	680.4
2012/13	Tadi Khola	5,000
2012/13	Middle Chaku	1,800
2012/13	Charnawati Khola	3,520
2013/14	Lower Chaku	1,765
2013/14	Ankhu Khola	8,400
2013/14	Bhairab Kunda	3,000
2013/14	Radhi Khola	4,400
2013/14	Chhote Khola	993
2013/14	Mailung Khola	5,000
	Total kW	**255,647.4**

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Trend and Probability Analysis of Gorkha Earthquake-2072

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Abstract: *An earthquake is the shaking of the surface of the Earth. Earthquake is a natural disaster and it affects the artificial structures as well as natural bodies of the earth heavily. The earthquake can be violent enough to destroy major buildings and kill thousands of people. The damages of the structures depend upon the magnitude of earthquake and its epicenter. There is a trend to follow the earthquake by several aftershocks normally less magnitudes than the main one. However, the affects of aftershocks are equally danger to damage the structures. That means aftershocks of high magnitude earthquake eventually help to damage the structures for a long duration. Hence it is necessary to know the probability of repetition of different magnitude aftershocks and its occurrence trend, so that it is possible to update human knowledge and become more confidence for secure life. In this paper, it is analyzed the trend of occurrences of aftershocks of Gorkha Earthquake-2072 and probability levels of occurrence of different magnitude aftershocks. The analysis the aftershocks of Gorkha Earthquake-2072 show that the occurrence of aftershocks is diminishing both repetitions in time duration and magnitude. From probability analysis, it shows that the chances of occurrence 5.0 Richter scale or high magnitude aftershocks are less than 10 percent.*

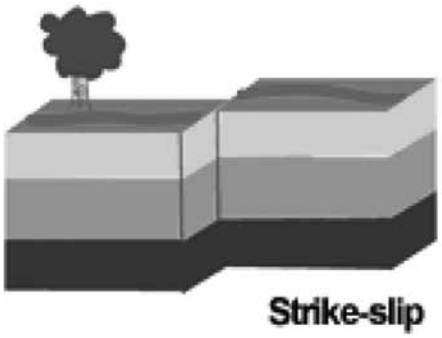
Introduction

An earthquake is the perceptible shaking of the surface of the Earth, which can be violent enough to destroy major buildings and kill thousands of people (Wikipedia, 2015 Sept). In scientific terms it also known as a quake, tremor or temblor. The range of severity of the shaking scaled from barely felt to violent enough. Actually, they result from the sudden release of energy in the Earth's crust that creates seismic waves. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

Seismometers are the equipments using to measure the earthquakes. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter magnitude scale (Wikipedia, 2015 Sept). However, these two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible. Magnitude 7 and over potentially cause serious damage over larger areas. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. The most recent large earthquake of magnitude 9.0 or larger was a 9.0 magnitude earthquake in Japan in 2011 and March 2014 (Earthquake FAQ, 2014).

Motive of Earthquake Events

Earthquake normally occurs naturally. The movement or displacement takes place by disturbing the earth's fault plane. A fault plane is the plane that represents the fracture surface of a fault. A fault trace or fault line is the intersection of a fault plane with the ground surface.



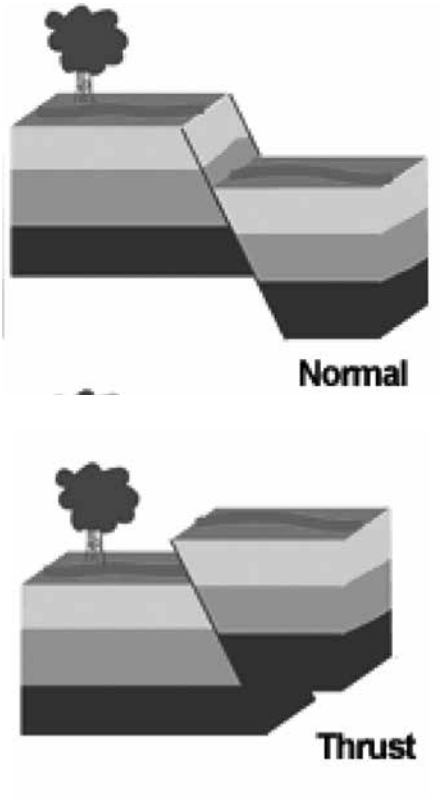


Figure 1: *Fault types (Ohnaka, 2013)*

Elastic strain energy leads to drive fracture propagation along a fault plane and tectonic earthquakes occur anywhere in the earth. The sides of a fault move past each other smoothly. However, if there are no irregularities or asperities along the fault surface, then it increase the frictional resistance and moves aseismically. Most fault surfaces do have such asperities and this leads to a form of stick-slip behavior. Once the fault has locked, continued relative motion between the plates leads to increasing stress and therefore, stored strain energy in the volume around the fault surface. This continues until the stress has risen sufficiently to break through the asperity, suddenly allowing sliding over the locked portion of the fault, releasing the stored energy (Ohnaka, 2013).

Sometimes, when the epicenter of a large earthquake is located in sea, it may cause a tsunami. Earthquakes can also lead for trigger landslides, and occasionally volcanic activity.

Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity and landslides. An earthquake's point of initial rupture is called its focus (hypocenter) and the point at ground level directly above the hypocenter is called epicenter.

Nepalese Earthquake History

In Nepal, many types of disaster come one by another or repeated the same type of disaster such as earthquakes, landslides, floods, etc. Hence, Nepal is a disaster prone country. Many people loss their life from such type of disaster. One of the most dangerous disasters is earthquake and country losses many lives and wealth because of earthquake from time to time. Disaster Preparedness Network Nepal has done a long research on Nepalese earthquake history. As per its collection, it can conclude that Nepal is a seismic prone country and the risks it faces from earthquakes are very high. Past records have shown that Nepal can expect two earthquakes of magnitude 7.5-8 on the Richter scale every forty years and one earthquake of magnitude of 8+ in Richter scale every eighty years. The last great earthquake to strike Nepal was in 1934 which had a magnitude of 8.3 Richter. It caused considerable damage to buildings along with great loss of lives. Since then, the population in Nepal has skyrocketed; urban development, unplanned and construction practices have deteriorated. If a similar earthquake to that of 1934 was to strike now, it would cause a greater loss of lives and properties (http://www.dpnet.org.np).

From the recorded major earthquakes of Nepal show that it does not follow the frequency and trend regularly; however a probability trend can be clearly identified. Table 1 shows the major recorded earthquakes of Nepal and their tentative destructions to the society. From records, it can be seen that 1255 AD earthquake also killed the king Avaya Malla too. That means the strength of that earthquake was very high and epicenter might be in Kathmandu Valley. In such a great threat due to earthquake disaster, we need to know the trend of its aftershocks so that human can make their living more secure and more conscious.

GORKHA EARTHQUAKE - 2072

A strong shock was felt in Kathmandu on April 25, 2015 at 11:56 AM (Nepal Standard Time). Many people lost their conscious due to the strong disaster event. Immediately, it was known an Earthquake (EQ) of magnitude 7.6 ML battered at Barpak of Gorkha district of Nepal that heavily shocked the whole country. The earthquake (commonly known as Gorkha Earthquake-2072) severely damaged the physical infrastructure of many districts in the country. The country suffered heavily by this great pain. After 17 days of the first hit, (i.e. on May 12, 2015 at 12:50 PM) another Earthquake of magnitude 6.8 ML hit the country which have epicenter at Dolakha District. Several aftershocks (around 383) of this earthquake are following until till the date. Nepalese peoples are under great shocks and have feared to re-occurrence of such type of events. Even they are unable to sleep well till the date. People of Nepal, will never forget such a painful event. The earthquake shocks were spread to most parts of Nepal.

The recorded earthquake data are taken from the official website of National Seismological Centre, Government of Nepal and develop a graph. Figure 2 shows the magnitude of earthquakes (>= 4 ML) that hit Nepal on different dates until August 23, 2015 (6 Bhadra 2072). In Figure 2, it can be seen that on April 25, 2015, while a great magnitude earthquake (7.6 ML) battered, several aftershocks were followed in the same day with nearby high magnitudes than, aftershocks were followed sufficiently, but lesser in magnitudes. Similarly, on May 12, 2015, while another strong earthquake was battered, several aftershocks were followed in the same day or within 24 hours. Here it should be noted that,

Table 1: Some recorded major earthquakes of Nepal since 1310 BS and their affects

Date		Magnitude (ML)	Damage Level	Remarks
BS	AD			
1310	1255 June 7	7.7	Severely	-One third of total population of Kathmandu killed -King Avaya Malla Killed
1316	1260	-	Severely	- Many buildings and temples collapsed - Reign of King Jayadev Malla
1463	1408 August		Severely	- Many temples and buildings collapsed - Heavy loss of lives and livestock - Reign of king Shyam Singh
1737	1681 December		Severely	- Heavy loss lives as well as many buildings were collapsed
1866	1810 May		Severely	- Many houses, building were damaged - Seventeen earthquake tremors of various magnitudes were felt - Reign of King Girban Yudha Bikram Shah
1890	1833 August		Severely	- Two major strikes were experienced - Many houses, temples were collapsed - Dharahara tower was also severely damaged - Many building and temples were utterly destroyed (4214 houses)
1891	1834 June		Severely	-Four major earthquakes were felt -The Bagmati River was over flooded and a bridge over the river also swept away -Many houses collapsed all over the country (More than 18000 houses)
1990 Magh	1934 January	8.4	Severely	-Known as Bihar Earthquake 1934 - 8519 people lost their lives in Nepal - 126355 houses were severely damaged - 80893 buildings were completely destroyed

Source: Collection from web-report of Disaster Preparedness Network Nepal

the second earthquake also the aftershock of first one and it followed the principle of science (i.e. aftershocks are normally lesser magnitudes than the main earthquake). The analysis of the earthquake events, Figure 2 shows that aftershocks after the earthquake on May 12, 2015, are all expected magnitudes. Almost all are lesser than 5.5 ML magnitudes and majority events fall under 4.5 magnitudes. However, aftershocks between 4.0 ML to 5.0 ML, there are sufficient fluctuations in magnitudes and events. But, from Figure 1, there is possible to extract the confidence that the earthquakes are settling slowly.

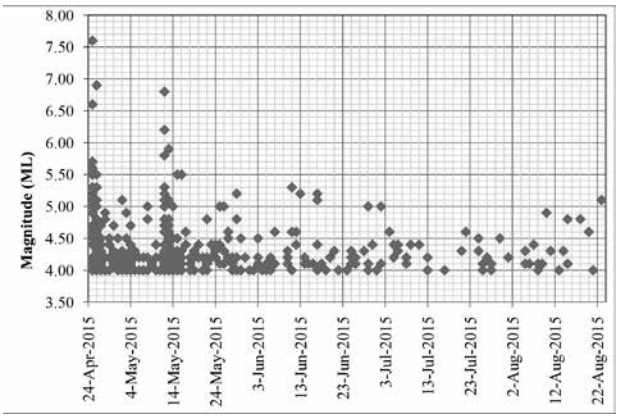


Figure 2: *Trend of aftershocks of Gorkha Earthquake-2072 (Till August 23, 2015)*

The frequency analysis of the aftershocks of Gorkha Earthquake-2072 is shown in Figure 3. The Figure 3 shows that while a great earthquake of magnitude 7 ML happened, then the chances of happening equal magnitude aftershock is null. However, there might be chances to happen the nearly equal magnitude of aftershocks. In Figure 3, it shows that the 7.6 ML magnitude earthquake is followed by 6.8 ML magnitude and lesser the others. Hence from analysis of frequency graph of aftershocks of Gorkha Earthquake-2072, it can be noticed from Figure 3 that, there is very less chance to come aftershock of 5.0 ML or greater one. Figure 2 shows that the chances of occurring after shock of magnitude 5.0 ML are less than 10 percent. And from our experiences, it can be say that up to 5.0 ML magnitude earthquake is not that much harmful to us or not severely damages the structures and tolerable to human lives.

Epicenters of aftershocks were also analyzed based on political boundary. However, political boundary cannot relate to earthquake, it only realizes the people's interest. Eleven political places were selected to demonstrate their epicenter evaluation. The data is presented through Figure 4. Figure 4 shows that, even though the main earthquake centre was in Gorkha, the aftershocks were hits far from its originated points. That means, Dolkha and Sindhupalchowk were faced several hits rigorously.

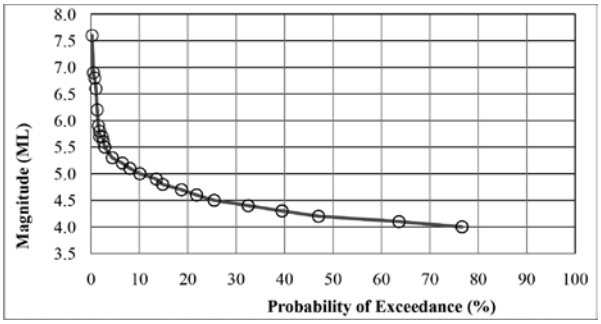


Figure 3: *Probability of exceedance of aftershocks of Gorkha Earthquake-2072*

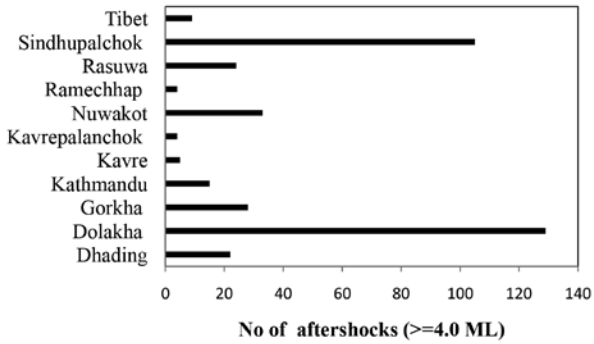


Figure 4: *District wise aftershocks of Gorkha Earthquake-2072*

Conclusion

The aftershocks data of Gorkha Earthquake-2072 are analyzed for trend and probability prediction. The frequencies of aftershocks are also examined for different districts. The trend analysis shows that the aftershocks are decaying in order. The probability analysis shows that there is very little chance to repeat the earthquake of magnitude greater than 5.0 ML. From probability analysis, it already shows that the chances of occurrence 5.0 Richter scale or high magnitude aftershocks are less than ten percent. Since, 5.0 ML earthquake is tolerable to human life as well as physical structures, there is not necessary to fear about the earthquake more than necessary. Hence, it can be conclude that the aftershocks from Gorkha Earthquake-2072 of magnitude 7.6 ML is almost matured and now can go ahead to re-build structures safely.

Acknowledgement

The Author likes to acknowledge the 'National Seismological Centre, Government of Nepal' by providing the data freely downloadable.

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Removing-Time Period of Formwork for RCC Structures

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Abstract: *Determination of the removal time of formwork is a major issue in concrete construction. This time can be predicted using the maturity method. Various literatures suggest that attainment of 70% of concrete design strength is reasonable for formwork removal, especially from the bottom of bending members. Different codes and norms prescribe a minimum stripping time of form-work varying from 12 hours to 28 days. However, experimental evidence suggests that the stripping time of formwork for horizontal member, such as beams and slabs, varies from 2 days to 117 days depending on temperature and cement type. Likewise, the stripping time of formwork for vertical member, such as column and sides of beams, varies from 12 hours to 6 days depending on the same factors, assuming that the formwork can be removed if no cracks are formed at the corners of the specimen during de-moulding or formwork removal. Experiments also indicate that increase in cement content shortens the stripping time of formwork.*

Key words: *Concrete, Destructive test (DT), Compressive test, Compressive Testing Machine (CTM), Admixtures ,Ordinary Portland cement(OPC), Portland Pozzolana Cement(PPC) , Super plasticizer, specific gravity of aggregate, Granite, Gabro, Sieve analysis and high strength concrete.*

Introduction

Concrete is required in virtually all forms of construction. It is an extremely plastic and mouldable material which accurately reflects the shape, texture and finish of the surface against which it is cast.

The success of concrete structures depends upon several factors, one of which is the in-place strength of concrete at the time of form stripping. Stripping of forms before the concrete gains adequate strength has resulted in several fatal accidents around the world. These accidents have drawn the attention of engineers and researchers towards the need for defining the minimum stripping time periods for concrete formwork.

In Nepal, construction of concrete structures started around 1950 A.D. However, practically no assessment of the kinetics of strength of concrete before the removal of formwork has been conducted in the country to come up with some idea about the possibilities of removing the formworks without consequences. Consequently, dispute always arise between clients, consultants and contractors regarding the stripping time of formwork of concrete structures. It is quite evident that the construction industry in Nepal is suffering from lack of proper norms of stripping time of formwork.

The need for defining formwork stripping times for Nepal gains significance when one considers the great variation of temperature throughout the country - the maximum temperature in one of the cities of Nepal, Dhangadhi was recorded at 46.4° C whereas temperatures as low as -14.0° C was recorded in Jumla (Department of Hydrology and Meteorology). These variations have a direct bearing on the formwork striping time in concrete constructions in these areas.

Theoretical Background

Prediction of Concrete Strength

Concrete strength can be defined in terms of its maturity, which is defined as the summation of the product of time and temperature after mixing of cement and water, the two of the main constituents of concrete. Since the strength of concrete depends on the period of curing age and temperature during curing, the strength can be visualized as a function of period and temperature of curing time.

The combined effects of time and temperature on concrete strength gain are quantified by means of maturity function. Maturity concepts have been around for over 50 years, but they were not recognized until a string of fatal construction failures took place in the 1970s. As there was no readily available procedure to estimate the in-place strength of concrete at that time, these failures sparked an interest in the maturity method and early-age concrete temperatures, especially when researchers noticed that these failures occurred when the in-place concrete was cured at much lower temperatures (7 to 10°C or 45 to 50°F) than the laboratory strength specimens. The need for a procedure to make reliable estimates of in-place strength was realized with the approval of ASTM C 1074 in 1987, the first specification applying the maturity method. It has

now been established that maturity concept is a very useful tool for determining stripping time of formwork at different temperatures. This maturity concept is also used for different construction planning approach.

Maturity Method

The Maturity Method is a globally standardized procedure for estimating concrete strength. In this method, maturity functions are used to convert the actual temperature history of concrete to a factor which is indicative of how much strength has developed.

In 1951, Saul presented the maturity rule which states that "concrete of the same mix at the same maturity (reckoned in temperature-time) has approximately the same strength whatever combination of temperature and time go to make up that maturity". He linked the term "maturity" to the product of time and temperature, suggesting that maturity should be calculated with respect to a "datum temperature", which is the lowest temperature at which strength gain is observed. Thus, maturity was defined in terms of the temperature history using the following relationship known as the Nurse- Saul function:

$$M = \sum (T - T_O)\Delta t \qquad (1)$$

where, M is maturity at age t, T is average temperature of the concrete during time interval Δt, and To is datum temperature. Recognizing that concrete continues to harden (gain strength) at temperature below 0°C once it has set, Saul recommended a datum temperature of -10.5°C for the use of Equation (1). Based on test data, Plowman (1956) suggested a value of -12.0°C for the datum temperature.

The Nurse-Saul function can be used to convert a given temperature-time curing history to an equivalent age of curing at a reference temperature as follows:

$$t_e = \frac{\sum (T - To)\Delta t}{(Tr - To)} \qquad (2)$$

where, t_e is the equivalent age at the reference temperature and Tr is the reference temperature.

Strength-Maturity Relationships

In 1956, Nykanen proposed the following exponential strength-maturity relationship:

$$S = S\infty\,(1 - e^{-kM}) \qquad (3)$$

where, S is the compressive strength, S∞ is the limiting compressive strength, M is the maturity and K is a constant. Later, a hyperbolic strength–maturity function expressed in the following form was used for this purpose (Bernhardft, 1956; Goral; American Concrete Institute 229; Chin., 1971):

$$s = \frac{M}{\frac{1}{A} + \frac{M}{S\infty}} \qquad (4)$$

Where, M = maturity, S∞ = limiting strength, and A = initial slope of strength- maturity curve. The shape of this curve is controlled by the value of the initial slope. The above equation can be transformed into the following linear equation:

$$\frac{1}{S} = \frac{1}{S\infty} + \frac{1}{A}\frac{1}{M} \qquad (5)$$

Thus, if test data obey the hyperbolic function, the data would lie on a straight line when the inverse of strength vs. the inverse of maturity is plotted.

As Equation (4) assumes that strength development begins at M = 0, Chin introduced an " offset" maturity, Mo, to account for the fact that strength development does not begin until a finite value of maturity has been reached. Thus, Equation (4) was modified into the following form:

$$S = \frac{(M - Mo)}{\frac{1}{A} + \frac{(M - Mo)}{S\infty}} \qquad (6)$$

Strength – maturity relationship was proposed by Lew and Richard (CRC Manual). Based on their test data and previously published data, they recommended the following empirical strength – maturity relationship:

$$S = \frac{K}{1 + D[\log(M - 16.7)]b} \qquad (7)$$

Freiesleben, Hansen and Pederson suggested that strength-maturity relationship should be similar to the relationship between heat of hydration and maturity:

$$S = S\infty * \exp\left(-\left[\frac{\tau}{M}\right]^{a}\right) \qquad (8)$$

Where, S∞ is limiting strength, M is Maturity, τ is Characteristic time constant, and a is shape parameter.

Strength Gain of Concrete

A mathematical expression to describe the compressive strength development of concrete was presented in 1956 by Bernhardt, who assumed the rate of strength gain (dS/dt) at any age (t) to be a function of the current strength (S) and the temperature (T), that is,

$$\frac{dS}{dt} = f(s).k(t) \qquad (9)$$

Where, F(S) is a function of strength and k (t) is a function of temperature. Based on empirical evidence, Bernhardt proposed that

$$f(s) = S\infty\,(1 - S/S\infty) \qquad (10)$$

Where, S∞ = limiting strength at infinite age. When strength begins to develop, f(s) = S∞. Therefore, the initial rate of strength development is

$$\left.\frac{dS}{dt}\right|_{s=0} = S_{\infty} k\,(t) \qquad (11)$$

The temperature function k (t) is called the rate constant because it affects the initial rate of strength development.

If S∞ is assumed to be independent of curing temperature and Equation (9) is combined with equation (10), the following integral equation is obtained:

$$\int_0^S \frac{dS}{\left(1-\frac{S}{S\infty}\right)^2} = S\infty \int_0^t k(T)dt \qquad (12)$$

This integral is the general form of the maturity function, and it is be denoted as M (t, T):

$$M\,(t, T) = \int_{to}^{t} k(T)dt \qquad (13)$$

From Equation (12) and (13) one obtains the following general strength-maturity relationship:

$$S = S\infty \frac{M(t,T)}{1+M(t,T)} \qquad (14)$$

Maturity Functions - Isothermal Conditions

When curing temperature is constant, the temperature function k(T) has a constant value. Therefore, the maturity function becomes

$$M\,(t, T) = k_T\,(t\text{-}to) \qquad (15)$$

Where, k T =value of the rate constant at the curing temperature

The strength-maturity relationship, Equation (19), becomes the following strength- age relationship:

$$S = S\infty \frac{kT(t-to)}{1+kT(t-to)} \qquad (16)$$

Experimental Investigations and Result

Shankar (2006-2007) conducted experiments at the Institute of Engineering, Pulchowk Campus, Tribhuwan University, to investigate the effect of temperature and type of cement on the stripping time. The results of the investigations are described below.

Experimental Set-up

Different types of cement are available in Nepal. However, for this research, only two categories of cement namely Ordinary Portland cement (OPC) and Portland pozzolana cement (PPC) have been used. The OPC used in the work are Udaypur cement, Hetauda cement and Vishwakarma cement while the PPC were J. P. (Buland) and J.P. (Buniyad) especially imported from India. These types of cement are mostly used in construction work in Nepal.

Natural crushed aggregates collected from a single source (Mahadevbesi) and available in Kathmandu valley were used in the research. The aggregates were sieved through a 20 mm sieve and washed. 20 mm passing aggregates are used in whole experiment.

Natural sand obtained from a single source (Belkhu) was used. To remove foreign materials, the sand was very carefully washed. Tap water available in the laboratory was used directly.

Using the above material, 100 mm x 100 mm cube specimens were prepared. The specimens were divided into five groups, which differed in the type of cement. Group I used Udaypur cement (OPC), Group II J.P. (Buland), Group III Hetauda cement (OPC), Group IV Vishwakarma cement (OPC) and Group V - J.P.(Buniyad) (PPC). All specimen cubes were prepared and cast at normal laboratory temperature. After demolding, the cubes were cured at different temperatures: - 20°C, 25°C , 35°C, 45°C and 23°C. All the specimens were allowed to cool in air, brought to room temperature and tested.

Concrete mix of ratio 1:2:4:0.5 was used in most of the research. However, a few sets of specimens were also prepared using the ratio of 1 : 1.5 :3 : 0.5.

Eight different ages of concrete in days were adopted for testing - 1, 2, 3, 4.33, 7.11, 14.11, 28.06, and 56 days. All groups of specimens were tested at these days.

Result Analysis and Discussion

Concrete mix 1: 2: 4: 0.5 with Udaypur cement

The table 1 given below lists the average compressive strength of three specimens vs. concrete age for 100 mm concrete cubes cured in water bath at 23°C .The mixture had water - cement ratio of 0.50 and was made from Udaypur Ordinary Portland cement.

Table 1: Compressive strength vs. age at 23 C (w/c=0.5, Udaypur cement)

Age (days)	Compressive Strength (MPa)
0	0
1	7.48
2	12.2
3	15.20
4.33	16.53
7.11	19.23
14.11	22.26
28.06	27.73

The data reported in Table 1 have been used to construct strength–maturity relationship to illustrate how the maturity method could be applied on a construction project. First, these data are plotted in Figure 1.A.

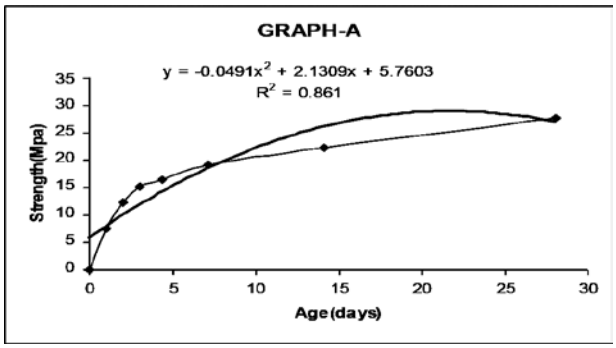

FIG. 1A: Strength vs. age for curing at 23°C; curve represents best fit data.

Now, the limiting strength is estimated by considering the data for tests beyond 4 days. Figure 1.B shows the reciprocal of strength plotted against the reciprocal of age. From linear regression analysis, the intercept is 0.0343, which is equal to the reciprocal of the limiting strength. Therefore, the limiting strength is S∞ =1/0.0343 MPa = 29.15MPa.

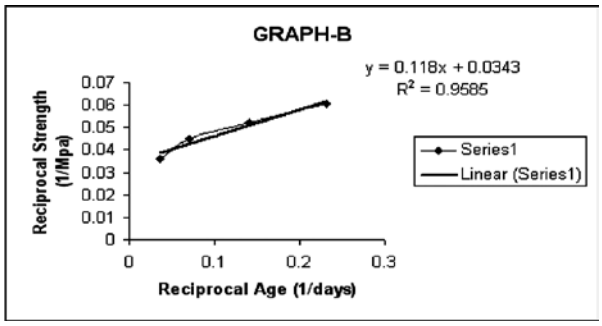

FIG. 1B: Plot of reciprocal strength vs. reciprocal age to evaluate the limiting strength

In the next step, the rate constant is estimated considering the strength from the first three test results as shown in Table 1. In our case, this reflects the strength up to the age of 3 days. The quantity S / (S∞ -S) is plotted against age as shown in Figure 1C. From linear regression analysis, the slope of the line is found to be 0.3722day-1, which is the value of the rate constant at 23°c. The intercept of the line with the age axis is 0.0704days.

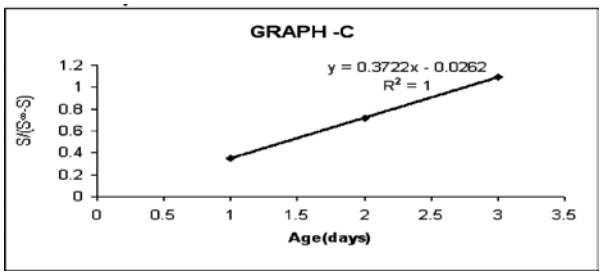

FIG. 1C: Plot to evaluate the rate constant and the age when strength development begins

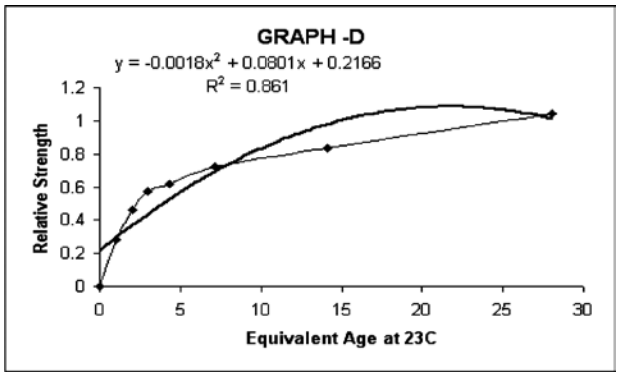

FIG. 1D: Relative strength vs. equivalent age at 23 °C

Based on the above figures, the following values of constants are obtained:

S∞ = 0.0343 -1 = 29.15 MPa

K_r = 0.3722

t_o = 0.0262/.3722 = 0.0704 day

Thus, the hyperbolic strength-equivalent age relationship for this concrete mixture is

$$S(MPa) = S \propto \frac{K_r(t_e - t_o)}{1 + K_r(t_e - t_o)}$$

$$= 29.15 * \frac{0.3722\ (t_e - 0.07042}{1 + 0.3722\ (t_e - 0.0704}$$

S28 = 29.15* 0.9122 = 26.60 MPa.

Fraction of limiting Strength,

$$RS \propto = \frac{S}{S \propto}$$

$$RS \propto = \frac{0.3722\,(t_e - 0.0704)}{1 + 0.3722\,(t_e - 0.0704)}$$

$$\frac{S_{28}}{S_\infty} = 0.9122$$

Thus, the 28-day strength is 91.22% of the limiting strength. Also, the limiting strength is 1/0.9122 = 1.0963 times the 28-day strength.

Planning of Construction

70% of design strength = 70% x 26.60 = 18.62 MPa

Equivalent age,

$$t_e = \frac{RS_\infty}{K_r(\phi - RS_\infty)} + t_0$$

$$t_e = \frac{0.7}{0.3722\,(1.0963 - 0.7)} + 0.0963$$

$$= 4.8024 \text{ days} \sim 5 \text{ days}$$

To find 'age- conversion factor':

$$\alpha = e^{-\frac{E}{R}\left[\frac{1}{273+T}-\frac{1}{273+T_r}\right]}$$

R = 8.3144 J/ (mol.K)
T ≥ 20°C, Activation energy, E = 33,500 J/ (mol.K)
T < 20°C, E = 33,500 + 1470 (20-T) J/ mol
For 0°C, E = 62,900 J/mol
5°C, E = 55,550 J/mol
10°C, E = 48,200 J/mol
15°C, E = 40,850 J/mol

The number of days needed to reach an equivalent age of 5 days at 23°C is obtained dividing the equivalent age by the age conversion factor and presented in Table.2 (for slab). Based on this table a further Table 3 has been generated incorporating the stripping period for beams and columns.

Table 2 Equivalent age conversion factor and formwork stripping period for slab

Temperature	Age conversion factor	Days to reach te = 5 days at 23°C
0°C	0.12	42 days
5°C	0.23	22 days
10°C	0.41	12.5 days
15°C	0.63	8 days
20°C	0.87	6 days
25°C	1.10	5 days
30°C	1.37	4 days
35°C	1.70	3 days
40°C	2.09	2.5 days
45°C	2.56	2.0 days

From various literatures and IS456:2000, it is found that the stripping period of formwork of beam is twice the stripping period of formwork for slab. This aspect has been considered to arrive at the stripping period of beams.

For vertical members, the stripping period of formwork is generally not considered from the aspect of load carrying capacity. Rather, it is considered in terms of curing time at which no cracks are formed at the corners of the specimen during demoulding or formwork removal. This aspect has been adopted in this work in identifying the striping time of formwork for columns as compression members and respective data are presented in Table 3.

Table 3 Formwork Stripping Time of Concrete (Cement- Udaypur; Mix - 1: 2: 4: 0.5)

Temperature (°C)	Types of formwork		
	Vertical Members	Horizontal Member	
		Slabs	Beams
0°C	5 days	42 days	84 days
5°C	3 days	22 days	44 days
10°C	2 days	12.5 days	25 days
15°C	24-36 hours	8 days	16 days
20°C	24 hours	6 days	12 days
25°C	24 hours	5 days	10 days
30°C	12-24 hours	4 days	8 days
35°C	12-24 hours	3 days	6 days
40°C	12-24 hours	2.5 days	5 days
45°C	12-16 hours	2 days	4 days

Similar calculations and standard procedures are adopted for calculating stripping period of formwork for other concrete mix also, as given below:

Table 4 Stripping Period of Formwork for different type of Cement for VERTICAL MEMBERS (Ratio 1:2:4:0.5)

Temperature (°C)	Type of Formwork				
	Vertical Members				
	Udaypur Cement	HetaudaCement	VishwakarmaCement	JP (Buland) Cement	JP (Buniyad) Cement
	OPC	OPC	OPC	PPC	PPC
0°C	5 days	4 days	5 days	6 days	6 days
5°C	3 days	2 days	3 days	5 days	4 days
10°C	2 days	2 days	2 days	3 days	3 days
15°C	24-36hrs	24-36hrs	24-36hrs	2 days	2.5 days
20°C	24hrs	24hrs	24hrs	24hrs	24-36hrs
25°C	24hrs	24hrs	24hrs	24hrs	24-36hrs
30°C	12-24hrs	24hrs	24hrs	24hrs	24hrs
35°C	12-24hrs	12-24hrs	24hrs	16-24hrs	24hrs
40°C	12-24hrs	12-24hrs	12-24hrs	16-24hrs	24hrs
45°C	12-24hrs	12hrs	12-24hrs	16-24hrs	24hrs

Table 5 Stripping Period of Formwork for different type of Cement for HORIZONTAL MEMBERS (SLAB) (Ratio: 1:2:4:0.5)

Temperature (°C)	Type of Formwork				
	Horizontal Members (Slab)				
	Udaypur Cement	Hetauda Cement	Vishwakarma Cement	JP (Buland) Cement	JP (Buniyad) Cement
	OPC	OPC	OPC	PPC	PPC
0°C	42 days	46 days	54.5 days	50 days	58.5 days
5°C	22 days	24 days	28.5 days	26.5 days	30.5 days
10°C	12.5 days	13.5 days	16 days	15 days	17.5 days
15°C	8 days	9 days	10.5 days	10 days	11.5 days
20°C	6 days	6.5 days	7.5 days	7 adys	8.5 days
25°C	5 days	5 days	6 days	5.5 days	6.5 days
30°C	4 days	4.5 days	5 days	4.5 days	5.5 days
35°C	3 days	3.5 days	4 days	4 days	4.5 days
40°C	2.5 days	3 days	3.5 days	3 days	3.5 days
45°C	2 days	2.5 days	3 days	2.5 days	3 days

Table 6 Stripping Period of Formwork for different type of Cement for HORIZONTAL MEMBERS (BEAM) (Ratio: 1:2:4:0.5)

Temperature (°C)	Type of Formwork				
	Horizontal Members (Beams)				
	Udaypur Cement	Hetauda Cement	Vishwakarma Cement	JP (Buland) Cement	JP (Buniyad) Cement
	OPC	OPC	OPC	PPC	PPC
0°C	84 days	92 days	109 days	100 days	117 days
5°C	44 days	48 days	57 days	53 days	61 days
10°C	25 days	27 days	32 days	30 days	35 days
15°C	16 days	18 days	21 days	20 days	23 days
20°C	12 days	13 days	15 days	14 days	17 days
25°C	10 days	11 days	12 days	11 days	13 days
30°C	8 days	9 days	10 days	9 days	11 days
35°C	6 days	7 days	8 days	8 days	9 days
40°C	5 days	6 days	7 days	6 days	7 days
45°C	4 days	5 days	6 days	5 days	6 days

Table 7 Stripping Period of Formwork for different type of Cement for Ratio: 1:1.5:3:0.5

Temperature (°C)	Type of Formwork					
	Vertical Members		Horizontal Members			
			Slabs		Beams	
	Udaypur	JP (Buland)	Udaypur	JP (Buland)	Udaypur	JP (Buland)
	OPC	PPC	OPC	PPC	OPC	PPC
0°C	4 days	5 days	38 days	42 days	76 days	84 days
5°C	2 days	3 days	20 days	22 days	40 days	44 days
10°C	2 days	2 days	11 days	12.5 days	22 days	25days
15°C	24-36hrs	24-36hrs	7.5 days	8 days	15 days	16 days
20°C	24hrs	24hrs	5.5 days	6 days	11 days	12 days
25°C	24hrs	24hrs	4.5 days	5 days	9 days	10 days

Table 7 continued

30°C	24hrs	24hrs	3.5 days	4 days	7 days	8 days
35°C	12-24hrs	12-24hrs	3 days	3 days	6 days	6 days
40°C	12-24hrs	12-24hrs	2.5 days	2.5 days	5 days	5 days
45°C	12hrs	12-24hrs	2 days	2 days	4 days	5 days

Principal Findings

On the basis of the experimental study, the following conclusions have been drawn:

1. All database of experimental test of strength of concrete depicted that: i) strength of concrete increases with the decreases in w/c ratio; ii) the 28-days strength of concrete of the same mix increased with increase in curing temperature; iii) the formwork removal period of reinforced concrete structures shortened with increase in ambient air temperature; and iv) after 28-days age of concrete, the strength of PPC increased rapidly than OPC.
2. The maturity rule is verified up to age-14 days from its instant of casting of concrete cubes made of Ordinary Portland Cement such as Udayapur cement, Hetauda cement and Vishwakarma cement when concrete cubes were casted at laboratory temperature and de- moulding at the same temperature and put in curing tank at different controlled temperatures ranging from 20°C to 35°C (i.e., 20°C, 23°C, 25°C, and 35°C). But this rule is verified up to the age of 7 days from the instant of casting of concrete cubes when samples were put in oven just after casting at controlled temperature of 30°C or 45°C and de-moulding after 24 hours and put in curing tank with temperature of 30°C or 45°C respectively.
3. The maturity rule is verified up to the age of 21 days of concrete from its instant of casting of cube using Portland Pozzolana Cement such as J.P.(Buland) and J.P.(Buniyad) cement. But this rule is verified up to the age of 14 days from the instant of casting of concrete cubes when cube samples were put in oven just after casting them at controlled temperature of 30°C and 45°C; de-moulded after 24 hours and again put in curing tank of controlled temperature of 30°C and 45°C respectively.
4. Formwork stripping time of concrete structures constructed by using Ordinary Portland Cement vary from 12 hours to 5 days for vertical members, 2 days to 54.5 days for slab and 4 days to 109 days for beams depending on the ambient temperature from 45°C to 0°C respectively. This temperature range almost covers most of the hilly and Terai areas of Nepal.
5. Formwork stripping time of concrete structures constructed by using Portland Pozzolana Cement vary from 1 day to 6 days for vertical members, 3 days to 58.5 days for slab and 12 days to 117 days for beam depending on the ambient temperature from 45°C to 0°C respectively.

Recommendations for Cold Weather Concreting

Any concreting operation done at a temperature below 5°C is termed as cold weather concreting. Some recommendations regarding cold weather concreting are as:

Temperature Control of Ingredients

The temperature at the time of setting of concrete can be raised by heating the ingredients of the concrete mix. It would be easier to heat the mixing water. The aggregate are heated by passing stream through pipe embedded in aggregate storage bins. Another precaution taken along with the heating of ingredients is to construct a temporary shelter around the construction site. The air inside is heated by electric or steam heating or central heating with circulating water. The temperature of ingredients should be so decided the resulting concrete sets at a temperature of 10°C to 20°C.

Use of Insulating Formwork

A fair amount of heat is generated during the hydration of cement. Such heat can be gainfully conserved by having insulating formwork covers capable of maintaining concrete temperature above the desirable limit up to the first 3 days (or even 7 days) even though the ambient temperatures are lower .The formwork covers can be of timber, clean straw, blankets, tarpaulins, plastic sheeting, etc., and are used in conjunction with an air gap as insulation. The efficiency of the covers depends upon the thermal conductivity of the medium as well as ambient temperature conditions. For moderately cold weather, timber formwork alone is sufficient.

Proportioning of Concrete Ingredients

The important factor for cold- weather concreting is the attainment of suitable temperature for fresh concrete. Since the quantity of cement in the mix affects the rate of increase in temperature, an additional quantity of cement may be used .It would be preferable to use high alumina cement for concreting during frost conditions, the main advantage being that higher heat of hydration is generated during the first 24 hours. During this period, sufficient strength (approximately 10 to 15 MPa) is developed to make the concrete safe against frost action .No accelerator should be used if high alumina cement is used. Alternatively, the rapid hardening Portland cement or accelerating admixture used with proper precautions can help in getting the required strength in a shorter period. Air-entraining agents are generally recommended for use in cold weather. Air-entraining increases the resistance of the hardened concrete to freezing and thawing and normally, at the same time, improves the workability of fresh concrete. The calcium chloride used as accelerating admixture may cause corrosion of

reinforcing steel. In any case, calcium chloride should not be used in prestressed concrete construction.

Placement and Curing

Before placing the concrete, all ice, snow and frost should be completely removed. Care should be taken to see that the surface on which the concrete is to be placed and eminent parts are sufficiently warm. During the periods of freezing or in near- freezing conditions, water curing is not applicable.

Delayed Removal of Formwork

Because of slower rate of gain of strength during the cold weather, the formwork and props have to be kept in place for a longer time than in usual concreting practice.

The problem of concreting in cold weather can be minimized by adopting precast construction of structures. Precautions can be taken and concreting can be done in the controlled condition.

Recommendations for Hot Weather Concreting

Any operation of concreting done at atmospheric temperature above 40°C or where the temperature of concrete at the time of placement is expected to be beyond 40°C may be categorized as hot weather concreting. Some recommendations regarding cold weather concreting are as Temperature Control of Concrete Ingredients The temperature of the concrete can be kept down by controlling the temperature of the ingredients. The aggregates may be protected from direct sunrays by erecting temporary sheds or shelters over the aggregate stockpiles. Water can also be sprinkled on to the aggregate before using them in the concrete. The mixing water has the greatest effect on lowering the temperature of concrete, because the specific heat of water (1.0) is nearly five times that of common aggregate (0.22). Moreover, the temperature of water is easier to control than that of other ingredients. Under certain circumstances, the temperature of water most economically be controlled by mechanical refrigeration or mixing with crushed ice. The precooling of aggregates can be achieved at the mixing stage by adding calculated quantities of broken ice pieces as a part of mixing water; provided the ice is completely melted by the time mixing is completed.

Proportioning of Concrete Mix

The mix should be designed to have minimum cement content consistent with other functional requirements. As far as possible, cement with lower heat of hydration should be preferred to those having greater fineness and heat of hydration .Use of water-reducing or set-retarding admixtures is beneficial. Accelerations should not be used under these conditions.

Production and Delivery

The temperature of aggregates, water and cement should be maintained at the lowest practical levels so that the temperature of concrete is below 40°C at the same time of placement. The temperature of the concrete at the time of leaving the batching plant should be measured with the suitable metal clad thermometer. The period between mixing and delivery should be kept to an absolute minimum by coordinating the delivery of concrete with its rate of placement.

Placement and Curing of Concrete

The formwork, reinforcement and sub grade should be sprinkled with cool water just before the placement of concrete. The area around the work should be kept wet to the extend possible to cool the surrounding air and increases its humidity. Speed of placement and finishing helps minimize problems in hot weather concreting. Immediately after compaction, the concrete should be protected to prevent the evaporation of moisture by means of wet (not dripping) gunny bags, Hessian, etc. After the concrete has attained a degree of hardening sufficient to withstand surface damage, moist-curing should begin. Continuous curing is important because the volume changes due to alternate wetting and drying promote the development of surface cracking. On the hardened concrete, the curing shall not be much cooler than the concrete because of the possibilities of the thermal stresses resultant cracking. High velocity winds causes higher rate of evaporation, and hence wind breakers should be provided as far as possible. If possible, the concreting can be done during night shifts.

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पूर्वाधार विकासका समस्या

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नेपालको पूर्वाधार विकासको गति, प्रक्रिया र संस्थागत क्षमत हेर्दा अतिकम विकसित राष्ट्रबाट विकासोन्मुखतर्फ यात्रा कठिन हुने देखिन्छ । किन यो स्थिति बन्दैछ ? यसबारे बहस हुनु आवश्यक छ ।

माथिल्लो सेती र तनहुँ जलविद्युत आयोजनामा यतिबेला विवाद छ । कारण, जलाशयमा बालुवा थिग्रने समस्या र समाधानमा परामर्शदाता कमजोर अनुभवलाई औंल्याइएको छ । अर्थ र ऊर्जा मन्त्रालयले बनाएको समितिको औचित्य र कसको कुरा सही भन्नेमा पनि विवाद नै छ । त्यस्तै, सरकारले सार्वजनिक निजी साझेदारी (पीपीपी) नीतिअन्तर्गत फास्ट ट्रयाक निर्माणका लागि निजी क्षेत्रबाट प्रस्ताव पुनःआह्वान गरेको छ । जसमा न्यूनतम प्रतिफल (ट्राफिक) ग्यारेन्टी गर्ने प्रावधान राखिएको छ । तर, करिब ७ वर्षअघि सुरू गरिएको आयोजनाको सम्भाव्यता अध्ययनले कूल निर्माण खर्चको प्रारम्भिक अनुमान मात्र गर्न सकेको छ र निजी कम्पनीको लागतमा न्यूनतम प्रतिफल ग्यारेन्टी तोकी सम्झौता गर्न आवश्यक विस्तृत डिजाइन एस्टिमेट गर्न सकिएको छैन । यस्तो अवस्थामा निजी क्षेत्रले सम्भाव्य प्राविधिक या व्यवस्थापकीय अनिश्चितालाई ध्यानमा राख्दै आयोजनाको लागत बढी देखाई न्यूनतम प्रपिफलमार्फत् अन्ततोगत्वा सरकारमा अनावश्यक वित्तीय भारपर्ने जोखिम देखिन्छ ।

कथाव्यथा झन् गहिरो छ पूर्व–पश्चिम विद्युतीय रेलमार्गको २०६७ सालमा सरकारले करोडौं रूपैयाँ खर्च गरेर भारतीय र नेपाली साझेदार कन्सल्ट्यान्टमार्फत् पूर्व–पश्चिम विद्युतीय रेलमार्गको अध्ययन गऱ्यो । नेपाल सरकारले रेलमार्गलाई राष्ट्रिय यातायात पूर्वाधारको मेरूदण्डको रूपमा विकास गर्ने रणनीतिक दूरदृष्टि रँख्न सकेको देखिन्न । प्रतिवेदनमा दशको पुरानो भारतीय प्रविधिलाई मूलप्रवाहको प्रविधि मानिएको छ । भारतमा समेत नयाँ रेलमार्ग ब्रोडगेजको सट्टा स्टयान्डर्ड गेज बनाउन लागिएको छ, तर हामी कहाँ ब्रोडगेज नै सिफारिस गरिएको छ । जसले गर्दा भविष्यमा चाहिने रेलको डिब्बालगायत अन्य उपकरण खरिदमा आधुनिक र सस्तो प्रविधिबाट हामी बन्चित हुनपर्नेछ । पुरानो प्रविधिमा लागु हुने १ प्रतिशत ग्रेड (उकालो ओरालोपन) भन्दा बढीमा जाननसकेका कारण हेटौंडा र नारायणगढ रेलमार्गबाट छुटेको छ । काठमाडौंलाई नवलपरासी हुँदै खैरेनीबाट जोड्ने उपाय प्रतिवेदनमा आयो । जबकि, अन्तराष्ट्रिय स्तरमा ४ प्रतिशतसम्म ग्रेड हुने गरी रेलमार्ग बन्न सुरू भएको धेरै वर्ष भइसकेको छ । बिडम्बना त के छ भने, यस्तो प्रतिवेदनको पुनरवलोकन गर्ने पद्धति र जनशक्ति योजना आयोगका साथै मन्त्रालयहरूमा अभाव छ ।

समस्याको चुरो र समाधान

पूर्वाधार आयोजनाको डिजाइन, निर्माण र सञ्चालन गर्ने प्रक्रिया जटिल त हुन्छ नै । हाम्रो जस्तो कम प्राविधिक क्षमता र चुनौतिपूर्ण भूबनौट भएको देशमा अझै जटिलता थपिने भयो नै । यस्ता जटिलताका मुख्यतयाः २ वटा पक्ष हुन्छन् । पहिलो, जहाँ पनि देखिने एकै प्रकारका प्राविधिक समस्या हुन् । यसलाई कन्सल्टेन्टहरूले समाधान गर्न सक्छन् । तर, अर्को समस्या भने स्थानविशेष, देशविशेष र आयोजनाविशेष हुन्छ । जस्तो : तनहुँ जलविद्युत आयोजनाको हकमा जलाशयमा थिग्रने बालुवा र त्यसको निकासको संरचना डिजाइन गर्नको लागि अर्को देशको बनिबनाउ निर्देशिका या पाठ्यक्रमले काम नगर्न सक्छ । त्यसमा हाम्रो भूबनोट, नदीको स्वरूप, बालुवाको प्रकृति आदि कुराले प्रभाव पारेको हुन्छ । यस्तो विषयको समाधानको उपाय कहिले पनि "रेडिमेट" हुँदैन । यस्ता प्राविधिक समस्याको समाधान परियोजनाका कन्सल्टेन्टले मात्र गर्न सक्दैनन् । त्यसका लागि आधारभूतरूपमा विश्वविद्यालय, प्रयोगशाला, नास्टजस्त संस्थामार्फत् अनुसन्धान गर्नुपर्छ । त्यस्तै, नीतिगत समस्या समाधानका निम्ति निर्णय गर्नुपर्ने निकाय या प्रत्येक मन्त्रालयमा कम्तीमा एक एक वटा अनुसन्धान गर्ने स्वतन्त्र "थिंक टयांक" संस्था (विभाग)को अनिवार्य व्यवस्था गरिनुपर्छ । अध्ययन–अनुसन्धानबाट हरेक नीतिगत अल्पकालीन र दीर्घकालीन समाधान निकालेपछि कार्यान्वयनमा जान सहज हुन्छ । विदेशी कन्सल्टयान्टबाट नै काम गर्नुपर्ने भयो भने पनि कस्तो शर्तमा लगाउने भने कुरा पनि अनुसन्धानबाट निर्क्यौल गर्न सकिन्छ ।

विगत ६१ वर्षको हाम्रो योजनबद्ध विकासको इतिहासमा हामीसँग त्यस्तो एउटा पनि निर्माण कम्पनी छैन । जसले ५१ जना इन्जिनियरलाई नियमित रोजगारी दिएको होस् । एउटा पनि परामर्शदाता (कन्सल्टयान्ट) छैन । जसले ठूला परियोजनामा आवश्यक परामर्श दिनसकोस् । विदेशीसँग कथित 'ज्वाइन्ट भेन्चर' मा जोडिएर सानो र सजिलो, कम नाफामै सीमित कन्सल्टयान्ट तथा निर्माण कम्पनी मात्र तयार हुने हाम्रो नीति कायमै छ । दशकौं संलग्नता हुँदाहुँदै पनि ठूला परियोजनाहरूमा समेत काम गर्ने क्षमता, आवश्यक प्राविधिक ज्ञानसहितका जनशक्ति या आत्मविश्वासमा उल्लेख्य प्रगति भएको छैन । गर्दैसिक्दै (लनिङ बाइ डुइङ)बाट पूर्वाधार निर्माणका लागि क्षमता विकास गर्ने अवसरलाई हामीले उचित उपयोग गर्न नसकेको पक्कै हो ।

हाम्रा ठूला परियोजना विदेशी परामर्शदाता र ठेकेदारलाई जिम्मा दिंदा परियोजनाको खर्च अत्यधिक बढिरहेको हुन्छ । अन्तराष्ट्रिय बजारमा एक अनुभवी इन्जिनियरको मासिक पारिश्रमिक लाखौं रूपैयाँ छ । हाम्रा परियोजनाबाट ती विदेशी परामर्शदाता र ठेकेदारले पनि जनशक्तिको यस्तै मूल्य असुल गर्छन । कैयौं नेपाली इन्जिनियर यस्ता परामर्शदाता र ठेकेदारसँग काम गरिरहेका छन् । हाम्रा जनशक्ति पनि 'विश्वस्तर' का छन् । तर, हामीले उनीहरूलाई जीविकोपार्जनको लागि चाहिने न्यूनतम पारिश्रमिकको व्यवस्था गर्न नसक्दा दिनदिनै हाम्रा इन्जिनियर अस्ट्रेलिया, क्यानडालगायतका मुलुकमा गइरहेका छन् ।

सन् १८७२ मा जापानले पहिलो रेलमार्ग बनाउँदा उसको

आन्तरिक प्राविधिक क्षमता शून्यबराबर थियो । आर्थिक क्षमता पनि कमजोर थियो । हाम्रो २००७ सालको जस्तै मेजी क्रान्तिपछि बनेको जापानी सरकारको एक मुख्य एजेन्डा रेलमार्ग निर्माण प्रारम्भ र विस्तार थियो । सबै प्राविधिक र आवश्यक पूँजी बेलायतबाट ल्याइएको थियो । उक्त रकम बेलायती इन्जिनियरको तलबभत्ता तिर्न तथा निर्माण सामग्री खरिदमा खर्च गरिएको थियो । जापानका नीतिनिर्माताले तुरून्तै महसुस गरे कि, यस्तो तरिकाले देशभर रेलमार्गको सञ्जाल विस्तार असम्भव छ । त्यसैले रेलमार्ग निर्माणको सिलसिलामामा प्रत्येक बेलायती इन्जिनियरसँगै आफ्ना मान्छे पनि खटाउन थाले र एउटा रेल लाइन सक्दानसक्दै आफ्ना प्राविधिकहरूलाई पूर्णरूपमा दक्ष बनाए । त्यसपछि सबै रेलमार्ग आफ्नै प्राविधिक तथा आर्थिक क्षमतामा निर्माण गरे ।

त्यस्तै, सन १९६७ मा दक्षिण कोरियाका राष्ट्रपतिले सोलपुसान ४ लेनको द्रुत मार्ग बनाउन आफूसँग प्राविधिक र आर्थिक क्षमता शून्यबराबर भएकोले विश्व बैंकलाई अनुरोध गरे । तर, विश्व बैंकले ४ लेन बढी भयो भन्दै त्यसलाई कम गर्न तथा कन्सल्टयान्ट र ठेकेदार पनि विदेशी हुनुपर्ने शर्त राख्यो । कोरिया सरकारले उत्तर दियो "४ लेन हामीलाई भविष्यको लागि हो र विदेशी कन्सल्टयान्ट र ठेकेदार भए पनि नेतृत्व हाम्रो हुनुपर्छ, किनकि हामीले काम गरेर नै सिक्नु पनि छ ।" अन्ततः विश्व बैंक तथा कुनै दाताले सहयोग नगर्ने निर्णय गरे । कोरिया सरकारले समृद्धिका लागि यो सडक त नभै हुँदैन, आफै भए पनि बनाउनुपर्छ भनेर निर्णय लियो । कोरियामा त्यतिबेला कुनै राम्रो ठेकेदार भनेको अहिलेको हुन्डाई कम्पनी सुरू गर्ने मालिक अमेरिकाको सैनिक क्याम्पको निर्मँणको "पेटी कन्टयाक्ट" मा काम गरिरहेका थिए । सरकारले बोलाएर सोध्यो – यो काम गर्न सकिन्छ ? सरकारको सहयोग भयो भने सकिन्छ भनेर उनले उत्तर दिए । सरकारले जुनसुकै सहयोग गर्नेछ भन्यो । निर्माण सामग्रीमा भन्सार छुट कुनै कानुन नयाँ वा सुधार गर्नुपर्‍यो भने पनि गरिदिने बचन सरकारले दियो । स्थानीय ठेकेदारलाई संलग्न गराउनुपर्ने कुरो पनि भयो । काम सुरू गर्दा कोरिया सरकारलाई निर्माण सामग्री आयात गर्नको लागि डलरको संकट पर्‍यो । डलर जुटाउन भियतनाम युद्धमा कोरिया सरकार पनि सामेल हुने र त्यहाँबाट कोरियन नागरिकको रगतबाट बनेको हो भनिन्छ । अन्ततः सन १९७१ मा निर्धारित समयभन्दा अगाडि, २१ महिनामा नै ४२८ किलोमिटर सडक तयार भयो । यसकारण कोरियाको प्राविधिक र आर्थिक क्षमता चमत्कारिक ढङ्गले बढ्यो ।

जापान या कोरियाले अंगिकार गरेको उपाय नेपालमा हुबहु उतार्न सकिन्छ भन्ने होइन । तर, विदेशका यस्ता अनुभवलाई नीतिनिर्माताले प्रेरणाको रूपमा लिएर हाम्रो आफ्नै मौलिक नीतिगत संरचना बनाउन सकिन्छ । माथि उल्लेख गरिएको जापान र कोरियाको जस्तो अवस्थामा अहिले नेपाल छैन । स्पष्ट इच्छाशक्ति र क्षमता विकासको ठोस योजनाका साथ सरकारले काम गर्ने हो भने सन् २०२२ सम्ममा अतिकम विकसित मुलुकबाट विकासोन्मुख मुलुकमा स्तरोन्नति हुने लक्ष्य पूर्वाधार विकासको माध्यमबाट पुरा गर्न सम्भव छ ।

नागरिक न्यूज अनलाईनमा प्रकाशित - वि.सं. २०७१ पौष १८ गते

आत्मनिर्भरताको लागि कृषि जलस्रोत र पर्यटन

ई.रविन्द्र फोजू
ईन्जिनियर समाज नेपाल

वि.स. २०७२ साल नेपाल र नेपाली जनताले सदैव कष्टकर वर्षको रूपमा सम्झिरहने छ । २०७२ सालको प्रारम्भ सँगै भोग्न परेको विनाशकारी भुकम्प र संविधानसभाको बहुमतले नेपालीहरूले आफ्नो बलमा बनाएको संविधानमा उसको (भारतको) अनुकुलका बुँदाहरू संविधानमा समावेश गराउन नसकेको निहुँमा भारतले लगाएको नाकावन्दीका कारण नेपालको अर्थतन्त्र र नेपाली जनताको जनजीवन नराम्ररी थलियो । राष्ट्रिय योजना आयोगका अनुसार भुकम्पले करीव सात लाख र नेपाल राष्ट्र बैंकका अनुसार नाकावन्दीले करीव आठ लाख नेपालीहरू गरीवीको रेखामुनी थपिएको तथ्यांङ्क प्रकाशित भयो ।

वि.स. २०७२ असोज ६ गतेको भारतीय नाकावन्दीका कारण नेपालको अर्थतन्त्र तहसनहसको अवस्थामा छ । नाकावन्दीले नेपाल भारतसँग कति परनिर्भर रहेछ भन्ने प्रष्टाएको छ । सारा नेपालीहरू २०४६ सालदेखि आजसम्मका सत्तामा गएका पार्टीहरू, नेताहरूको अदुरदर्शिता अकर्मण्यता, अपरिपक्ता, अपारदर्शिता, व्यक्तिगत स्वार्थ, अक्षमता, भ्रष्टाचार, अराजकताका पराकाष्ठाको परिणति व्यहोर्न बाध्य भएका छौं । आजसम्मका सरकारहरूले देशलाई आत्मनिर्भरताको बाटोमा लैजाने प्रयास सम्म गर्न नसकेको २०४६ सालसम्म भारतसँग ३३ प्रतिशत रहेको व्यापार २०७२ सालसम्म आईपुग्दा करीव ६३ प्रतिशत जति पुग्नुले स्पष्ट हुन्छ ।

अझ मित्र राष्ट्रहरूले नेपाल आत्मनिर्भर बन्न सकून् भन्ने उद्देश्यले निर्माण गरिदिएका दर्जनौ उद्योगधन्दा, कलकारखाना जस्तै बाँसवारी छाला जत्ता कारखाना, भृकुटी कागज कारखाना, भक्तपुर ईटा तथा टायल उद्योग, हरिसिद्धि टायल उद्योग, बीरगञ्ज चिनी कारखाना लगायत सरकारी उद्योगधन्दालाई कौडीको मुल्यमा निजी क्षेत्रलाई सुम्पिदियो । देशलाई आजको भड्खालोमा पुऱ्याउन भुमिका खेल्नेहरूले उत्कृष्टताको पुरस्कार पाउँदा को नेपाली खुसी हुन सक्छ ? र त्यस्ता व्यक्ति उक्त पुरस्कार पाउनु सारा नेपालीहरूको दुर्भाग्य नै मान्नुपर्छ ।

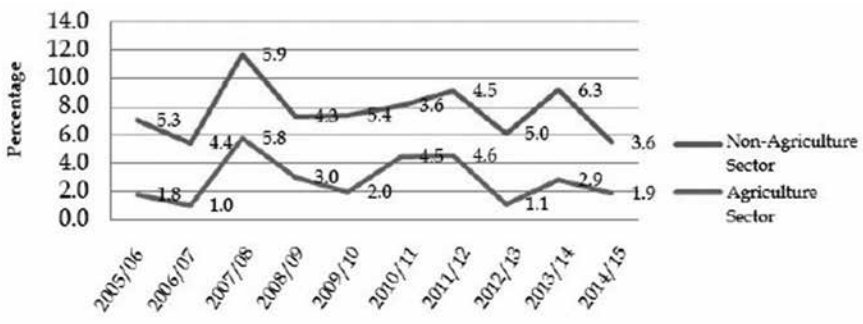
प्राकृतिक स्रोत साधनका हिसावले धनी देशमा गनिने नेपाल अथाह सम्भावना हुँदा हुदै पनि किन समृद्ध नेपाल बन्न सकेन ? प्रत्येक सचेत नेपालीहरू बीच छलफलको बिषय बनेको छ । नेपाल एक भुपरिबेष्ठित देश हो । संसारमा अन्य देशहरू भन्दा भुपरिवेष्ठित देशको आर्थिक विकासको स्तर साह्रै कमजोर स्थितिमा छ । संयुक्त राष्ट्र संघमा सूचीकृत १९५ देशमध्य ४४ देश भूपरिवेष्ठित मुलुक छन्, जसमध्ये ७० प्रतिशत अविकसित छन् ।

समुद्री पहुँच नहुदाँ विश्वका अन्य मुलुकसँग व्यापार व्यवसाय गर्न छिमेकी देशसँग सम्झौता गर्नुपर्ने वाध्यता र स्थल मार्ग प्रयोग गर्दा लाग्ने खर्च र समयका कारण अन्तर्राष्ट्रिय बजारमा प्रतिस्पर्धात्मक क्षमता बृद्धि गर्न नसक्नु अर्न्तराष्टिय व्यापारलाई सहज बनाउन छिमेकी देशसँगको सम्बन्धमा पनि भर पर्नु पर्ने हुदाँ समुद्रसँग सहज उपलब्धता भएको देश भन्दा भुपरिवेष्टित देश पछाडि परेको यर्थाथता हो । यस्तो परिस्थितिबाट पूर्व जानकार रहँदा रहँदै पनि त्यस अनुरूपको दृष्टिकोण, कार्ययोजना बनाई देशलाई कसरी समृद्धि बाटोमा दोहऱ्याउने भन्ने विषयमा ध्यान दिन नसक्दा आज नेपालीले बिषम परिस्थितिको सामना गर्न बाध्य भएका छन् ।

कृषिप्रधान देश नेपालको अर्थतन्त्र कृषिमा निर्भर छ । कुल ग्राहस्थ उत्पादन (GDP) मा कृषिको योगदान ३३ प्रतिशतको हाराहारीमा रहेको छ । देशको आर्थिक बृद्धि दर धानको उत्पादनमा निर्भर रहेको छ । धानको उत्पादनमा घटबढका आधारमा देशको आर्थिक बृद्धि दर घट्ने या बढ्ने गरेको देखिन्छ । सन् २००२ सम्म धानको निर्यातकर्ता नेपालमा प्रति हेक्टर तीन हजार के.जी. धान उत्पादन हुने गरेको छ । जुन अन्य देशको तुलनामा अत्यन्त कम उत्पादन हो । देशको कुल ग्राहस्थ उत्पादन (GDP) मा कृषि र उद्योग धन्दाको योगदान घट्दै गएको र सेवा क्षेत्रको योगदान बढ्दो अवस्थामा छ । देशको व्यापारघाटा चुलिदो छ । एक दशक अघि कुल ग्रार्हस्थ उत्पादनको १५.३ प्रतिशत रहेको व्यापारघाटा ७०।७१ मा बढेर ३२ प्रतिशतको हाराहारीमा पुगि बजेट आकारको बनेको छ । यस वर्ष आयात र निर्यातको माग ८९ प्रतिशत र १० प्रतिशत हुने अनुमान गरेको छ । यसरी निर्यात भन्दा आर्यातमा ९ औं गुणाले बृद्धिले परनिर्भरताले अझ ठूलो आकार लिदै गएको प्रष्ट हुन्छ ।

देश विकासका लागि कृषि, जलस्रोत र पर्यटन

सन २०२२ सम्म नेपाल अन्य विकसित (Least Developed Country LDC) बाट विकासशील मुलुकमा पुग्न नेपालको आर्थिक बृद्धिदर हालको ३-४ प्रतिशत लाई ८-९ प्रतिशत पुऱ्याउनु पर्ने हुन्छ । जुन यस वर्षको भुकम्प र भारतीय नाकावन्दीले अझ चूनौतीपूर्ण बनाएको छ ।

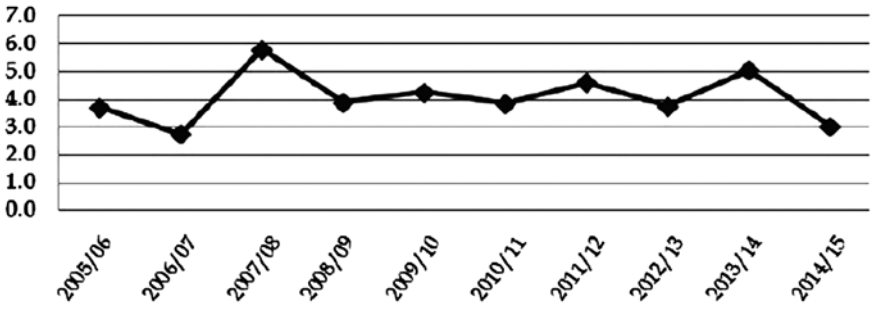


Growth Rate of Agriculture and Non-agriculture sector

तथ्यांङ्क विभागका अनुसार ७० प्रतिशत घरधुरी कृषिमा आधारित रहेको छ र कुल

निर्यातको ९० प्रतिशत भन्दा बढि कृषिमा निर्भर रहेको छ । ६५ प्रतिशत भन्दा बढि जनसंख्याको प्रमुख आयस्रोत कृषिमा १० वर्षको तथ्यांङ्क हेर्ने हो भने २.९ प्रतिशत मात्र बृद्धि भएको पाइन्छ । अझ यस वर्ष कृषिमा १.९ प्रतिशत मात्र बृद्धि हुने प्रक्षेपण गरिएको छ । कृषि प्रधान देशमा भारतबाट चामलको निर्यात हरेक बर्ष बढ्दो छ । सन २०११।१२ को तुलनामा २०१२।१३मा ९८.२ प्रतिशत र २०१२।१३ को तुलनामो २०१३।१४ मा ४६.४ प्रतिशत ले निर्यातमा बृद्धि भएको देखिन्छ ।

कृषि देशको अर्थतन्त्रको मेरूदण्ड हो । तर कृषिको कुल ग्राहर्स्थ उत्पादनमा योगदान झन् झन् घट्दो अवस्थामा छ । हाम्रो जस्तो किसोन्मुख देशको अर्थतन्त्रमा कृषिको महत्वपूर्ण योगदान रहेको हुन्छ । विश्वमा गरिवीको रेखामुनि रहेको जनसंख्या न्यून गर्न कृषिले महत्वपुर्ण भुमिका खेलेको हुन्छ । विश्वमा अझ पनि ३ अर्व मानिसहरू ग्रामीण भेगमा बसोवबास गर्छन् । ग्रामीण भेगमा बसोबास गर्ने मध्ये अधिकाशको मुख्य आर्थिक स्रोत कृषि नै रहेको पाईन्छ । मानव विकास सुचाङ्क २०१४ मा नेपालमा ३० प्रतिशत युवा अनुत्पादक बसेको बताईन्छ । अतः १३ लाख ३१ हजार ५ सय २१ हेक्टर सिंचाई योग्य जमीनमा सिचाईको राम्रो र व्यवस्थित बन्दोबस्त मात्र गर्न सकेको खण्डमा उत्पादकत्व बढ्ने निश्चित छ । क्रान्तिकारी भुमिसुधारको लागु, कृषिमा आधुनिकरण, व्यवसायिकता, सिचाईको बन्दोवस्त उच्च प्राविधिको उपयोग, अनुत्पादक रहेका युवालाई कृषिमा आकर्षणका लागिबिशेष योजना र कार्यक्रम, कृषिमा अनुदान, कृषि ऋणमा प्रोत्साहन लगायतको विषयमा ध्यान दिन सके कृषि क्षेत्रमा ठूलो फड्को मार्न सकिन्छ ।

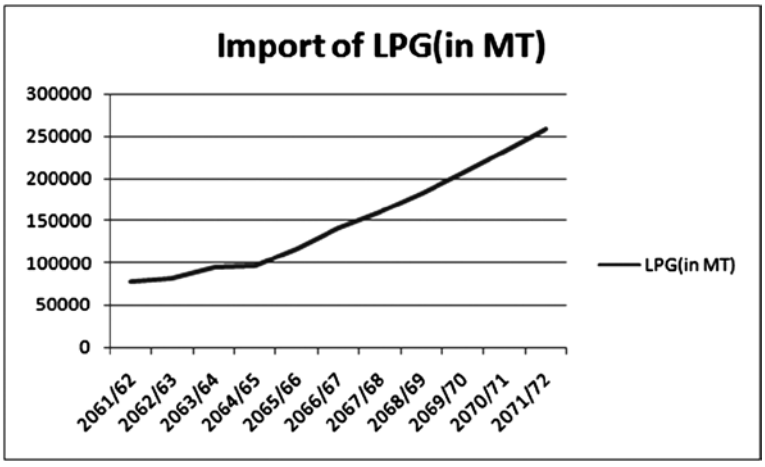


Economic Growth Trend (at Base Price)

तर जलस्रोतको धनी मानिने देशमा सन १९११ मा ५०० किलोवाटको फर्पिङ हाइड्रोपावर स्टेसनबाटजलविद्युत उत्पादन गर्न थालनी गरेको देशमा आज १०४ वर्षसम्म आईपुग्दा पनि आठ सय मेघावाट जलविद्युत उत्पादन गर्न सकेका छैनौं । संसारमा पानीको महत्व बढ्दो छ । भोलिका ठूल - ठूला द्वन्द र युद्धहरू पानीका विषयमा केन्द्रीत हुने सम्भावना बढ्दो छ । तर हामी भने आफ्नो देशको पानीलाई बहु उपयोग गरेर देशमा जलविद्युत उत्पादन गरेर हरेक क्षेत्रमा विद्युतीकरण गर्न चुकिरहेका छौं । अहिले देखिको आयात र निर्यात बीचको विकराल असन्तुलनलाई समायोजन गर्न देशको जलस्रोतको भरमग्दुर उपयोगमा ध्यान जानु आवश्यक छ । दैनिक १४ - १५ घण्टा सम्म लोडसेडिङको मार खेप्न परेको देशका नागरिकहरू कति उत्पादनमुलक क्षेत्रमा सक्रिय हुन सक्छन् सोचनीय बिषय छ । उर्जाको अभावका कारण देशमा विद्यमान उद्योगभन्दा धरासयी मात्र बनेको छैन, नयाँ उद्योगधन्दा स्थापना गर्न पनि हतोसाही पारेको छ । जसका कारण रोजगारी सृजना गर्ने बाटो प्राय बन्द बनेको छ ।

जलस्रोतमा सम्भाव्यता

सार्क राष्ट्रहरू मध्ये सबैभन्दा कम आर्थिक बृद्धिदर भएको देश मध्ये नेपाल एक हो । नेपालको अर्थतन्त्र इन्धनमा आधारित भारतमूखि अर्थतन्त्र हो भन्ने कुरा यस पटकको भारतले लगाएको नाकाबन्दीले पुष्टि भएको छ । नेपाल आयल निगमको १० वर्षको तथ्यांङ्कलाई नियालेर हेर्दा पेट्रोलियम पदार्थ आयात तीब्र रूपमा उक्लिएको छ । आजका दिनसम्म एक थोपा पेट्रोलियम पदार्थ उत्पादन गर्न नसकेको देश दिन प्रतिदिन अन्य देशमा निर्भर हुनुपर्ने इन्धन आयातलाई कटौतीको बैकल्पिक बाटो खोल्न चुक्दै गयो । नेपाल आयल निगमको ग्राफमा २०६१।६२ मा ७६ हजार ९७ किलो लिटर आयात गर्दै आएको पेट्रोल २०७१।७२ सम्म आईपुग्दा २ लाख ८७ हजार ४ सय २३ किलो लिटर आयात भइरहेको छ । त्यसैगरी २०६१।६२ मा ३ लाख ८ हजार ७६ किलो लिटर डिजेलभित्रने गरेको मा ७१।७२ मा ९ लाख २१ हजार ७ सय १४ किला लिटर पुगिसकेको छ । त्यसैगरी अझ LPG ग्यास ७७ हजार ५ सय बाट २ लाख ५८ हजार २ सय मेट्रिक टन ग्याँस भित्र्याइरहेका छौं । इन्धनमा अझ परनिर्भता बढ्दो छ ।



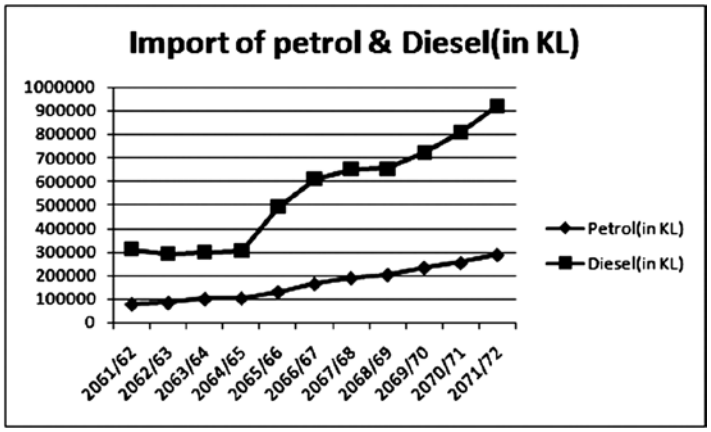
पर्यटन

जमिनको हिसावले विश्वको ०.१ प्रतिशत क्षेत्रफल ओगटेको नेपालमा २ प्रतिशत फुल फुल्ने विरूवाहरू, ८ प्रतिशत चराहरू, ४ प्रतिशत स्तनधारी र करिव ५०० जातका पुतलीहरू पाउने देश हो । Biodivesity को हिसावले धनी नेपालमा पर्यटन क्षेत्र अथाह सम्भावना बोकेको क्षेत्र हो ।

पर्यटकीय गन्तव्यका दृष्टिकोणले नेपाल विश्वका उत्कृष्ट १० देश मध्ये एक मानिन्छ । मनोरम प्राकृतिक सौन्दर्यता, विश्वका अग्ला हिमालहरू सांस्कृतिक धरोहर, विश्व सम्पदा

क्षेत्रको सँगमस्थल नेपालमा पर्यटन क्षेत्र प्रवर्द्धनमा विशेष ध्यान दिन सके आर्थिक गतिविधी एवम् आर्थिक विकास सँग सँगै रोजगारी सृजना गर्ने र गरीवी न्यूनीकरण गर्ने माध्यम बन्न सक्छ ।

पर्यटन क्षेत्र एक उत्पादनमुलक व्यवसाय हो । दक्ष, अदक्ष, अर्धदक्ष, शिक्षित, अशिक्षित लगायतका व्यक्ति सहभागी बन्न सक्ने क्षेत्र भएकाले प्रत्यक्ष र अप्रत्यक्ष रूपमा तल्लो तहका स्थानीय जनतासम्मलाई रोजगारी सृजन गर्न सक्ने क्षेत्र हो । पर्यटन क्षेत्रले सन् २०१३ मा देशको कुल ग्राहर्स्थ उत्पादनमा (GDP) मा २ प्रतिशतको योगदान गरेको छ भने १,७८,००० जनाले रोजगारी पाईरहेको छ । कुल विदेशी मुद्धाको १५ प्रतिशत र कुल राजश्वको ३० प्रतिशत कमाई पर्यटन क्षेत्रबाट हुने गरेको तथ्याङ्क छ ।



सन् २०१२ देखि १४ सम्मको तथ्याङ्कलाई हेर्दा बार्षिक ७ लाख पर्यटकहरूले नेपाल भ्रमण गर्ने गरेको देखिन्छ । Rafting, Trekking, Paragliding, Jungle Safari, Rock Climbing, Mountaineering, Bungee Jumping, Hunting, Ultra Light, Air Craft Mountain Flight लगायत विश्व सम्पदा सुचीमा सुचिकृत सम्पदा क्षेत्र लगायतका दर्जनौ क्षेत्र पर्यटकका आकर्षणका केन्द्रहरू रहने गरेको छ । राजनैतिक अस्थिरता, अपर्याप्त र कमजोर पूर्वाधार, सिमित पर्यटन क्षेत्रको विकास र विस्तार,बायु प्रदुर्षण, सम्पदा क्षेत्रको अपर्याप्त सुधार, अर्न्तराष्ट्रिय विमान स्थल, अव्यवस्थित र असुरक्षित आन्तरिक हवाई मार्ग लगायतका कारण नेपाल भ्रमण गर्ने पर्यटकको संख्यामा उल्लेखिए सफलता पाउन सकेका छैनौं ।

विश्वका जनसंख्या हिसावले एक तिहाई संख्या भएका र अर्थतन्त्रका दृष्टिले विश्वको दोस्रो र सातौं अर्थतन्त्र भएको चीन र भारतका बीचमा रहेको नेपालले छिमेकी देशका पर्यटकलाई मात्र पनि भ्रमणका लागि आकर्षण गर्न सकेको खण्डमा पयर्टन क्षेत्र आर्थिक विकासको एउटा महत्वपूर्ण हिस्सा बन्ने निश्चित छ ।

A Brief Overview of Wireless Power Transfer Techniques

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Abstract: *The necessity to distribute energy wirelessly has been spurred by the tremendous growth in the use of portable devices. Mobile devices have become ubiquitous and the circuits within them have been optimized to consume extremely low amounts of power. Such portable electronic sets are in constant use and the frequent need to recharge them; using conventional wired mechanisms have hindered the mobility of users. Wireless transmission of energy to power-up devices has been proposed since the days of Tesla and since then many theories and methods have been invented. This paper discusses some of those techniques briefly.*

Keywords: *Cordless Electricity, Wireless Energy, Wireless Electricity*

Introduction

The transmission of energy without cords with the intent of charging or supplying power to a remote electronic device has been underway since the time of Tesla. One of Tesla's ambitious goals was to be able to demonstrate a system capable of worldwide distribution of wireless power [4]. The lack of funds together with the primitive technology caused the idea to be abandoned for many years since then. Interest in this field has resurfaced recently mainly due to the advent of mobile electronic devices that are constantly on the move and need to be frequently charged. A successful demonstration of wireless power transfer (WPT) was performed in 2007 by a team of researchers from the Massachusetts Institute of Technology (MIT). They were able to light a 60 Watt incandescent bulb located at a distance of 2 meters from the source without using wires [2]. The intent of wireless power transfer is to move electric charge stored in a reservoir to a distant location without the use of transmission cables. Such a system will increase the portability of light electronic devices and free users from the tedious task of transporting power cords. Since our society is already familiar with the concept of wireless communication provided by cellular phones and wireless local area networks, the obvious question to ask is what is preventing us from hauling energy wirelessly?

Methodology

Out of the numerous wireless energy transfer techniques that have been proposed in research labs and in theory papers, three of them stand out the most. The first method utilizes directed microwaves as the source of wireless energy and rectennas as the converters of microwaves back to electricity, the second scheme makes use of laser technology to beam photons onto photovoltaic cells which in turn convert the photons into electricity, and the third plan implements mutual induction between two coils operating at the same resonant frequency [4].

1) Microwave Assisted Wireless Power Transfer

In this process, a microwave oscillator produces microwaves having frequencies within the range of 1-GHz to 1000-GHz. These waves are then beamed to a remote distance with the help of directional antennas. The microwaves bombarding the receiving antenna are transformed back into electrical energy to power an attached load. The system installed at the receiving end whose responsibility is to convert microwaves into direct-current is called a rectenna. The building blocks of a rectenna include a dipole antenna with a RF diode connected across the dipole elements [3]. The diode helps to rectify the alternating-current that gets induced at the antenna terminals by the microwaves to generate direct-current. Rectennas having conversion efficiencies of 95% have been reported [3]. Microwave assisted wireless power transfer has been proposed for the transmission of energy from orbiting solar powered satellites to Earth.

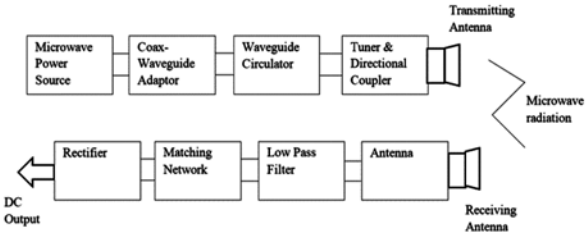

Figure 1: Block Diagram of Microwave based Wireless Power Transmission System [4]

As demonstrated in figure 1, first the microwaves are generated by a microwave generator. This radiation then passes through a coax-waveguide adaptor which in turn is connected to a waveguide circulator. The waveguide circulator protects the microwave source from reflected power [5]. The tuner matches the impedance between the transmitting antenna and the microwave source. The attenuated signals will then be separated based on the direction of signal propagation by a directional coupler. The transmitting antenna radiates the power uniformly through free space to the receiving antenna at which the microwave radiation passes through a low pass filter, followed by a matching network, and lastly through a rectifier as it is converted to DC power.

2) Laser Assisted Wireless Power Transfer

This method is similar in concept to the generation of electricity via solar cells, whereby solar energy from the sun gets converted into electricity. However, in this method the source of light will be a laser that beams photons across a distance to a receiving unit. Photons emerging from the laser diverge as the distance between transmitter and receiver increases, and so to focus the beam onto a narrow spot, the photons are made to pass through converging lenses as they travel towards their destination [1]. The receiving system is composed of a group of photovoltaic cells designed to convert light of a particular wavelength into electricity to energize a load connected at the output stage of the photovoltaic cells [1].

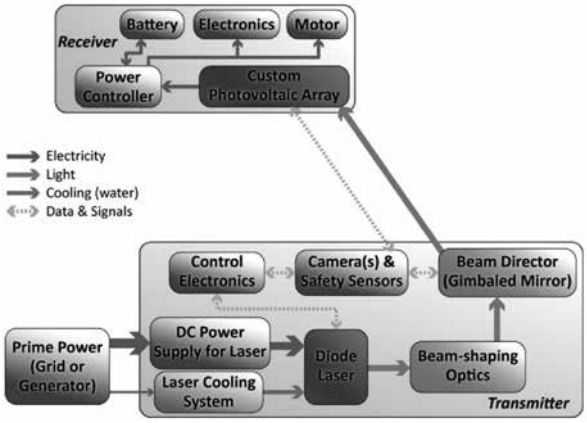

Figure 2: Block Diagram of Laser based Wireless Power Transmission System [8]

As shown in figure 2, laser power beaming (LPB) uses electricity from a common source, such as the electrical grid or a portable generator, and converts it into light via a laser [8]. This laser beam is then shaped with a set of optics, and directed via a gimbaled mirror (also known as the beam director) to a remote photovoltaic (PV) receiver. The PV receiver converts the light back into electricity to be used to charge a battery, run a motor, or to do other work [8]. In many ways, the system can be viewed as a kind of extension cord, with electrical power going in at one end, and electrical power coming out at the other end. The best form of current laser technology is a fiber laser which can produce peak powers in the hundreds of kilowatts [8].

3) Magnetic Resonance Assisted Wireless Power Transfer

From Maxwell's equations it can be seen that a time varying current passing through a coil produces a magnetic field around its surrounding space. As this time-varying magnetic field interacts with another coil placed in the vicinity of the coil producing the magnetic field, an induced current arises in the second coil [2]. This is called mutual induction between the two coils, and the frequency at which the coupling waves attain their maximum amplitude is called the resonant frequency. In this method, primary and secondary coils serve as transmitting and receiving antennas respectively. Some of the critical parameters affecting the performance of this system include the operating frequency, diameter, resistance and the number of turns of the coils [2]. As shown in figure 3, inductive power transfer works by creating an alternating magnetic field (flux) in a transmitter coil and converting that flux into an electric current in the receiver coil. Depending on the distance between the transmitting and receiving coils, only a fraction of the magnetic flux generated by the transmitter coil penetrates the receiver coil and contributes to the power transmission [6]. The more flux reaches the receiver; the better the coils are coupled.

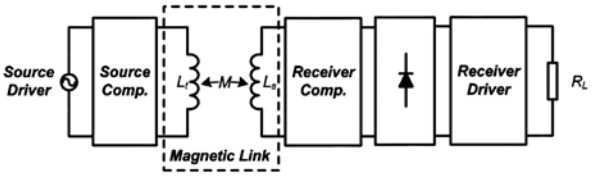

Figure 3: Concept of Magnetic Resonance based Wireless Power Transmission System [7]

In conventional inductive coupling, efficiency drops off rapidly as distance increases. Magnetically coupled resonators with sufficiently high quality factor (Q) coils exhibit a surprising behavior [10]. Maximum power transfer efficiency can be achieved over a broad range of distances and orientations. The transmit antenna consists of a LC based transmitting coil. As electricity travels through this coil, the coil begins to resonate. The oscillator generates a signal at a frequency where maximum power transfer takes place; the signal is then amplified through a power amplifier thus resulting in an oscillating magnetic field [9]. The magnetic waves resonating at a specific frequency are transmitted from the transmitter to a receiver [11]. These magnetic waves interact with a coil at the receiver to induce an electric current at the receiver. If the receiving coil is tuned so that its resonant frequency matches the frequency of the magnetic waves, the current it produces is amplified. The received power would have an alternating current, which is undesirable for powering a DC load, thus a rectifier would be needed to rectify the AC to into a smooth DC.

Each of the three WPT methods discussed in this paper has its own merits and demerits. The three WPT methods have been compared with respect to output power, transmitting distance range, economic feasibility, system efficiency and biologic effects. Table 1 summarizes the results.

	Comparison Parameters				
WPT Methods	**Output Power**	**Distance**	**Cost**	**Efficiency**	**Biological Effects**
Magnetic Resonance	60 Watts [9]	Few Meters [9]	Inexpensive\	Up to 45% [9]	No harmful effects [11]
Microwave	100 kW [12]	Few Kilometers [12]	Expensive	Up to 54% [12]	Damages living tissue [12]
Laser	Several hundred kilowatts [14]	Few Kilometers [14]	Expensive	Up to 30% [14]	Damages living tissue [14]

Table 1: Performance Comparison Wireless Power Transfer Methods

Conclusion

The idea behind wireless power transfer is ground-breaking and its large scale adoption will be the greatest breakthrough in the field of energy transfer. Just as wireless communication has changed the way we communicate, wireless electricity will open doors to new scientific avenues. To make wireless energy transfer commercially viable, researchers still need to increase energy transfer efficiency and develop circuits that can work with minute levels of power. In this paper we have presented a short overview of the techniques currently being explored to transfer power without cords. Out of the various methods of transferring energy wirelessly, the choice depends upon factors such as distance, medium, application, complexity and cost.

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Variable Flux Machines for Electric Vehicle Applications

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Abstract: *Because of environmental concerns, there is growing interest in electric and hybrid electric vehicles. An efficient, low weight, high torque density electric machine is required for such vehicles. All of these requirements are met with permanent magnet synchronous machines using rare earth permanent magnets. However, the price of rare earth magnets is high and its supply is limited and unpredictable. Moreover, PMSMs require field weakening current for speed above base speed that causes increase in stator copper loss for high speed operation. This result in lower efficiency at high speed region and narrow torque-speed envelope. These drawbacks can be addressed by utilizing low coercive force magnets like Sc-Co and AlNiCo for rotor field excitation. Magnet flux can be varied in electric machines utilizing these magnets. Such machines are called variable flux machine which has wide torque speed envelope as the field weakening current can be made low at speed above base speed.*

Introduction

Vehicles driven by internal combustion engines (ICE) is one of the major source of air pollution and greenhouse gas emission. As reported, transportation in a typical city accounts for up to 41% of the CO2 emissions[1]. Because of growing environmental concerns and worldwide interest in clean energy, there has been growing interest in electric (EV) and hybrid electric vehicle (HEV) technology. Recent advancement in high quality magnetic materials and power electronics have contributed to new energy efficient high performance electric drives that is suited for EV and HEV application. Among various types of electrical machines, permanent magnet synchronous machines (PMSM) and induction machines (IM) are the most demanded by auto industries[2] owing to high efficiency of PMSM and lower cost of IM [3].

PMSMs utilizes rare earth magnets having high remanant flux density and high coercive force. The high remanant flux density allows the PMSM to be operated at high flux density giving high output torque and power density. The high coercive force makes the PMSM tolerant to demagnetization from stator current. Since permanent magnets provide the excitation to the PMSM, continuous supply of current for field excitation is eliminated making it the most efficient electrical machine. However for extended speed operation, due to the limited inverter voltage, the PMSMs require continuous field weakening current. Since there is limitation to the stator current, increase in field weakening current limits the torque producing current. This makes the torque speed envelope for the PMSMs to be narrow. While electric vehicles require wide torque speed range for efficient operation[4] in all operating regions, oversized PMSMs are required. Moreover, due to the field weakening current, there is increase in stator copper loss in extended speed region. Thus efficiency of the PMSMs drop at speed above base speed. Another issue with rare earth magnets is that its price is high and fluctuating. Due to increased interest in EVs and HEVs,the demand of these magnets is increasing but there is limited supply. This generates uncertainty of its availability and prohibits long term design planning in automotive market[5].

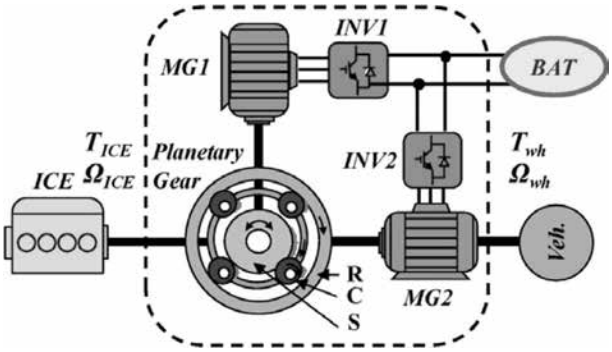

Figure1. Toyota Prius hybrid system diagram [5]

As an alternative to rare earth magnets and to achieve wide torque speed envelope with variable torque-speed characteristics, Samarium Cobalt (Sc-Co) was utilized in [6]and [7]. Besides, AlNiCo as low coercive force magnet was utilized in [8] and [9] to achieve high torque density machine with wide and variable torque-speed characteristics. Both Sc-Co and AlNiCo are less expensive and readily available compare to rare earth magnets. The magnet flux in electrical machines using these alternative magnets can be varied by supplying d-axis stator current. These machines are called variable flux machine (VFM). The concept of variable flux motors was proposed in [10] to achieve an extended flux weakening region. The proposed memory motor usually required an oversized inverter, as the inverter should be able to re-magnetize the magnets by an armature current. In [11], VFM using AlNiCo magnets was designed for reduced inverter rating. It was possible due to low coercive field for AlNiCo. The added benefit using AlNiCo magnets is higher remanant flux density comparable to rare earth magnets.

EV and HEV

Hybrid electric vehicles (HEV) are jointly powered by ICEs and electric machines. The ICE is operated at constant speed of highest fuel efficiency while the electric machine is operated as variable speed drive to charge the battery during low speed and drive the load when high torque is required.

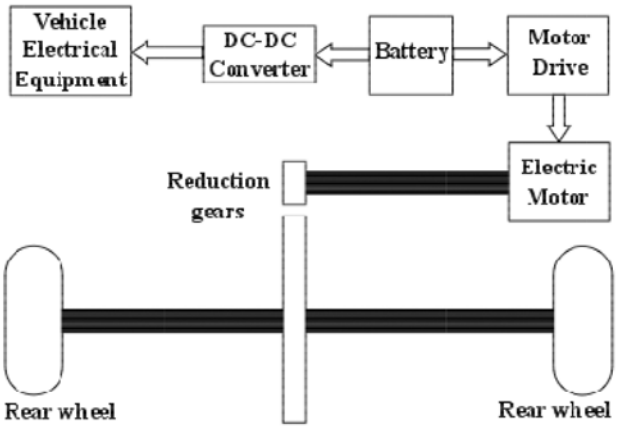

Figure2. Typical system schematic of EVs [12]

Fig. 1shows the hybrid system employed in the 2004 Toyota Prius. It consists of two PMSMs. MG1 is a smaller machine that acts mainly as a generator to charge the battery pack through energy taken from the output of the ICE. MG2 is a larger machine which is directly coupled to the vehicle wheel and the torque provided to the wheels is the sum of the torque form MG2 and ICE minus the torque taken from MG1.

In Electric vehicles, an electric motor or a few electric motors are used to drive the wheels of the vehicle. Figure 2 shows the typical schematic of EVs. Battery is the main source of energy and provides power to the electric motor drive and other equipment. Based on the drivetrain systems, EVs can be conventional type with electric motor replacing conventional ICE, transmission less type with electric motor directly feeding differential gear, In-wheel with reduction gears type with motors directly feeding the wheels through reduction gears, Cascade type with no differential gear, In-wheel direct drive type and Four wheel direct drive type with four in wheel motors to drive four wheels as shown inFig. 3.

Characteristics of Motor drives for EVs

The basic characteristics of an electric machine for traction applications are as follows[4].

- High torque and power density.
- High starting torque, high torque at low speeds for hill climbing, and high power for high speed cruising.
- Wide speed range, with a constant power range of around 3-4 times the base speed.
- High efficiency over wide speed and torque ranges, including low torque operation.
- Intermitted overload capability, typically twice the rated torque for short durations.
- High reliability and robustness appropriate to the vehicle environment.
- Acceptable cost
- Low acoustic noise and low torque ripple.

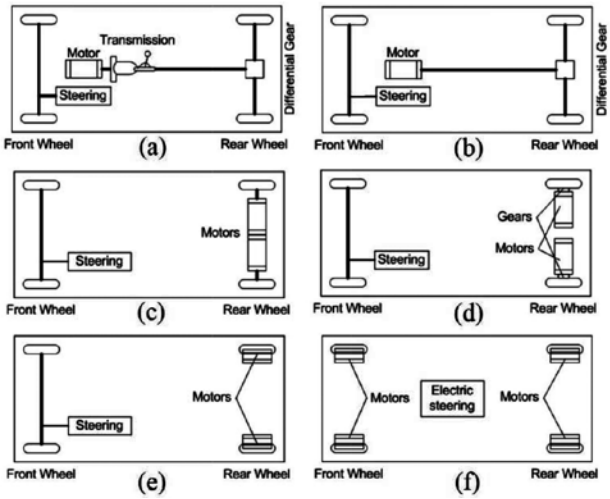

Figure 3.Different types of drivetrain systems in an EV (a) Conventional type. (b) Transmission-less type. (c) Cascade type. (d) In-wheel type with Reduction gears. (e) In-wheel direct-drive type. (f) Four-wheel direct-drive type [12].

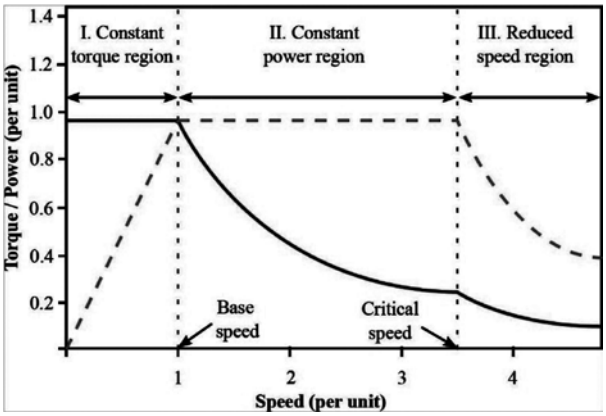

Fig. 4.Idealized torque/power-speed characteristics of electric motors

Typical torque speed characteristics for traction machines is shown in Fig. 4. In constant torque region I, the maximum torque capability is determined by the current rating of the inverter, while in the constant power region II, flux weakening has to be employed due to limited inverter voltage and current. In region III, the torque and power reduce due to increasing influence of the back-EMF.

Permanent magnet synchronous machine

PMSM uses permanent magnets for the field excitation. Usually, high performance PMSMs use the rare earth magnets. These magnets have the highest remanant flux density, high coercivity and highest energy density. Further, the demagnetization characteristics of these magnets is linear. So they are ideal source of magnetic field for electric machines.Fig. 5 shows different topologies of radial field PMSMs. Because of thepermanent magnets in the rotor in PMSMs, continuous field current is not required. This makes PMSMs more efficient than other types of motors. Other advantages of rare earth PMSMs are high power density, high torque per unit current, higher torque to inertia ratio, smaller rectifier and inverter volt ampere rating,

small and compact in size and less weight. However, PMSMs using rare earth magnets are costlier and they require absolute position sensor.

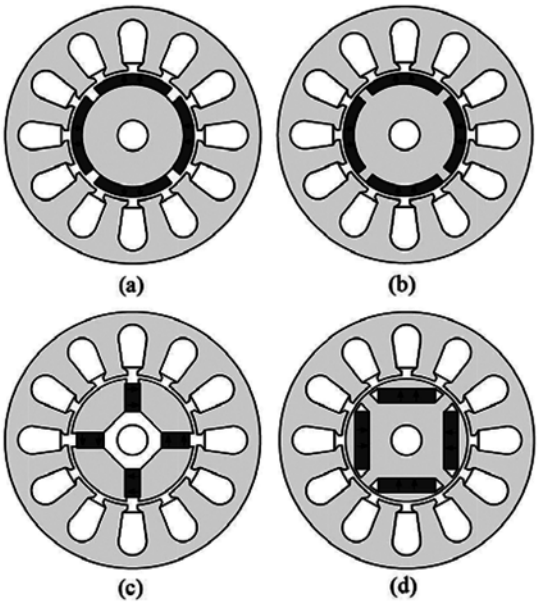

Fig. 5. Different topologies of radial field PMSMs. (a) Surface mounted PMSM. (b) Inset PMSM. (c) Buried PMSM. (d) Spoke type PMSM.

Vector control of PMSMs

All AC machines are controlled using vector control technique for high performance applications. For vector control, dq model is used in which the three phases in PMSM is modeled using two orthogonal coils. The d-axis is along the direction of the magnet flux and the q-axis leads the d-axis by 90o electrical. For modeling PMSMs, rotor reference frame is used, in which d- and q- axes are rotating synchronously with the rotor. Fig. shows the three phase stationary coils and equivalent rotating d- and q- axes coils in rotor reference frame. Expressions for d-axis voltage, v_d and q-axis voltage v_q are given by (1) and (2).

$$v_d = \frac{2}{3}\left[v_a \sin\theta + v_b \sin\left(\theta - \frac{2\pi}{3}\right) + v_c \sin\left(\theta + \frac{2\pi}{3}\right)\right] \quad (1)$$

$$v_q = \frac{2}{3}\left[v_a \cos\theta + v_b \cos\left(\theta - \frac{2\pi}{3}\right) + v_c \cos\left(\theta + \frac{2\pi}{3}\right)\right] \quad (2)$$

Where, v_a, v_b, v_c are phase voltages and θ is the position of q-axis from phase a-axis. Dynamic equations for PMSM can be written as (3)-(6).

$$v_d = R_s i_d + \frac{d\lambda_d}{dt} - \omega_r \lambda_q \quad (3)$$

$$v_q = R_s i_q + \frac{d\lambda_q}{dt} + \omega_r \lambda_d \quad (4)$$

$$\lambda_d = L_d i_d + \lambda_f \quad (5)$$

$$\lambda_q = L_q i_q \quad (6)$$

Here R_s is the stator resistance, i_d and i_q are d- and q-axes currents, λ_d and λ_q are d- and q- axes flux linkages, λ_f is the magnet flux linkage, ω_r is the rotor speed, L_d and L_q are d- and q- axes inductances.

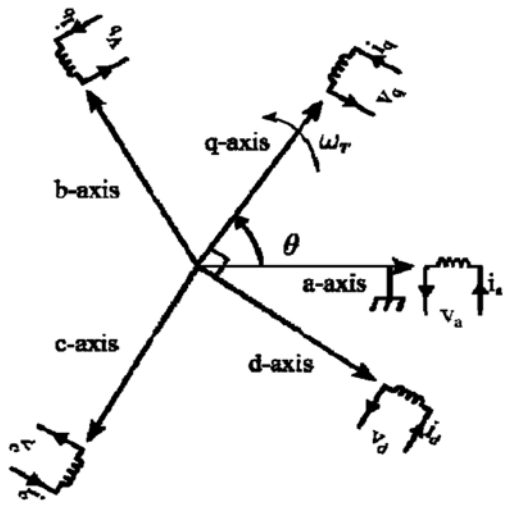

Fig. 6 Three phase stationary coils and equivalent rotating d- and q-axes coils in rotor reference frame.

Variable Flux Machine

Magnet flux in a VFM can be varied so as to gain varying torque speed characteristics. This gives an extra degree of freedom to the permanent magnet machine. At speed higher than the base speed, field weakening current is applied to normal PMSM, however, for VFM, the magnets can be demagnetized to lower magnet flux so that no field weakening current is required. This technique enhances the torque speed envelope and improve the efficiency at speed higher than base speed. The VFM utilizes low coercivity magnets so that the magnetizing and the demagnetizing currents are lower. As explained in section I, AlNiCo and Sc-Co have been utilized in VFMs. Fig. 6 shows the cross section of a pole pair of VFM utilizing AlNiCo magnets[11]. It also shows the d- and q-axes flux paths in the machine.

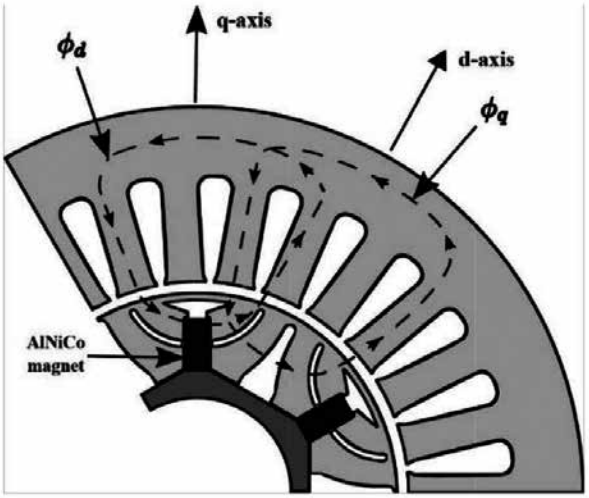

Fig. 7. A portion of cross section of a tangentially magnetized VFM utilizing AlNiCo magnets showing d- and q-axes flux paths[11]

Magnetization and demagnetization characteristics

To have control over the magnet flux, magnetization and demagnetization characteristics of a VFM is required. To obtain these characteristics, the rotor is locked at the d-axis and current pulse of different amplitude is applied

[13]. For each current pulse, the magnet flux is measured by running the VFM as generator and measuring the no load back emf. Magnetization characteristics is obtained from positive d-axis current pulse and demagnetization characteristics is obtained from negative d-axis current pulse. Figure 8 and Figure 9 shows measured magnetization and de-magnetization characteristics for a prototyped VFM.

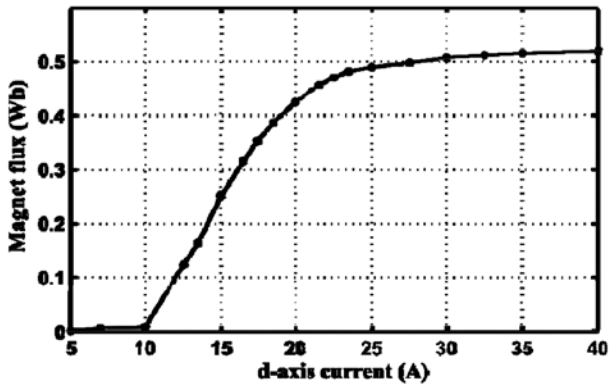

Fig. 8 Magnetization characteristics of a prototyped VFM

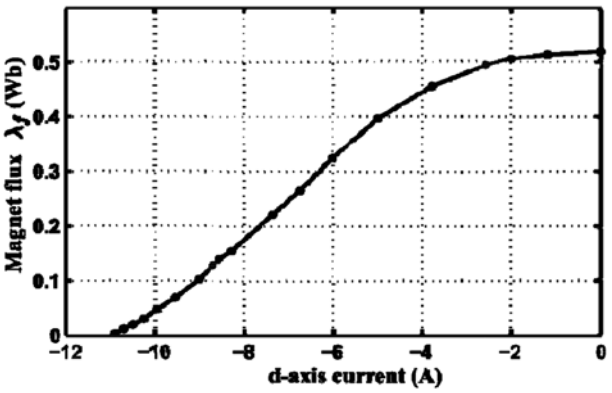

Fig. 9 Demagnetization characteristics of a prototyped VFM

Control strategy of VFM

Basic control strategy of a VFM using AlNiCo magnets is demonstrated in [13]. Vector control technique is usedto control the machine. The currents are controlled sothat highest possible torque is obtained at lower speedand the machine is demagnetized at speed higher thanthe base speed to reduce or eliminate the field weakening current. Figure 10 shows the proposed vector controlstrategy. The reference speed is compared with the measured speed to generate the reference q-axis current. Thed-axis current reference is set to zero for normal operation. However, when the speed increases and the invertercannot produce enough voltage to drive the motor forhigher speed, field weakening operation is initiated. InFigure 10, part I gives the reference q-axis current. Part II gives the limit to the field weakening current which de- pend on the present magnetization state of the machine.Part III generates the d-axis current for field weakeningoperation. Part IV gives the reference d-axis for magnetization and demagnetization depending on the speed ofthe machine.

Advantages of VFM

- It uses readily available less expensive magnets.
- For low torque and speed, PMSMs operate at fullmagnet flux while VFM can be operated at lower flux to improve the efficiency.
- At high speed, PMSMs require field weakening current that causes extra copper losses in stator windings. However, VFM can be demagnetized to lowermagnetization level to increase the torque speed envelope requiring no or less field weakening current.Thus efficiency is improved at speed above basespeed.
- Due to limitation in inverter voltage and current,the torque speed envelope is narrow for PMSMs. But the variability in torque speed envelope of VFM makes possible to operate the VFM at higher speed which is suited for electric vehicle application.

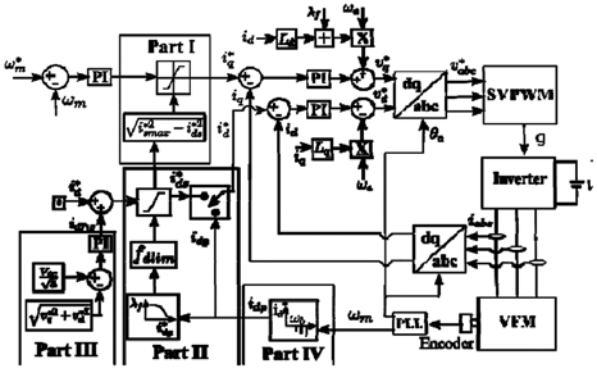

Fig. 10 Schematic of vector control drive for VFM

Conclusion

Environmental concerns is driving the transportation industry move towards electrical and hybrid electric vehicles. While hybrid vehicles uses both ICE and electricmachines, electric vehicles uses electric motors to drivethe vehicle. For the EVs, PMSMs are the suitable candidate owing to its high efficiency and high torque to inertiaratio. However, PMSMs uses rare earth magnets which islimited in supply and its supply is uncertain. Moreover, PMSMs require field weakening current at speeds above the base speed which decreases its efficiency at higher speed operation. This limits the torque-speed range and oversized machine is required for vehicular application.An alternative to rare earth magnets for PMSMs is touse low coercivity magnets yet having comparable remanant flux density for field excitation. These magnets are readily available and less expensive. The magnet flux inVFM can be varied by applying d-axis current. This improve efficiency at speed above base speed. Moreover, the torque-speed envelope of VFM can be varied. All these advantages makes the VFM, a suitable candidate for EVs application.

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Hydrological Response of the 2015 Gorkha Earthquake

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A magnitude 7.8 earthquake struck Nepal on April 25, 2015 and caused massive destruction. The main quake was followed by numerous aftershocks of magnitude 5 or higher causing further damage and losses. The aftershocks are continuing till today. Nepal's landscape, which is predominantly composed of hills and steep mountains combined with fragile geological formations and heavy monsoon rainfall, leads to wide range of geological and hydro-meteorological hazards affecting the country. In addition, Nepal's geological characteristics together with torrential rain during rainy season often result in landslides, debris flows, and floods.

The Gorkha earthquake not only disrupted lives and property, it also altered the movement of water across and under the affected plain. Groundwater levels changed, springs started flowing, and the some of the tributaries of Narayani River and Koshi River have been observed with change in their flow just after the earthquake. Nepal water professional and scientists are taking this rare opportunity to examine how the earthquake has affected the region's rivers and aquifers. This preliminary study aims to analyze data from existing water-level and flow monitoring networks of the Department of Hydrology and Meteorology. The data before and after one month (approximately) of the earthquake of Narayani, Tadi, Bhotekoshi, Tamakoshi and Dudhkoshi are taken and analyzed in this study. Selected stations are superimposed in orange in real-time observational hydro meteorological network map as shown in Fig. 1. The temporal changes in water level of selected stations are shown in following figures.

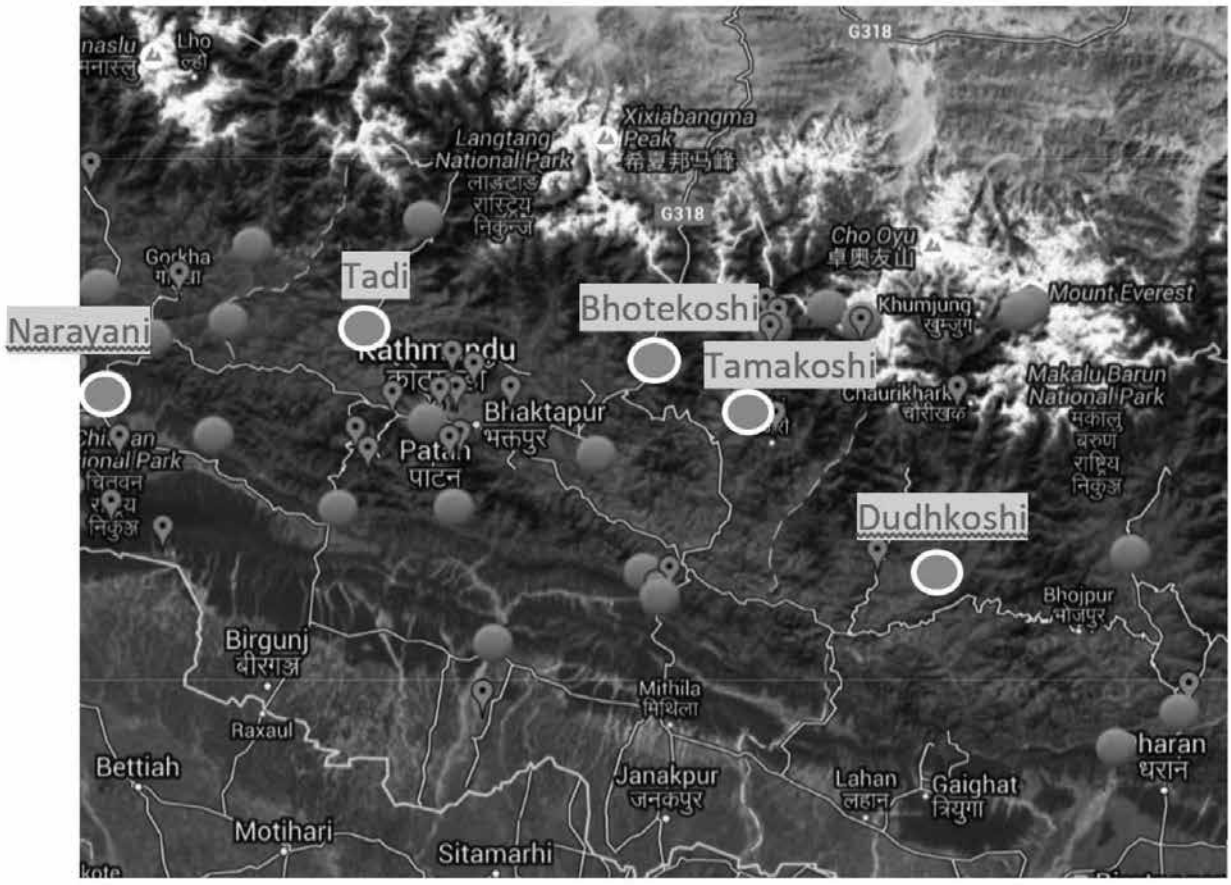
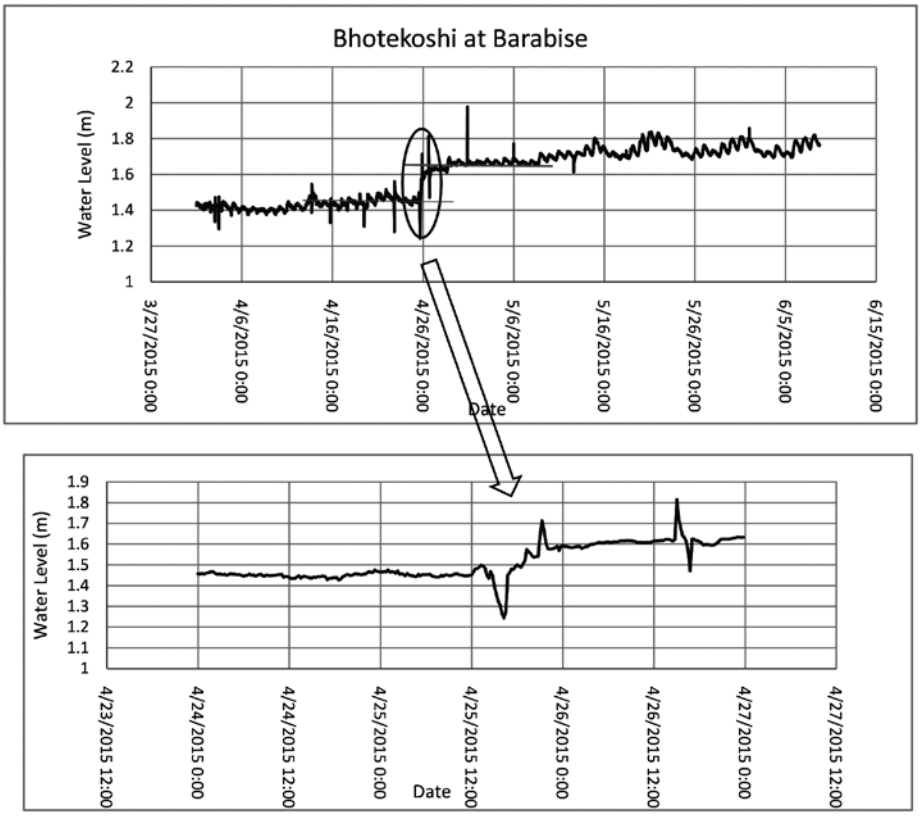
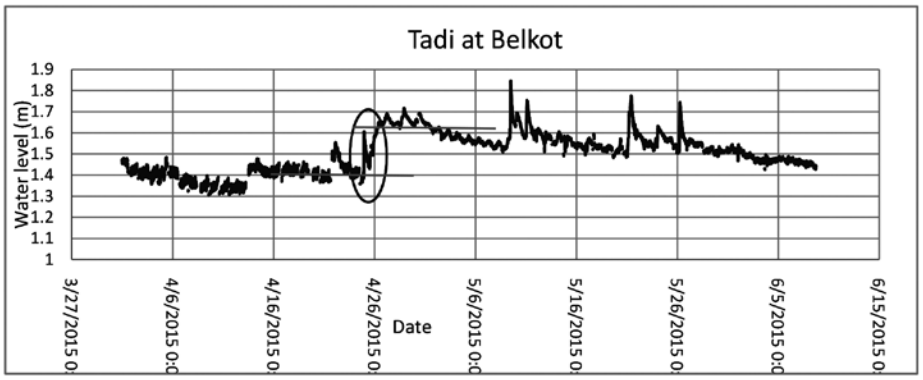


Fig. 1: Real time hydro-meteorological observational network (selected stations in orange)

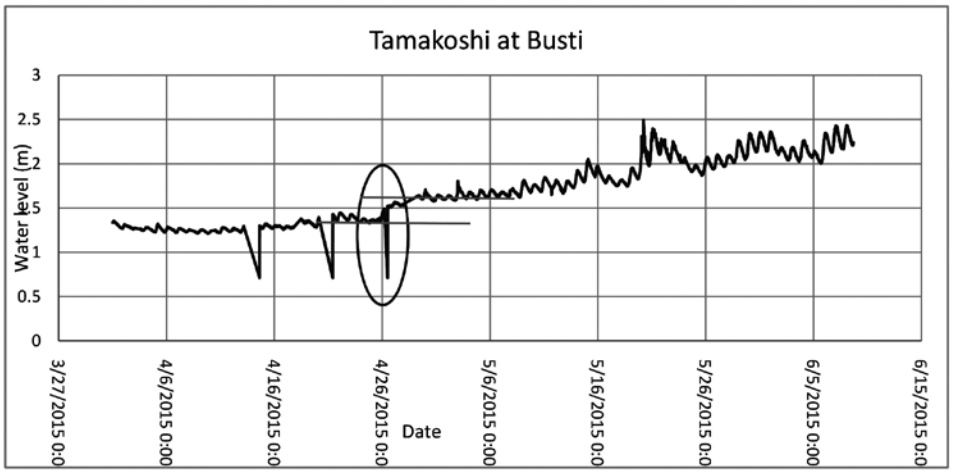
Water Level Profile of Bhotekoshi at Barabise



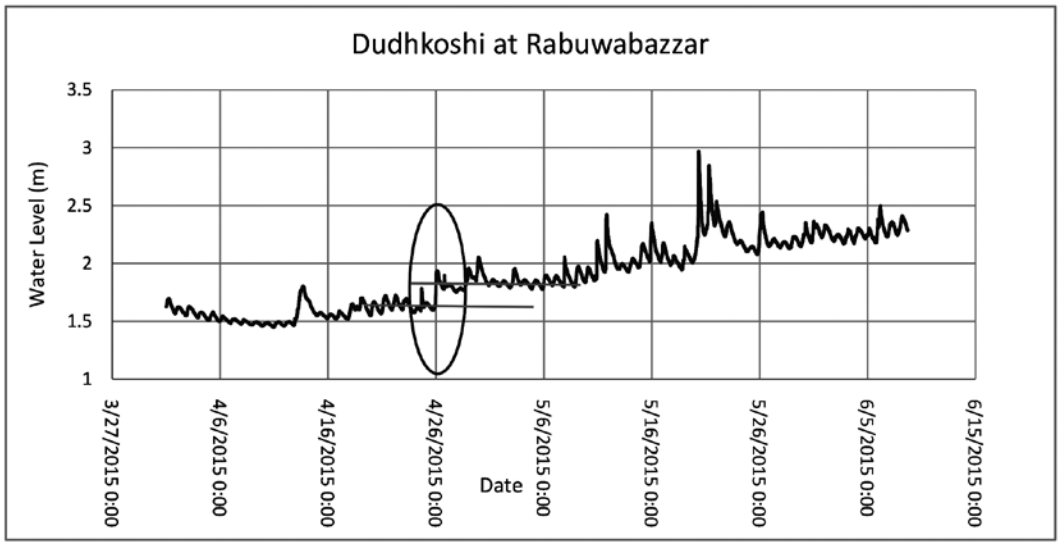
Water Level Profile of Tadi at Belkot



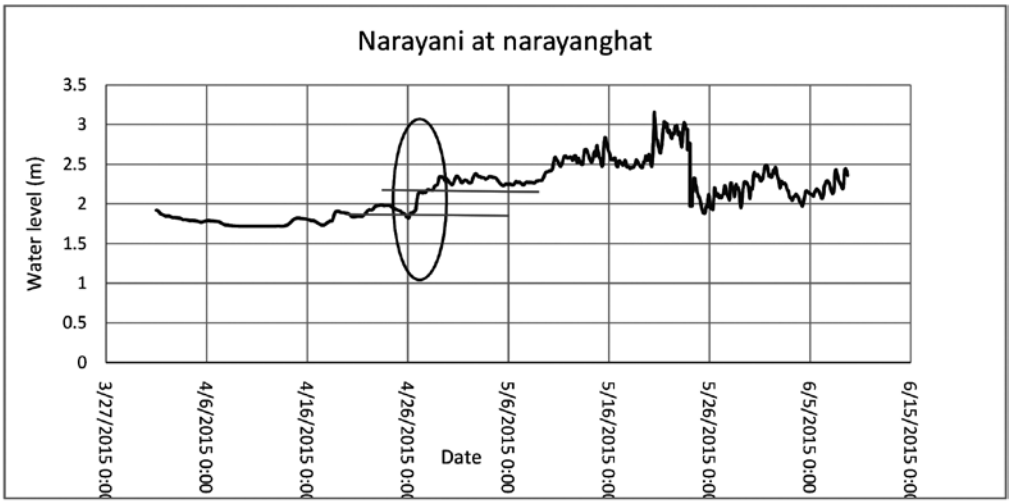
Water Level Profile of Tamakoshi at Busti



Water level profile of Dudhkoshi at Rabuwabazzar



Water level profile of Narayani at Narayanghat



Discussions

The stations taken as reference for this study are located in mostly affected regions of the Gorkha Earthquake. A clear picture of how the water level has changed is observed in all the stations. Minimum of 25cm in water level change after the earthquake in comparison to the before trend is observed in all five stations. A very interesting fact found is that the water level has decreased significantly just after the earthquakes for some hours in all stations and then the water level is increased. This is a matter of comprehensive study taking geological parameters under consideration but one of the reason could be the lateral flow during big shake and possible loss in the banks of the channel and other could be the change in spring sources by location and discharging capacity. But, after a few hours the water level in the river is ascended not only gaining the original level but has significantly amplified above the prior base level trend and this is common to all five stations. Which evidently signifies chances of flow change rather than the geological changes in the river channel and gauging stations. There was also not significant precipitation observed till one day after the earthquake in the region. All these evidences prove that the increase in flow was due to the changes taken place in the aquifers. The reason could be the settling of the formation inside resulting into more flow from the springs and aquifer outlets.

This preliminary study is limited to only 5 stations. In future many other stations need to be well inspected, other hydro-meteorological parameters need to be analyzed and simultaneously simulated numerically. As a conclusion, we interpreted this as a direct impact of the shaking on the valley-ridge scale sub-subsurface permeability, stressing the large potential effects of strong earthquakes on near-surface processes.

Acknowledgment

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Performance Evaluation of Energy Technologies in Residential Sector

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Abstract: *Energy situation of Nepal at present is very critical. Continuous energy crisis holds back economic advancement of the nation. With time, advance technologies are available and there is shift in consumption pattern as well. Assessment of preferences of technologies in residential sector was done. After reviewing of relevant scholarly literature and discussion with experts, an appropriate decision model was formulated consisting of goal, criteria, sub-criteria and alternatives. Existing technologies that utilizes Electricity, LPG, Fuelwood, Kerosene and Solar are the alternatives in all end use services. Economical, technical, social and environmental criteria are considered. Analytical Hierarchy Process (AHP) model was developed to highlight the preference of technologies in major end use services of residential sector. The output of the model shows electric technology as the preferred options in almost all the end use services of residential sector. Besides prioritization of technologies, the results from AHP can also be used in future energy planning. With the availability of electricity throughout the nation, preferences shifts from traditional to modern technologies.*

Keywords: *Energy; AHP; criteria; sub-criteria; residential; technologies*

Introduction

Energy is the vital element for sustainable development of country. Energy resources are regarded as the key strategic natural resources having the potential to be the catalyst for all round development and economic growth of the country. Unless the energy sector is geared up for efficient and indigenous sustainable resources along with their sustainable harnessing, economy cannot move forward on a higher growth path. Every advanced economy requires secure access to modern sources of energy to fortify its development and growing prosperity. While many developed countries may be focused on domestic energy security or decarbonising energy fuel mix, many other developing countries like Nepal are still seeking to secure enough energy to meet basic human needs (IEA, 2011). According to Human Development Index, Nepal rank 157th position with 0.458. Access to reliable and affordable energy services is fundamental to reducing poverty and improving health, increasing productivity, enhancing competitiveness and promoting economic growth.

The economy of Nepal is based mainly on agriculture with more than 76% of people engaged in it. According to the economic survey and statistics on Nepal by Asian Development Bank, the contribution of the agricultural sector has declined to 35% and that of the non-agricultural sector increased to 65% showing a positive sign of improving economic status of country(MoF, 2012).

Energy is an indicator of development. High per capita energy consumption signifies high living standard of people. Developed countries have significantly higher per capita energy consumption. For example, the United States has a per capita energy consumption of 314 GJ/year, Japan has 163 GJ/year, and United Kingdom has 142 GJ/year. According to world energy statistics of 2010, the per capita total primary energy supply (TPES) of Nepal is just 15 GJ/year, which is far less than world's average per capita TPES of 77 GJ/year. Energy consumption per capita of Nepal is lowest among south Asian countries and electricity consumption per capita is 104 kWh (UNESCAP, 2012). The EDI (Energy development Index) ranks Nepal at 74th position with EDI of 0.08. One of the main reasons for this fact is that about 37% of households do not have access to electricity that can boost economic indicator(SERN, 2011). The total primary energy consumption in the year 2008/09 was estimated to be about 401 PJ (WECS, 2011). Energy statistics of Nepal exhibit large dominance of traditional and non-commercial forms of energy such as fuel-wood, agricultural residue and animal waste. Energy carriers like petroleum fuels, coals and electricity contributes only 9%, 3% and 2% (WECS, 2010) respectively in total energy consumption.

Residential sector consume substantial amount of energy. Energy consumption characteristics of the residential sector are complex and inter-related, comprehensive models are needed to assess the techno economic impacts of adopting energy technologies (Lukas & Ugural, 2009). Residential energy consumption in Nepal for the year 2008/09 accounts for the major share of energy consumption (89%). This sector consumed about 357 PJ of energy. Biomass resources are the major fuels source in this sector that accounts to 99% of the total fuel wood consumed only in the residential sector. Similarly 91% of the agricultural residue is consumed and animal dung is being used in biogas generation which increased by about 15% in annual basis (WECS, 2010).

WECS (2006) has assessed that 48 PJ energy is consumed in the urban residential, which is equivalent to about 15% of the total residential energy consumption. In context of urban sector energy consumption, cooking purpose consumes large share of energy i.e. 52%

followed by electric appliances (14%) and lighting (13%) heating and cooling (10%). LPG contributes about 25% of the total consumption followed by kerosene (9%), animal residue and dung (3% each) and biogas (2%). Fuel wood share in rural residential is about 71%.

The energy synopsis report of WECS shows that there is distinct change (both in amount and type of fuel) in energy consumption over time. The total energy consumption of Nepal in the year 1994/95 was about 285 million GJ. About 92% of this energy consumption was met by traditional energy sources and the rest by commercial energy sources. In 2010, total energy consumption increases to 401 PJ and about 87% of this is met by traditional energy sources.

The total energy consumption data in the country shows an annual increase of about 2.4%. Significant rise of annual electricity consumption by around 10% implies growing demand for electricity as household income is rising. However, 25% annual surge of imported LPG fuel consumption seems perilous to national economy. As of WECS data 2008/09, fuel wood consumption share is 87% of total energy consumption and almost 99% of which is consumed in residential sector.

Nepal has huge potential for hydropower development with an estimated potential of 83 GW and feasibility of 42 GW . However to our dismay, only 2% of it has been harnessed. Further, eelectricity contributes only 2% of the total energy demands (SERN, 2011). At present, Nepal has a total installed capacity of 762 MW. Of the total installed capacity of the hydropower, 478 MW is contributed by NEA hydro, 5 MW by NEA thermal, 0.10 MW by solar and 230 MW-all Run-off-the River (ROR) by IPP hydro (NEA, 2009) (NEA, A Year In Review Fiscal Year 2012/13, 2013).

Nepal is totally dependent on imported petroleum fuels. Soaring international oil market price is making countriy's economy vulnerable. The nation spent approximately 126% of its commodity exports in 2010/11 on import of petroleum products which stood at 27% of the exports earnings in 2000/01 (MoF, 2001) (MoF, 2012). If Nepal can overcome the barriers of indigenous electricity production, it can avoid the cost of importing petroleum products. Without proper vision, strategies, and action plans for the sustainable development of energy sector, Nepal's economy could be in jeopardy in the coming years

Methodology

Existing technologies in residential sector for cooking, lighting, space heating and water heating were identified based on relevant literatures. Details of technologies were analyzed based on its performance and availability. Regional questionnaire survey conducted for the study of water and energy vision data were collected. The survey was conducted among 163 participants from five development regions among various strata of people from government bodies to energy experts. An AHP model is used for the selection and prioritization of energy technologies. Relative weights of criteria with respect to goal are calculated. Alternatives are incorporated in the final level of hierarchy for evaluation. Capital cost, investment cost, efficiency, emission level, durability.

Analytical Hierarchy Process (AHP)

AHP is a widely used Multi Criteria Decision Analysis (MCDA) method and considered a very effective and powerful technique (Athanasios & Pilavachi, 2009) (Belton & Gear, 1983). It is used in numbers of studies related to energy. AHP is comprehensive multiple criteria decision-making tool that has been used in almost all the applications related with decision-making (Vaidya & Kumar, 2006). Further, energy resource allocation can also be done using a multi-criteria decision with the criteria being quantitative and/or qualitative. Solving such a problem requires an integrated approach (Ramanathan & Ganesh, 1995).

AHP method employs a consistency test to screen out inconsistent judgments by any expert and this is also considered as an advantage of using AHP. It is important that the decision-makers should be consistent in their preference ratings expressed by pair wise comparisons. It has been recommended that consistency ratio (CR) should be less than 0.10 and mentioned that CR greater than 0.10 indicates serious inconsistencies and in that case AHP may not provide meaningful results (Saaty, 1980).

AHP Model

AHP model was developed using Expert's Choice. Technologies in residential sector were evaluated using numbers of criteria and sub-criteria. There are numbers of end use services considered in residential sectors namely cooking, lighting, space heating, space cooling and water heating. Different end use technologies based on survey output were considered as alternatives for each end use services in AHP. Each of the criteria and sub criteria were weighted based on literature and survey. In each criteria and sub-criteria, alternatives were rated and then normalized to prioritize the technologies.

Results and Discussions

Cooking

The analysis of data shows that at present most of people use LPG for cooking in residential sector but they preferred to cook in electricity in near future. People want to shift from traditional and imported cooking technologies to modern indigenous and efficient technologies. These data were incorporated in AHP along with other criteria. The preferences are as shown in table 1

Table 1 Preferences of Technologies in Cooking

Technologies	Current	Expected
TR	31.9%	6.4%
ICS	12.3%	7.8%
Gasifier	3.1%	4.0%
LPG	30.7%	9.5%

Table 1 continued

Kerosone	4.7%	0.6%
Electricity	10.2%	36.6%
Biogas	5.6%	14.5%
Solar stove	1.4%	20.5%

The efficiency, investment cost, O&M cost, and emission are given below in table 2.

Table 2 Factors affecting selection of technologies

Techno-logies	Efficiency	Investment Cost (Million Rs/TJ)	O&M Cost (Million Rs/TJ)	Life (Years)	Emission factor GHG tonnes/ TJ
Kerosene	23%	0.274	0.007	5	72.328
LPG	54%	0.967	0.024	10	63.254
Electric	65%	0.503	0.013	5	0
Fuel Wood	7%	0.000	0.000	1	120.692
Bio Gas	57%	0.398	0.010	10	54.754

Different criteria and sub criteria along with the alternatives were selected based on the literature and survey which are as shown in table 3.

Table 3 Criteria, sub-criteria and alternatives in cooking

Criteria	Sub-criteria	Alternatives
Economic	Investment cost	Fuelwood Kerosene LPG Electricity Biogas
	O&M cost	
Technical	Design	
	Maintainability	
	Efficiency	
	Availability	
Social	Peoples Acceptibility	
	Quality of life	
Environmental	Emission	

The assessment model indicates economic criteria as most important with relative weight of 50%. In addition, investment cost affects the technology selection as it weighs 75% compare to 25% for O&M cost. Based on this approach, ICS is the best technology to be adopted as investment cost is very low compare to other technologies in this end use

Figure 1 Screenshot of synthesis result of Cooking technologies

The performance evaluation of cooking technologies shows that ICS is the best technology to be adopted for cooking in residential sector. The priority weight is 0.3207 for ICS followed by electricity with 0.24. AHP thus shows that economic criteria plays crucial role in determining technologies. However when all four criteria are given equal weights in another scenario, AHP ranks electric cooking as the best. The overall inconsistency of 0.02 depicts the acceptability of output from AHP. Biomass also receives higher ranking depicting its low investment, O&M cost and simple design. Investment cost and operating cost is high for LPG. Kerosene stove is socially and environmentally outdated in modern technologies. Biogas and kerosene is least preferred technology in overall aspect. Biogas is mainly due to high installation cost and O&M cost and less acceptability of people due to requirement of daily man hour.

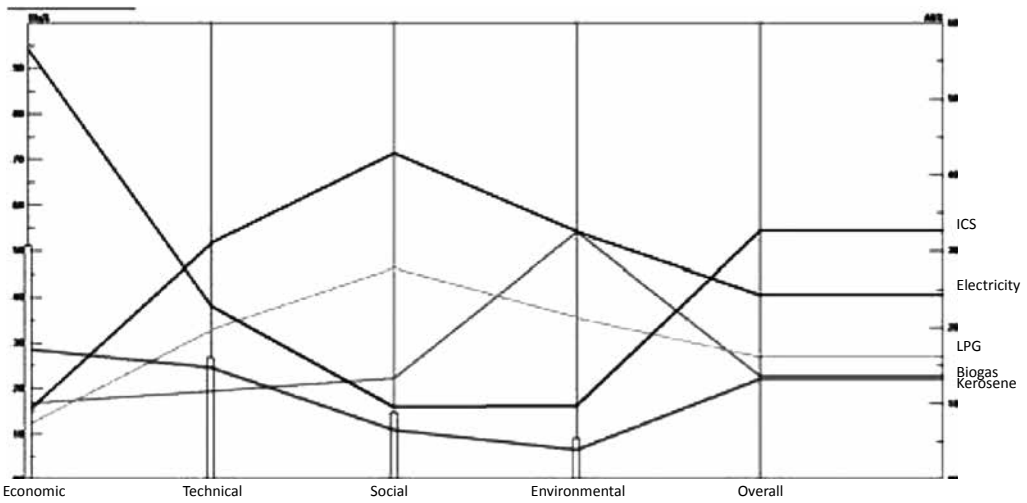

Figure 2 Sensitivity analysis of Cooking technologies

Lighting

In lighting, as per the survey data, most of the people are using CFL lamp at present followed by tube light and incandescent lamp. But in near future they preferred to use LED and CFL as major lighting technologies. Considering their preferences the AHP analysis was done under different criteria. The result shows that LED and solar are the most preferred technologies for lighting

Table 4 Technologies in lighting

Technologies	Current	Expected
Kerosene	9%	1%
Incandescent	19%	4%
Tube light	21%	14%
CFL	33%	24%
LED	15%	49%
Biogas	4%	4%
SHS	9%	26%

The criteria and alternatives for this end use service are as in table 5

Table 5 Criteria and alternatives in lighting

Criteria	Alternatives
Capital Cost	Incandescent
O&M Cost	Fluorescent
Reliability	CFL
Comfort	LPG
Efficiency	Solar

The sensitivity analysis for this service is as in figure 3. It imparts that LED and solar are the best options to be adopted for lighting in residential sector of Nepal. High efficiency, high comfort, reliability are the deciding factors. Reliability comfort and efficiency factor each weighs 25%.

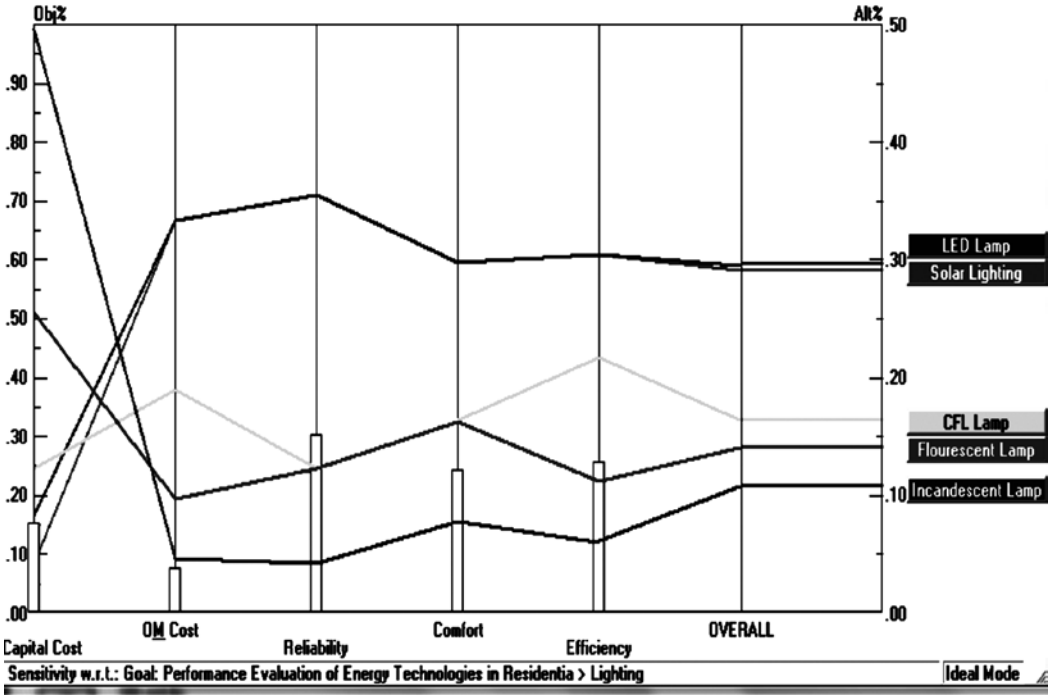

Figure 3 Sensitivity analysis of lighting technologies

The priority weight of both is 0.29 each. Capital cost is high as both are imported technology. Solar lighting is highly reliable and efficient. On the other hand electric LED lights are more efficient and durable. The prioritization of technologies is as shown with an overall inconsistency of 0.03. The sensitivity graph also shows the effect of criteria and their weight in prioritising the technology.

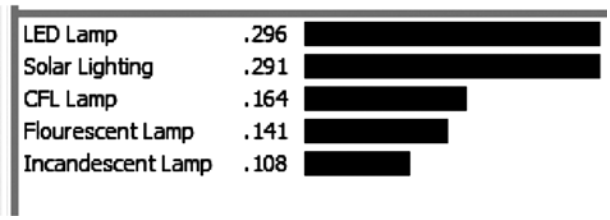

Figure 4 Ranking of lighting technologies

Space Heating and Water Heating

Currently, traditional biomass, LPG and electricity are used for space heating while the figure shows shift in future energy technology for the same. Criteria in space heating include reliability, comfort, efficiency, capital, operation and maintenance cost, time of repair, layout flexibility and emission. The overall weight of criteria shows that reliability and comforts have relative weight of 28% each, capital and O&M cost weighs 17% and 12% each.

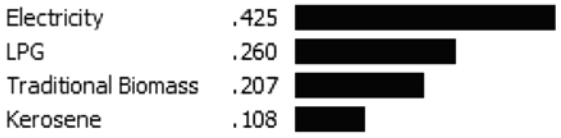

Figure 5 Synthesis result of space heating technologies

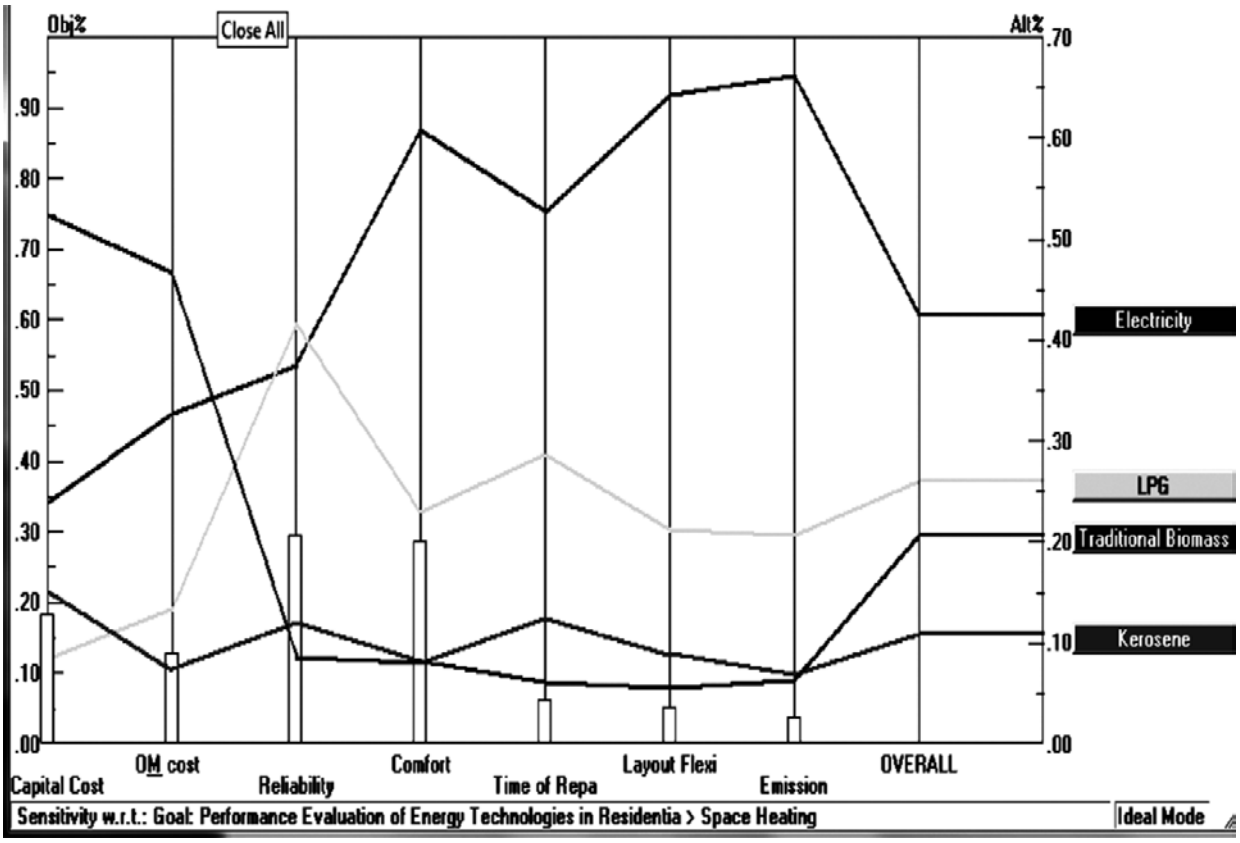

Figure 6 Sensitivity in space heating

The model thus gave ranking of technologies based on the weights of criteria. It ranks electricity as the best option with priority weight of 0.42 followed by LPG with 0.24. Electricity is less reliable in our country because of low electricity supply than demand, however, comfort from electricity is higher than other technologies and further it scores highest in all other criteria providing the highest overall weight to electricity. The overall inconsistency of result is 0.05.

Water heating is another residential energy technology consuming energy. Criteria in water heating include reliability, efficiency, capital, operation and maintenance cost, emission, energy saving, acceptability and maintainability. Reliability weights 24% of total weight, efficiency and energy saving weights relative 16% each. Thus reliability of technology affects the prioritization. Highly reliable water heating technologies surpass other technologies.

At present LPG and traditional fuelwood is use for water heating purpose however there are prospective approach to shift to modern energy technology.

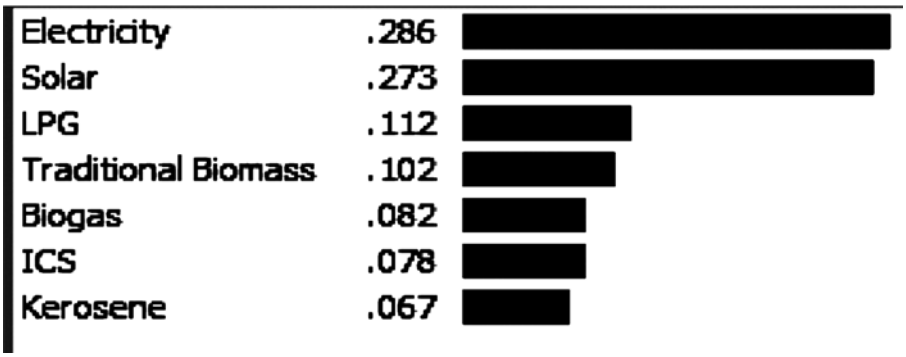

Figure 7 Synthesis result of Water Heating technologies

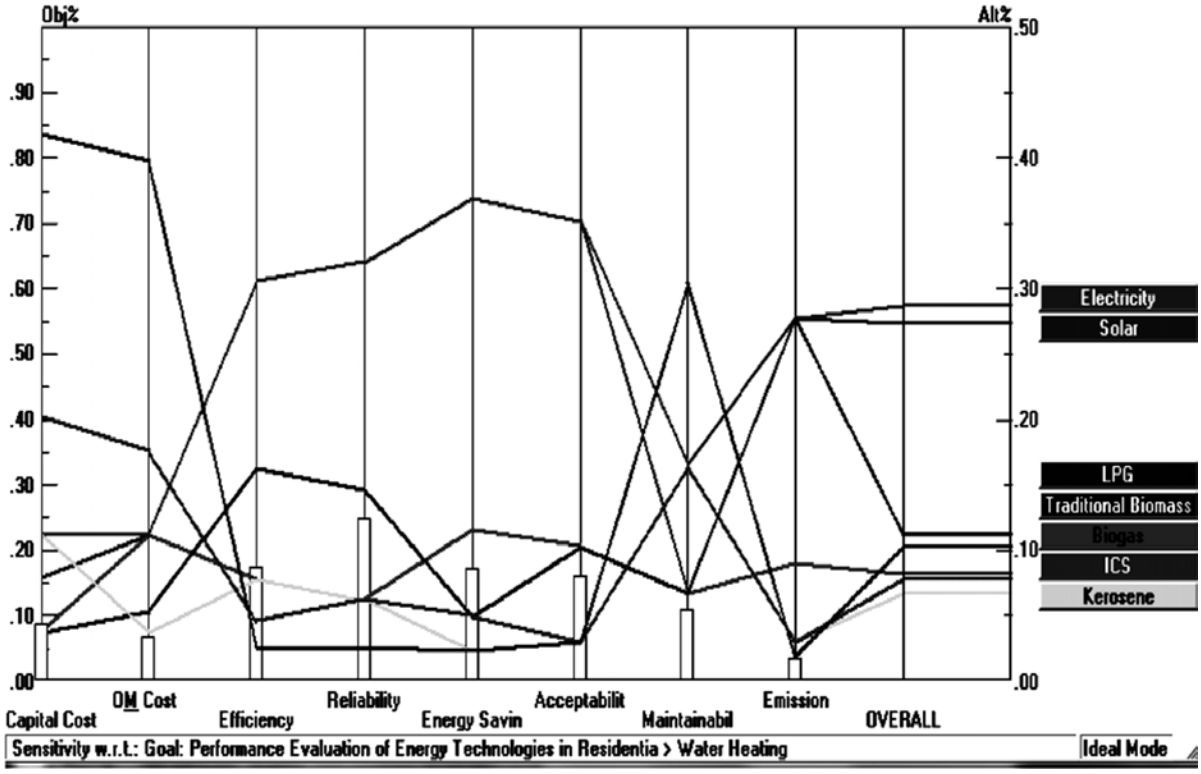

Figure 8 Sensitivity in water heating

Sensitivity analysis of water heating is as shown in figure 8. It indicates that electricity is the best technology for water heating followed by solar, LPG, traditional biomass and kerosene. Sensitivity result shows preference of technologies in each criterion. Electricity is less reliable in our country because supply is lesser than demand. However, it weighs higher than other technologies in remaining criteria. The overall inconsistency of result is 0.05. Solar and electricity are best option to be adopted in residential water heating

Findings

Performance evaluation of energy technologies shows that modern electric technology is the best technology to be adopted in future. The consumption pattern at present is mostly biomass, imported petroleum which by far is not the preference of people as shown by survey data analysis. Choice of technology depends on different criteria and sub-criteria. Economic criteria determine the technology prioritization in cooking, while reliability, acceptability, efficiency and design complexity determines the choice of technology in other end use services. To shift the energy consuming pattern in future, criteria and sub-criteria that play major role should be addressed. In cooking, electricity should be made available with low cost and technology cost should also be reduced. ICS should be made available in rural area where there is no grid connection. LPG is imported technology but is adopted due to reliability, efficiency, and social and environment point of view. In lighting, electric LED and solar are highly efficient, comfortable and reliable technologies. These are also energy saving technologies. Solar water heating and electric space heating are best technologies in residential sector. To meet demand of people to use best technology so as to improve living standard, supply of electricity needs to be sufficient. Huge potential of hydropower needs to be harnessed for domestic purpose.

Conclusions

Energy scenario of Nepal is poor and technology availability in the country is even poorer. The comparative study of energy consumption and preferred technology shows disparity in availability and desired technology.

The major findings of the survey is that electric technology is the most desired technology for cooking, lighting, water heating, space heating. In cooking, ICS is preferred best, however technically, socially and environmentally electric technology is best preferred LED light is preferred best for lighting in residential sector due mainly to its reliability, efficiency and comfort. In water heating, electricity and solar are best preferred technology as they are highly efficient, technically feasible, socially acceptable and durable followed by LPG water heater while least preferred are kerosene and biomass. In space heating, electricity and LPG are desired technology because of its comfort, layout feasibility, reliability and low emission while least preferred one is biomass and kerosene. Thus it can be concluded from above results considering each of criteria and sub-criteria that electric technology is the most desirable and suitable technology in residential sector of Nepal.

Recommendations

- Combined use of scenario building and participatory multi-criteria analysis (PMCA) can be done which

has been done separately in this study. Scenario analysis involves high degree of complexity inherent in the system while MCA assess options on the basis of multi-dimensional criteria and calculates ranking of options. Assessing scenario with PMCA involves intensive resource. 'Metacriteria' combination of scenario and primary criteria can be generated to address complex decision context.

- Further study can be done for other end-use sectors like commercial, transportation, industry, etc
- Comparative analysis of energy technology can be done using other decision making tools.

Limitations of the study

The study was solely based on the questionnaire developed for participants in regional workshop conducted for the study of water and energy vision conducted by Water and Energy Commission Secretariat in 2012 with total participants of 163 from different sectors. Required input data were generated from the analysis of survey data. Criteria and sub-criteria selected are basically the outcome of literature. Data base was developed based on available secondary database for 2010.

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भवननिर्माण गर्दा ध्यानदिनुपर्ने कुराहरु

- **जगमा ढलान गर्दा माटो राम्ररी पन्छाऔं । किनभने माटो सिमेण्टको शत्रु हो ।**
- ताजा सिमेन्ट प्रयोग गरौं । सिमेन्टको बोरामा उत्पादनमितिहेर्न नछुटाऔं ।
- **ओ.पी.सी.(*OPC*) र पी.पी.सी.(*PPC*) सिमेण्ट फरकफरक प्रयोजनका लागि बनाइएका हुन् । मुख्य मुख्य ढलान (*जग, बीम, पिलर, स्ल्याब र भऱ्याङ्ग*) मा सकभर ओपिसि सिमेण्ट नै प्रयोग गरौं।**
- मुख्य मुख्यढलान (*जग, बीम, पिलर, स्ल्याब र भऱ्याङ्ग*) गर्दा भाईब्रेटर र मिक्सर मेशिन अनिवार्य रुपमा प्रयोग गरौं ।

- **७ मि.मि. को (टोरकारी) डण्डी, पिलर र बीममा रिङ्गको रुपमा प्रयोग नगरौं ।**
- हरेक निर्माण सामग्री (*डण्ड, सिमेण्ट, गिट्टी, बालुवा र इँटा*) को गुणस्तरमा ख्याल गरौं ।
- **निर्माणपूर्व नै आफ्नो भवनको साकार नमूना बनाऔं ।**

निर्माणपूर्व नै आफ्नो घरको नमुना(**3D**) बनाएर हेर्दा नक्सा र निर्माण दुरुस्त बनाउन मद्दत गर्छ ।

- इँटा देखिने भित्ताको बाहिरी मोहडामा रङ्ग नलगाऔं ।
- **भऱ्याङ्गमुनि ट्वाइलेट नराखौं ।**
- कोठा र ट्वाईलेटमा प्रकाश र हावाको आवतजावतमा ख्याल राखौं ।
- **मौलिक एवं परम्परागत भवन पनि शताब्दीऔ टिकेको उदाहरण हामीसँग छ । त्यसैले परम्परागत भवन निर्माणमा जोड दिऔं ।**
- भूकम्पले असर गरेको घरमा आफूखुसी मर्मत नगरौ ।
- **भवन बनाउँदा सम्बन्धित प्राविधिक (अनुभवीआर्किटेक्ट, इन्जिनियर, ओभरसियर) को रेखदेखमा कार्य अगाडि बढाऔं ।**
- अनुभवी आर्किटेक्ट, इन्जिनियरबाट भवन डिजाइन गराएर मात्र निर्माण गरौं ।

निशुल्क परामर्शको लागि :

"विगत डेढ दशकदेखिभूकम्पप्रतिरोधात्मकएवं गुणस्तरीय भवननिर्माणमा प्रतिबद्ध"

मेथड कन्सल्टेन्सी

सूर्यविनायक बसस्टप, भक्तपुर,
फोन नं.: ०१६२१०५६८, ९८५१०६२६८०, ९८४१८४८०२०
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जनहतिको लागि ESGB को सहकार्य

PARAMETRIC STUDY OF PRESTRESSED BOX GIRDER BRIDGE UNDER DIFFERENT RADIUS OF CURVATURE

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Abstract: *In this paper, various behaviors like bending, shear, axial & torsion are presented for horizontally curved prestressed box bridges considering 3-D FEM using SAP software. FEM models are prepared for eight different bridges keeping the same span length material properties with varying degree of curvature from 50m to 200m for to get multiplication factor for various actions like BM, SF, AF & TM with respect to straight bridge to multiply the desired parameters of straight bridge to get that for curved bridge. This approach simplifies analysis & the preliminary design of curved bridge section. Similarly this paper also studies the behavior of curved bridge under earthquake loading along three directions that is along the span, perpendicular to span and along vertical direction.*

Introduction

Over the past few decades, in the modern road networks, traffic congestion, increasing demands on highways and multilevel interchanges, adaptation in the formulation of major highways that have to reduce the distances between cities and aesthetic and economic factors have rendered horizontally curved bridges popular, both in urban and non urban areas on major highways.

In the current specifications of IRC, no separate guideline is available for the curved bridge except consideration of torsion moment. Refined analysis is required to calculate torsional moment in the curved bridges. Finite element method is most suitable for analysis of such type of problem, but looking to the complexity involved in use of finite element method, the designer involved in the process of bridge designing need some simplified solution to solve the problem. In this paper, the authors have tried to solve the problem by introducing the term multiplication factor (M.F), which is used to find out desired action in the curved bridge by simply multiplying to the corresponding action of the straight bridge. The curvature has greatest influence on seismic response in horizontally curved bridge. In this study the influence of curvature on response of bridge subjected to earthquake load along three perpendicular directions are also studied by Non Linear Time History Analysis.

Bridge Description Modeling

The bridge used in this study is Andhi Khola Bridge, located at Syangja district. It is a prestressed concrete, two Lane Bridge with carriageway width 7.50 m with 800mm footpath on both sides. It consists of single span simply supported over pier cap. The structural geometry of the bridge was defined starting from drawings in hard copy availed by Bridge Unit, Department of Roads. A three-dimensional (3D) model of the structural system is required to capture the response of the entire bridge system and individual components under specific seismic demand characteristics. This enables correct evaluation of the capacity and ductility of the system under seismic loads or displacements applied along any given direction, not necessary aligned with the principal axis of the bridge. For the simulation of seismic behavior of the bridge, the structural model of the bridge was developed using a commercial finite element program SAP2000 v 14.0. Mainly superstructure consists of longitudinal girder, transverse girder and deck slab. The deck slab, longitudinal girder and cross girders are modeled as four node plane shell elements. The abutment is modeled using beam element supported on spring.

Parametric Study

A parametric study was conducted on the finite element model to study the response. Response in terms of Bending Moment, Torsion, Shear force, deflection and longitudinal stresses are studied. The only parameter that is varied is Radius of Curvature.

Parameter: Radius of Curvature		
Ranges	Span	Span to Curvature Ratio
Straight	50	0
200	50	0.25
175	50	0.28
150	50	0.33
125	50	0.4
100	50	0.5
70	50	0.71
50	50	1

Results and Discussion

Results of Static Analysis

Analyses of the curved and straight box girder bridge models for dead load, prestressed load and moving load conducted. The responses such as torsion, bending moment, longitudinal stress, deflections are monitored in each analysis. The non-dimensional parameter (L/R) is considered to plot the variation of the maximum responses curvature of the bridges.

Responses for the entire bridge model is considered under dead load prestressed load and moving load. The variation of response is plotted across a span length. A non dimensional parameter α, is introduced here which represents ratio of maximum response of curved bridge to that of straight bridge from moving load analysis. The variation of α is considered with the non dimensional parameter (L/R) for plotting the graphs.

Results of Time History Analysis

A non linear time history analysis is done on all bridge models using Gorkha Earthquake. North-South component of Earthquake (PGA=0.17g) is applied along U2 (Y-direction). The output time steps for (N-S) were 0.005 seconds for a total of 12000 steps indicating a total time of 60 seconds. East- West component of earthquake (PGA=0.126g) is applied along U1(X-direction). The output time steps were 0.005 seconds for a total of 11000 steps indicating a total time of 55seconds. The vertical component of Gorkha Earthquake (PGA=0.205g) is applied along vertical (z-direction). The output time step for vertical analysis is 0.005sec for a total of 13000 steps indicating a total time of 65sec. Torsion, Bending moment about vertical axis (M22) and vertical shear for all eight bridge models were observed at support (At 0m) only. Similarly Bending Moment about horizontal axis is observed at mid span of bridge.

Conclusions

From static analysis a multiplication factor for Torsion, Bending Moment, Shear and Longitudinal Stress is determined in terms of L/R ratio. When response of straight bridge is multiplied by this multiplication factor, it roughly gives the response of Curve Bridge. This method can be used in preliminary design of curved bridge.

1 From Static analysis of (DL+LL+prestressed) load, as radius curvature increases, torsional moment also increases almost linearly which can be approximately related by multiplication factor which is,

$$\alpha_{torsion} = 18.635L/R - 0.4226$$

From Static Analysis of (DL+LL+Prestressed) load, when radius of curvature increases longitudinal Bending Moment increases non linearly which can be given by multiplying bending moment of straight with multiplication factor which is

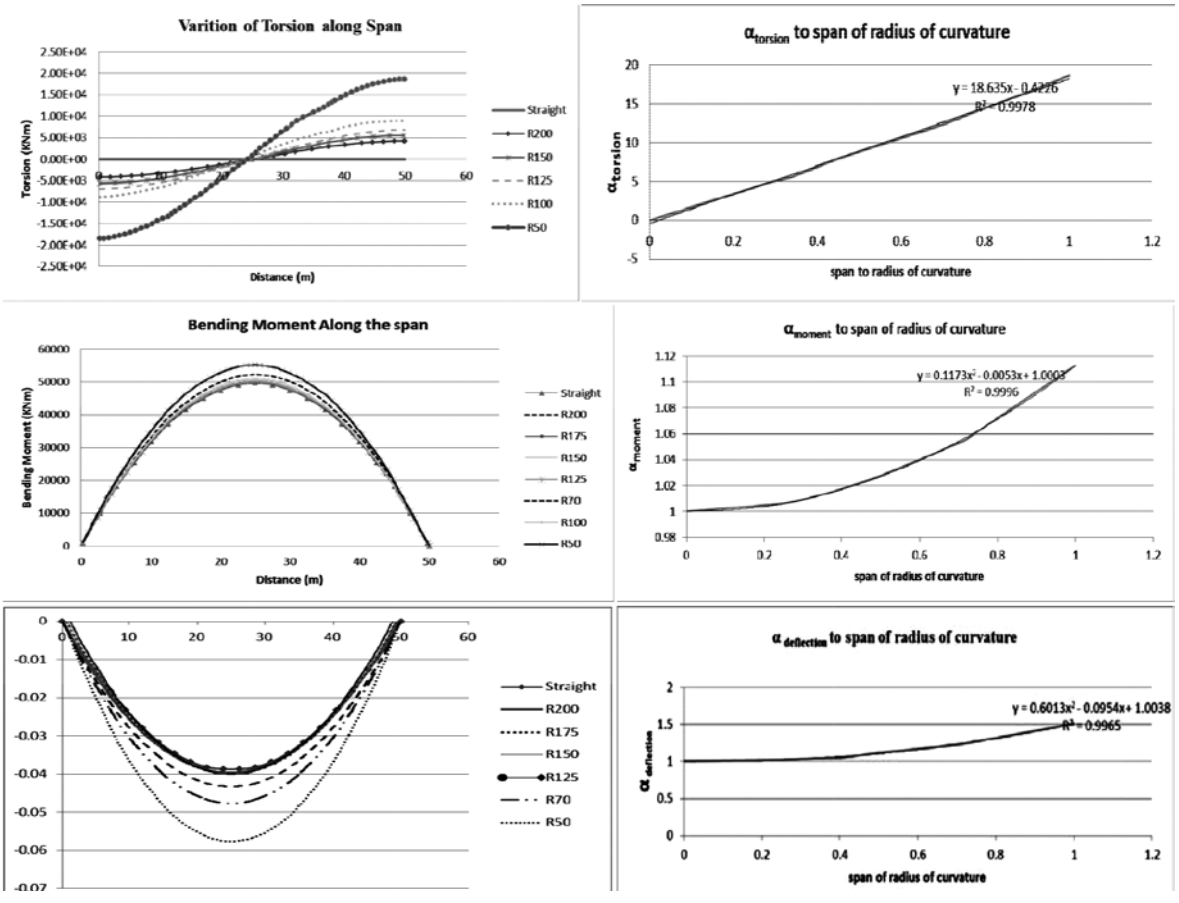
$$\alpha_{bending} = 0.1173(L/R)\ 2 - 0.0053(L/R) + 1.0003$$

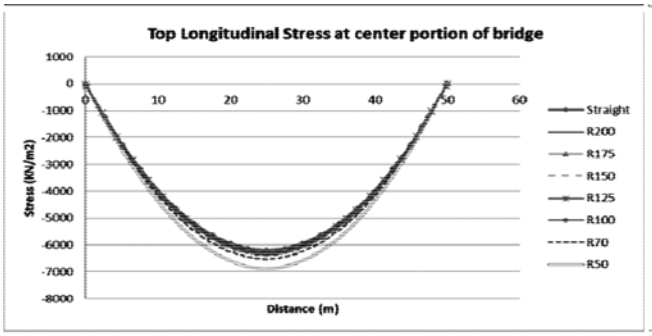
There slight increase in Bending Moment as radius of curvature increases for small curvature. When radius curvature increases up to 100m longitudinal Bending Moment is almost same as that of straight bridge. But with further increase in radius of curvature Bending Moment increases rapidly.

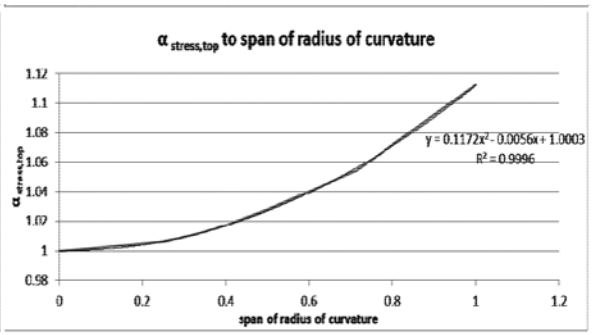
2 From static analysis we can conclude that similar to longitudinal bending moment for small radius of curvature i.e. up to R125 deflection of box girder is almost same as that of straight bridge but it rises rapidly at R100.Deflection of R50 is almost 45% more than that of straight bridge. Relation of deflection of box girder in terms of span to radius of curvature can be given roughly by

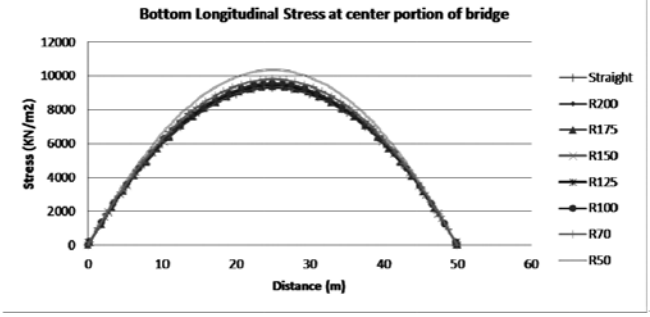
$$\alpha_{deflection} = 0.6013x\ (L/R)\ 2 - 0.0954x\ (L/R) + 1.0038$$

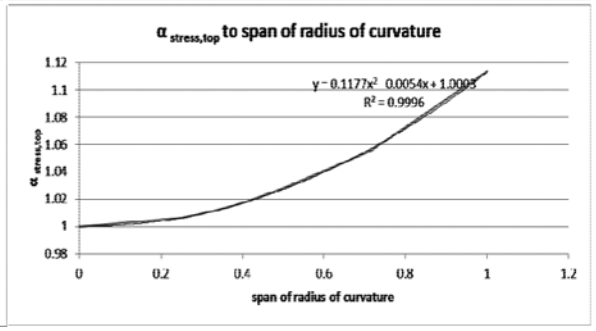
3 Longitudinal stress at top and bottom of the bridge increases as radius of curvature increases. Rate of











increase of stress is small up to small radius of curvature but it rises rapidly as curvature increases. With span to radius of curvature greater than 0.5 stresses increases rapidly with increase in curvature.

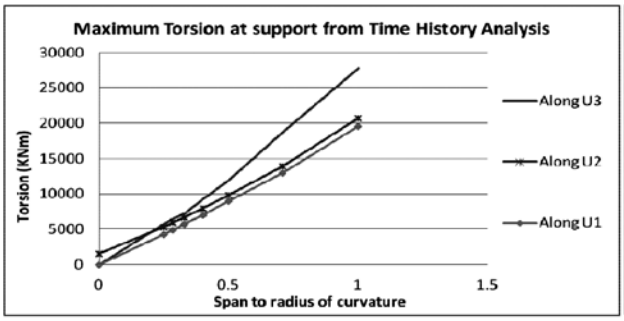
4 In all eight bridge models longitudinal stress at bottom is greater than that of longitudinal stress at top. With increase in span to radius of curvature both stresses increases at same rate and can be represented by same multiplication factor which is

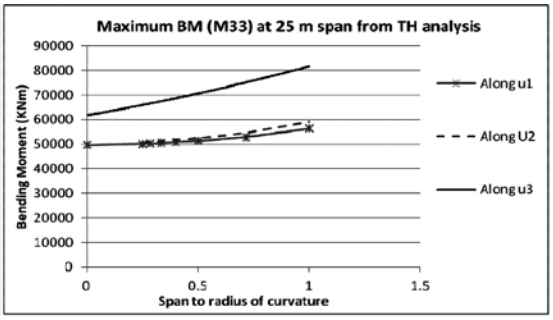
$$\alpha_{stress} = -0.1172x (L/R) 2-0.0056x (L/R) +1.0003$$

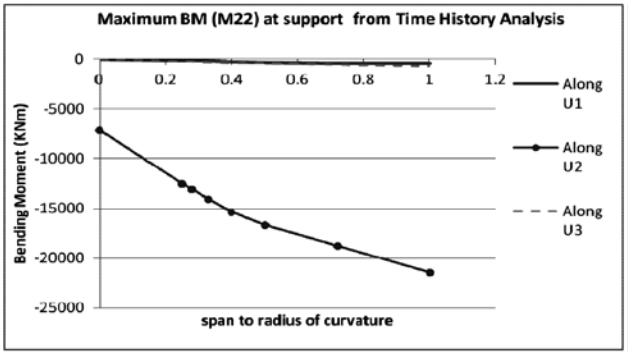
5 From Time History Analysis it can be concluded that when earthquake is applied along longitudinal direction torsion remain same as that of static load case. But torsion increases when earthquake is applied along transverse and vertical direction. For small radius of curvature torsion due to transverse and vertical earthquake component is almost same, but in higher curvature torsion due to vertical component is much higher than torsion due to transverse component of earthquake.

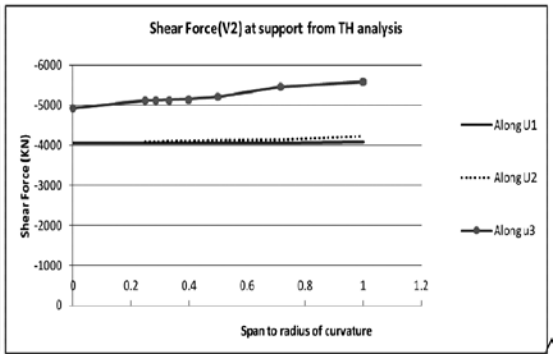
6 Similar to Torsion Longitudinal Bending Moment about horizontal axis does not increase when earthquake load is applied along longitudinal direction. When earthquake load is applied along transverse direction there is slight increase in Bending Moment.

Longitudinal Bending moment about horizontal is more critical when earthquake is applied along vertical direction. It increases rapidly with increase in span to









radius of curvature.

7 Longitudinal Bending Moment about vertical axis is negligible when earthquake load is applied along longitudinal and vertical direction. But it is much significant when earthquake load is applied along transverse direction.

8 Vertical Shear Force does not increase when earthquake load is applied along longitudinal direction.

When earthquake load is applied along transverse direction there is slight increase in vertical Shear Force.

Vertical Shear Force is more critical when earthquake is applied along vertical direction. It increases rapidly with increase in span to radius of curvature.

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Landslides distribution triggered by the April 25, 2015 Gorkha Earthquake

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Introduction

In mountainous regions, strong earthquakes trigger thousands of landslides in a wide area but in a very quick duration- a few minutes or hours. These landslides evolve a secondary chain of disasters like sweeping of settlements, landslide dams and flooding, blockade of lifelines and roads and damage to the infrastructure in a situation of emergency rescue and frequently occurring aftershocks. The earthquake induced landslides are the traces of seismic activation and energy travel, however, their occurrence is governed by a delicate interplay of the strong ground motion (e.g. fault plane geometry, rupture directivity and ground acceleration), topography (e.g. absolute elevation, slope angle, slope orientation and topographic position) and geology (e.g. soil cover and lithology) characteristics existing at a site. The landslides are localized however occur with some spatial relationships.

On 25 April 2015 at 11:56 am, Nepal Standard Time, a catastrophic earthquake Mw= 7.8 shook much of central Nepal, along the buried Main Himalayan Thrust fault (a shallow dipping mega-thrust accommodating half the India-Eurasia convergence avg. 20mm/year (eg. Bilham et al., 1997; Bettinelli et al., 2006)) locked portion and resulting over 8849 fatalities and 22232 injured (Government of Nepal, 2016). The main shock epicentre (28.147° N, 84.708° E) was located in Gorkha district, with focal depth ~15 km, which was followed by numerous aftershocks over the next several weeks.

The earthquake triggered more than 17000 landslides, avalanches, and rockslides above and near the rupture zone; some of which caused damages such as blocked roads, dammed rivers and streams, swept villages and damaged infrastructure in about 20500 sq. km. region of our area of investigation. The purpose of this study is to map all possible landslides triggered by the 25 April 2015 Gorkha earthquake- which were interpreted from available cloud free satellite imagery in Google Earth and then interpret their spatial distribution pattern and relations.

Methodology

We mapped more than 17000 landslides triggered by the Gorkha earthquake using Google Earth, broadly covering the mostly affected fourteen districts from this earthquake (i.e. Gorkha, Sindhupalchowk, Dhading, Kavre, Dolakha, Nuwakot, Ramechhap, Sindhuli, Rasuwa, Kathmandu, Lalitpur, Bhaktapur, Makwanpur and Okhaldhunga), which were covered by our area of investigation (AOI). For mapping of the landslides, polygon based inventory was prepared using the updated satellite imagery in the region affected by this earthquake, within few days after the earthquake. Google Earth imagery is normally within sub-metre resolution, and freely available, which provided the best conditions to carry out this research. Seismological data is derived using USGS seismological data archive, ASTER Global Digital Elevation Model of 30*30m was used to derive the slope, aspect and topographic position and geological data is derived using Department of mines and Geology database. The landslide polygons were overlaid in ArcGIS and the analysis was performed for further interpretation.

The Landslide Distribution: Patterns, Clustering and Major Findings

The landslides distribution is consistent with the modelled surface projection of the fault by USGS, most are bounded within it. Higher concentrations were observed along river valleys and nearby seismic rupture area. The landslide numbers distribution increases from main shock epicentral (Gorkha) area towards south-east (Sindhupalchowk-Dolakha area). This could possibly be because of the energy releasing trend of this earthquake towards the south-east direction, which is also consistent with the higher temporal concentration of aftershock epicentres towards the other extreme edge of the rupture zone (i.e. SEE areas). Interestingly, the landslide distribution seems to occur in an angular band to the main-shock epicentre at Gorakha. Another major finding includes the landslide were triggered at even very low Peak Ground Acceleration of 0.2g, suggesting the quasi-static equilibrium condition of the predominantly young mountain formation that exists in this part of the world. Topographically, slopes of range 40 to 75, South West and South East aspects and ridges and valleys were more susceptible to these landslides. The upper slopes nearby the ridges seem to be mostly vulnerable to such kind of seismic shaking, whereas the flatter slopes even in the intense shaking areas seem to be less affected. And because these occurred on steeper slopes, many of them had large run-out distances because the slope values are well beyond the angle of repose of soil debris to stop them from sliding. Geologically, most landslides

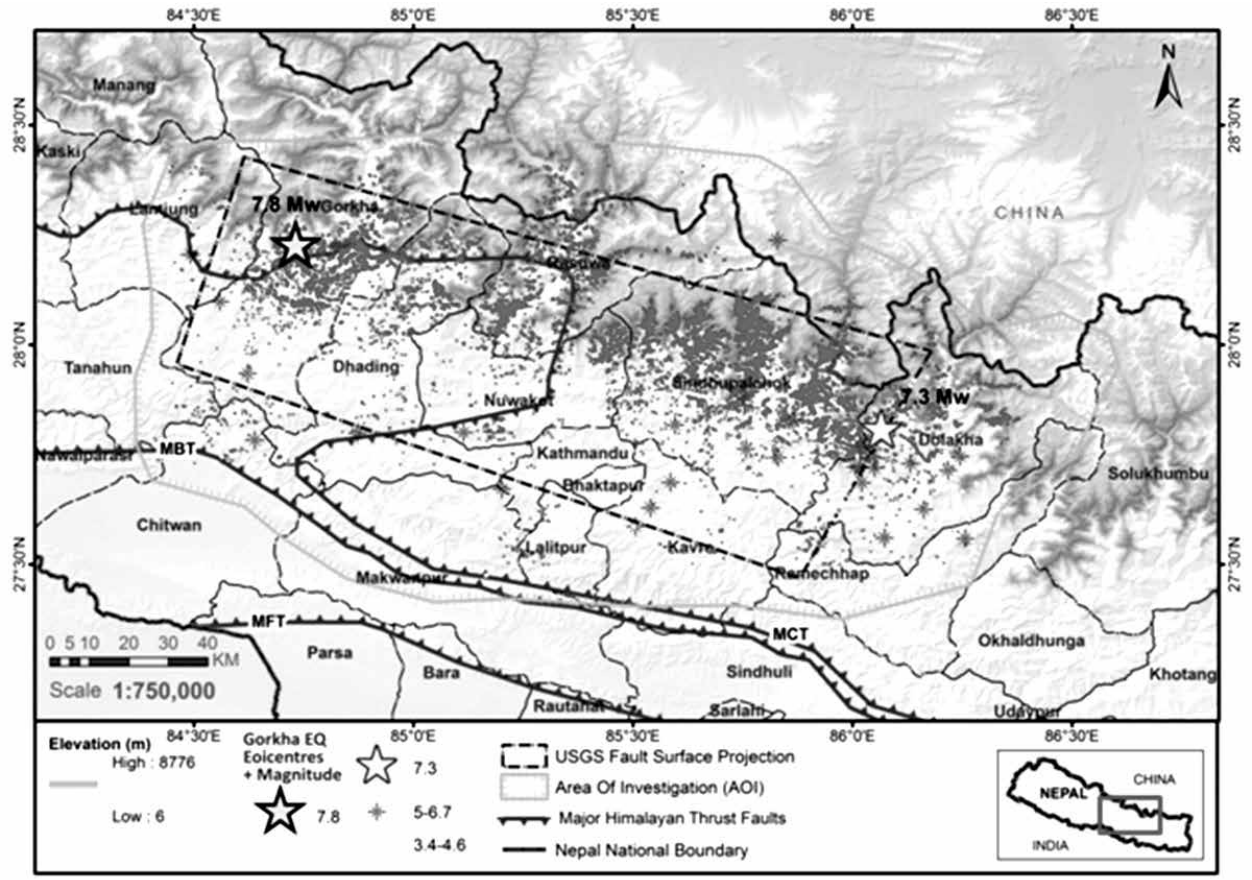

Fig. 1. Elevation map of the Gorkha Earthquake affected region, showing landslides triggered by the 25 April 2015 Gorkha Earthquake.

were observed in low-grade metamorphic rocks like schist, phyllite, etc. Many occurrences of landslides during the post seismic period by the aftershocks, were also observed.

Landslide Types

A large number of co-seismic and post-seismic landslides were triggered by the 2015 Gorkha earthquake. Most failures were shallow-disrupted landslides-mostly associating rock falls, typically involving the top few meters of weathered bedrock, regolith, and soil; many of which were also still active during our study. It is difficult to properly classify landslides from satellite imagery itself, thus we used the helicopter reconnaissance track video records archive during the post-seismic period and uploaded in the internet by (USGS, 2016), for this purpose. These have been also used partially for ground truth verification of the landslide inventory falling in the intersecting areas. An experience of reconnaissance field visit of some areas during the post-seismic period is used as an added advantage.. We classified the landslides triggered by the Gorkha earthquake 2015 into four broad categories: 1) Shallow disrupted landslides and dry debris falls, 2) Rock falls, 3) Debris avalanches 4) Deep-seated landslides. The general characteristics of the landslides were similar to those observed in other parts of the world with similar magnitude and mountainous topography. More than 99 percent of the landslides fall under the category 1.

A

B

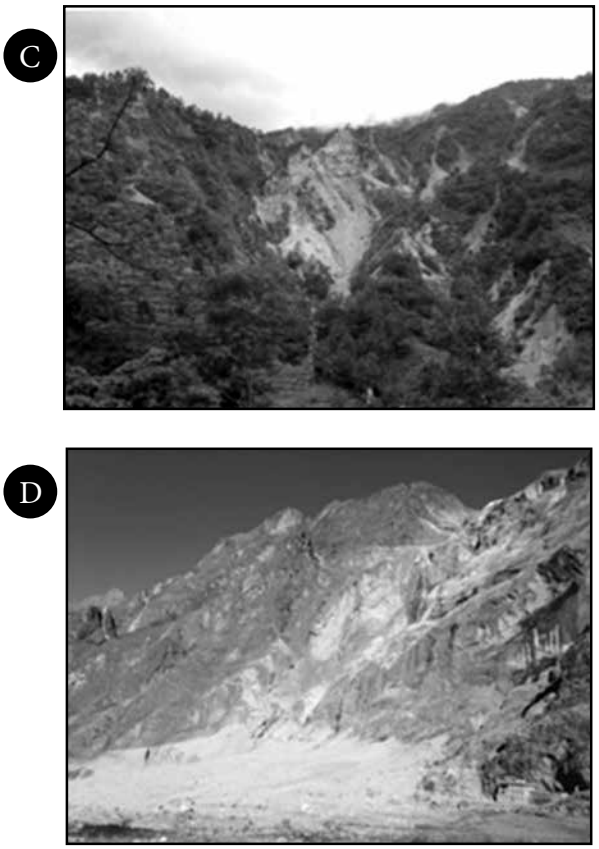

Fig. 2. Some landslide types triggered by the Gorkha earthquake. (a) Shallow disrupted fall. (b) Rockfall. (c) Dry debris fall. (d) Large landslides.

Conclusion

The co-seismic and post seismic earthquake induced landslides triggered by the 25 April 2015 Gorkha earthquake were mapped covering most of fourteen highly affected districts. More than 17000 landslides were mapped which were mostly clustered within the modelled seismogenic fault by USGS, and most were triggered at very low PGA. The increasing concentration was observed in the SEE direction. Significant number of landslides occurred on an angular band, steeper slopes greater than 40 degrees, in the slope with South and South-East aspect and nearby ridges and valleys. A preliminary understanding of the landslide distribution pattern and the triggering mechanism parameters is observed.

The detailed preliminary investigation paper is published in International Conference on Earthquake Engineering and Post-Disaster Reconstruction Process (ICEE-PDRP) 2016, conference proceedings as (Gnyawali et al., 2016).

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Understanding Hydrological Process through SWAT Modelling

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Water is one of our most precious natural resources. It is the basis to life on earth. The science that studies water, its movement and its complex interaction with living beings is hydrology. It encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle. The water cycle, or hydrologic cycle, is a continuous process by which water is purified by evaporation and transported from the earth's surface (including the oceans) to the atmosphere and back to the land and oceans. [1]

It is relatively easy to understand how the hydrologic cycle works and grasp the idea of water movement and water storage in a closed system "basin"theoretically but to quantitatively analyze the water movement and storage in the basin and its interaction with the land use, soil and land management practice is quite difficult. A basin is an extent or an area of land where all surfacewater from rain, melting snow, or ice converges to a single point at a lower elevation, usually the exit of the basin, where the waters join another body of water, such as a river, lake, reservoir, wetland, sea, or ocean.

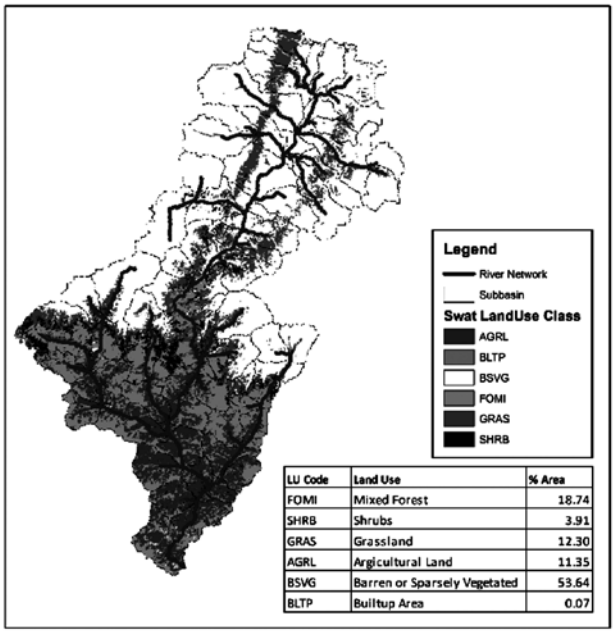
Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They are primarily used for hydrologic prediction and for understanding hydrologic processes.Two major types of hydrologic models can be distinguished:

A. Stochastic Models: These models are based on data and using mathematical and statistical concepts to link a certain input (rainfall,catchment area, catchment condition) to the model output (for instance runoff). Commonly used techniques are regression, transfer functions, neural networks and system identification. These models are known as stochastic hydrology models. These method are generally site specific and difficult to generalize for all conditions.
B. Process-Based Models: These models try to represent the physical processes observed in the real world. Typically, such models contain representations of surface runoff, subsurface flow, evapotranspiration, and channel flow, but they can be far more complicated. These models are known as deterministic hydrology models. Deterministic hydrology models can be subdivided into single-event models and continuous simulation models.

SWAT (Soil & Water Assessment Tool) is one of the widely used physically based semi distributedriver basin scale model developed to quantify the impact of land management practices in large, complex watersheds. SWAT was developed by Dr. Jeff Arnold for the USDA Agricultural Research Service at the Grassland, Soil and Water Research Laboratory in Temple, Texas, USA. It is a hydrology model with the following components: weather, surface runoff, return flow, percolation, evapotranspiration, transmission losses, pond and reservoir storage, crop growth and irrigation, groundwater flow, reach routing, nutrient and pesticide loading, and water transfer.

SWAT is a continuous time model that operates on a daily time step at basin scale. SWAT uses a two-level disaggregation scheme; a preliminary subbasin identification is carried out based on topographic criteria, followed by further discretization using land use and soil type considerations. Areas with the same soil type and land use form a Hydrologic Response Unit (HRU), a basic computational unit assumed to be homogeneous in hydrologic response to land cover change.[2]

The main input data for the SWAT Model are climate data, land use map of the basin (see Figure 1), soil type map of the basin (see Figure 2) and basin digital elevation model (DEM) (see Figure 3). The climate data include the precipitation, temperature, relative humidity, solar radiation and wind pressure.



LU Code	Land Use	% Area
FOMI	Mixed Forest	18.74
SHRB	Shrubs	3.91
GRAS	Grassland	12.30
AGRL	Argicultural Land	11.35
BSVG	Barren or Sparsely Vegetated	53.64
BLTP	Builtup Area	0.07

Figure 1 Land Use Map of the basin (ICIMOD, 2010)[3]

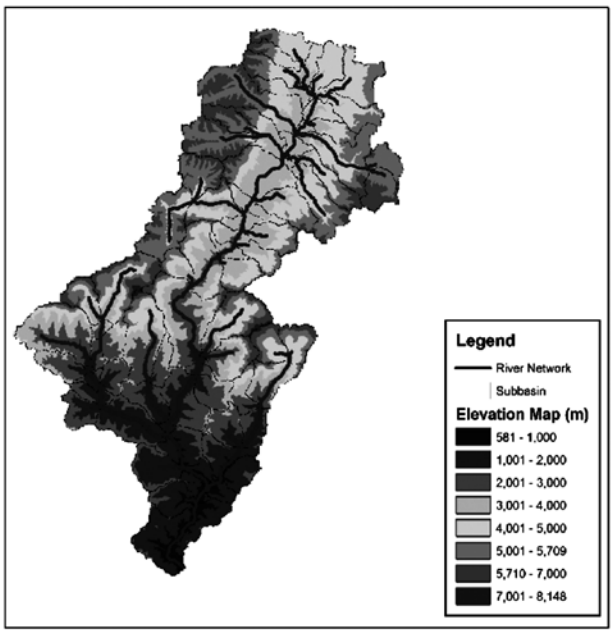
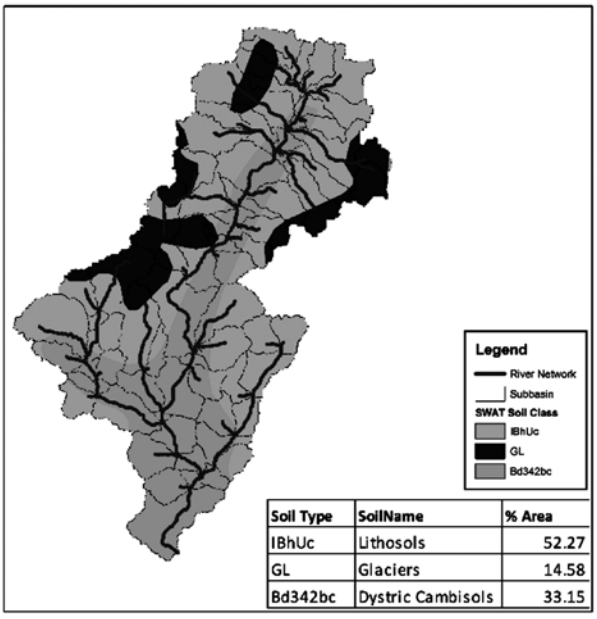


Figure 2 Soil Map of a basin (FAO, 2004)[4]



Soil Type	SoilName	% Area
IBhUc	Lithosols	52.27
GL	Glaciers	14.58
Bd342bc	Dystric Cambisols	33.15

Figure 3 SRTM Digital Elevation Model of the basin (USGS, 2013)[5]

The model is setup using the input data then the model simulates the flow in the basin which is plotted against the observed data at the gauged outlet. The model is calibrated for certain no. of years with change in basin parameter that directly affect the evapotranspiration, ground water movement, ground water infiltration, snowfall, snowmelt and various other parameter resulting in the change in the surface runoff (simulated flow). The performance evaluation of the model is done using, but not exclusively, Nash Sutcliffe Efficiency (NSE) and Coefficient of Determination (R2). Then the model is validated for certain no. of years other than the calibration period (see Figure 4). The model with NSE > 75% and R2> 0.8 in monthly scale is considered a good model.

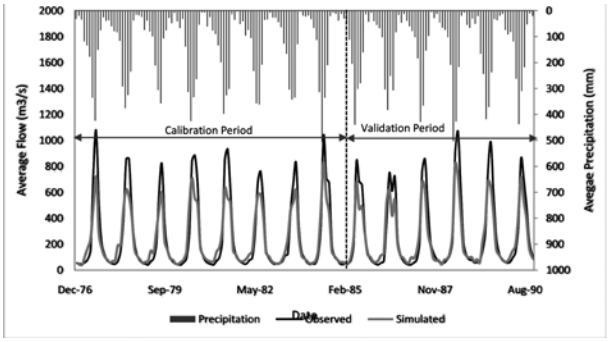


Figure 4 Calibration and Validation of the flow at the outlet of the basin

After the model is well calibrated and validated, impact in the output of the model (runoff, sediment, pesticide, nutrient, etc.) can be simulated due to the change in the input data. Since, the model is physically based, the modeler should keep it in mind that the parameters used in the calibration be within a permissible range i.e. the value of the parameters should be within a range of field value or standard value. This should be done by proper judgment of the modeler as the model should represent the actual basin. If all the above condition are met and model is developed then we have a better understanding of the hydrological process in the basin. The answer of how the hydrologic cycle affects the basin can then be found and future impacts can also be assessed with certain degree of certainty.

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बैशाष १२ को भूकम्प लगत्तैको भारतको अघोषित नाकाबन्दि सँगसँगै सम्पूर्ण नेपालीहरूलाई आफ्नो ठाउँ भूकम्पिय रूपमा सुरक्षित हुनुको साथसाथै मौलिक र आत्मनिर्भर पनि हुनुपर्ने पाठ सिकाएको छ । हामीले आफूसँग भएको आत्मनिर्भरतालाई आत्मसात नगरि र अझ त्यसलाई थप अनुसन्धान नगरि आधुनिकताको नाममा पश्चिमा शैलिलाई अँगाल्दा थप समस्याहरू उत्पन्न भएको छ । अक्कल सहितको नक्कल नगर्नाले हाम्रो बस्ति असुरक्षित समेत भएको छ ।

नेपालको इतिहासमा स्वर्णयुगमा मानिने लिच्छवि कालदेखि सुरू भएको हाम्रो नेवारी कला, संस्कृति तथा भाषाको उच्चता अंशुवर्माको पालामा शिखर चुम्यो । सातौ शताब्दीमा शासन गरेका उनको पालामा निर्माण भएको कैलाशकुट भवन एउटा उदाहरण हो । सातौ शताब्दीमा बनेका हरेक संरचनाहरू उत्कृष्ट थिए । त्यतिखेरको विकास, सामाजिक परिस्थिति अहिलेको यो कंकृटको जंगल भन्दा धेरै गुणा वैज्ञानिक थियो । त्यतिबेलाको जिवनशैलि हरेक हिसाबले आत्मनिर्भर थियो । रहनसहन, भेषभुषा, खानपान, नाचगाान आदि सबैमा नेवारहरूको आफ्नै शैलि छ । त्यस्तै एकआपसमा सहयोग गर्नको लागि गुठि, भजन बचाउनको लागि डाफा पूजा तथा मठ, मन्दिर संरक्षण गर्नका लागि त्यसको समूह बनाएर तथा खेतहरू समेत छुट्याएर राखिएका छन् । खेतिबालिका लागि आफ्नै घरमा सागाः (प्राङ्गारिक मल बनाउन बनाइएको खाल्डो) समेत हुन्थ्यो । राम्रो स्वास्थ्यको लागि मौसम अनुसार खानैपर्ने खानाका परिकार मिलाएर बनाइएका संस्कृति विश्वमै उदाहरणको रूपमा देखाउन सकिन्छ ।

कला संस्कृति तथा बास्तुकलामा पनि नेवारहरूआत्मनिर्भर थिए । बास्तुकलाका आफ्नै शैलि थियो । त्यसैगरि निर्माण सामाग्री समेत आफैले उत्पादन गर्ने हुनाले आयात गर्नुपर्दैनथ्यो । आफ्नै देशमा पोख्त कालिगढ तथा दकर्मीहरू थिए । त्यतिबेला जनशक्ति आयात गर्ने नभई उल्टो अन्य देशमा समेत गएर आफ्नो कला प्रदर्शन गर्ने गरिन्थ्यो । १३ औं शताब्दिमा अरनिको चीनमा गएर बनाएको सेतो प्यागोडा अहिले सम्म नेपालको शिर उँचो राख्न सफल छ । त्यतिबेला अहिले जस्तो एउटा घर, एउटा प्लानिङ्ग विकास नगरि पूरै बस्ति (शहर) बिकास गरिन्थ्यो । एउटा बस्तिमा धेरै जनसंख्या हुँदा अर्को एउटा थुम्कामा अर्को शहर बनाइन्थ्यो । जसले गर्दा भएका जनतालाई व्यबस्थापन गर्न सजिलो हुन्थ्यो । यसरी अलि थुम्कोमा बस्ति बिकास गर्दा कहिले पनि खेतियोग्य जमिन बिगारिदैनथ्यो । यसरी अलि थुम्कोमा बस्ति बिकास गर्दा एक त खेतियोग्य जमिन बच्थ्यो अर्को बाढी पहिरो जस्तो प्रकोपबाट बच्न सकिन्थ्यो । यतिमात्र नभई त्यतिबेला पुस्तौपुस्ताको अभ्यास र सुधार गर्ने बानिले गर्दा भूकम्पबाट बच्ने घर पनि बनाइएका थिए । खालि त्यसलाई बैज्ञानिक रूपमा प्रमाणित गर्न अनुसन्धान कम भए । यदि त्यसमा थप अनुसन्धान भएको भए प्राकृतिक एवं वैज्ञानिक रूपमा हाम्रो मौलिकता धैरै अगाडि पुगिसक्थ्यो । केहि नेवारी परम्परागत घरका जान्नै पर्ने कुराहरूको चर्चा अत्यन्त जरूरि छ ।

सुन्दर, सुसंकृत र स्वस्थ घर

पृथ्विमा विभिन्न चरणमा पशुपंक्षि, मानवजातिको विकासका क्रममा मानव नै यस्तो प्रजाति बन्न पुग्यो जसले आफ्नो बुद्धि बिवेक प्रयोग गरेर पृथ्वीमा आफ्नो केहि नयाँ चिजको विकास गरे । मानवले यसरी विकास गर्ने क्रममा प्रकृतिबाटै धेरै सिकेका छन्, र त्यसलाई आफ्ना सुविधाको लागि प्रयोग गरेका छन् । जस्तो उदाहरणका लागि गुफाबाट सिकेर घर बनाए, चराचुरूङ्गीबाट सिकेर उड्ने हवाइजहाज बनाए, सुर्यको प्रकाशबाट सिकेर बिजुलि बट्टीको आविश्कार गरे, आँखाको दृष्टिबाट शिक्षा लिएर क्यामेरा बनाए । यसरी बनाउने क्रममा यी चिजहरूलाई आफ्नो सुविधाको लागि झन् झन् परिमार्जित गर्दै लगे ।

घरको प्रसंगमा भन्ने हो भने, सुरूमा त रूखका हाँगाहरू, पशुका छालाहरू काढेर सानो ओट लाग्न मिल्ने संरचना विकास गरे । त्यसपछि बिस्तारै रूख काटेर त्यसबाट मिल्ने आकारमा काटेर घरहरू बनाउन थाले । त्यसैगरि ढुंगामाटो मिलाएर घर बनाउन थाले । पछि निर्माण गर्न सजिलोको लागि इँटाको प्रविधि विकास गरे । अहिले हुँदा हुँदा निर्माण सामाग्रीहरूका थुप्रै विकल्पहरूको विकास गरे । नेपालको सन्दर्भमा कुरा गर्नुपर्दा यहाँ थुप्रै जातजातिका आफ्नै मौलिक शैलिका घरहरू विशेषगरि स्थानिय रूपमा उपलब्ध निर्माण सामाग्री प्रयोग गरेर बनाइएका हुन्थे । जस्तो कि ढुङ्गा, माटो, काठ आदि । जुन चिज प्राकृतिक भएकाले एक त शरिरलाई हानि गर्दैन त्यसमाथि ती घरहरू भत्काउनु पर्दा ती चिजहरू पुनः प्रयोग गर्न सकिन्छ । या त ति पृथ्वीमा विलाउन सक्छ । अथवा भनौ त्यस्ता चिजले प्रकृतिमा पनि खास असर गर्दैन । नेपालमा विकास भएका ति वास्तुकला मध्ये नेवारी शैलि, गुरूङ्ग शैलिका तथा थकाली मगर शैलिका घरहरू चर्चित छन् । यस मध्येपनि पहिला "नेपाल"को रूपमा परिचित यस काठमाडौं उपत्यकाका वास्तुकला संसारमै प्रसिद्ध छ । कुनै यात्रीले एक समय नेपाल भ्रमण गर्ने क्रममा भक्तपुर घुमिसकेपछि व्यक्त गरेको अभिव्यक्ति संसारमै प्रचलित छ । "संसारको आधा भाग नरहोस् तर भक्तपुर बचोस् किनभने भक्तपुर घुमेपछि संसारको आधा भाग परिक्रमा गरे सरह हुन्छ ।" यसको मतलब यहाँका बास्तुकला त्यति उत्कृष्ट थिए । एउटा एकल घरले मात्र बास्तुकला उत्कृष्ट बनाउन मद्दत गर्दैन । समग्रमा एउटा बस्ति, शहरको बनावट, रहनसहन तथा कला संस्कृतिले त्यसलाई उत्कृष्ट बनाउन मद्दत गर्ने हो ।

आजकल मानिसहरू पश्चिमेलि शैलिको बिकासलाई खुब रूचाइरहेका छन् । यसको एउटा कारण नेवारी बास्तुकलाको विकास क्रममा आएको केहि समयान्तर (नबउ) ले गर्दा ती बिकास क्रम रोकिए त्यसमा थप अनुसन्धान भएन । जसले गर्दा ती परिमार्जन हुने क्रम रोकिए । यो समयान्तर शाह बंशको सुरूवात संगसंगै राणाकालमा आएर अझै बढ्यो । हाम्रो आफ्नो मौलिकतालाई ख्यालै नगरि राणाकालमा धमाधम ब्रिटिश शैलिका घर बन्न थाले । भएका

मल्लकालिन घरमा समेत सेतो पोट्न थाले । भक्तपुरको दरबार स्क्वायरमा पनि सुनकोढोका पश्चिमपत्ति जबरजस्ति सेतो पोतेर बृतिस शैलिको बनाएर दरबारक्षेत्रलाई विरूप पारे, राणा शासकहरूले । जसलाई हाल आर्ट ग्यालरीको रूपमा प्रयोग गरिएको छ । त्यसपछि इतिहास नपढेका नयाँ बास्तुविदले त्यसैलाई परम्परागत घर भनि व्याख्या गरे । नेवारी शैलिका घरलाई नयाँ पुस्ताले अपनाउनका लागि त्यसमा केहि परिमार्जन गर्न जरूरी छ । पुरानै शैलिमा बनाउँदाका फाइदा बेफाइदा समेत बुझ्नु जरूरी छ । दिर्घकाल सम्म हुने घरहरू बनाउनु पर्छ । यस प्रकार घरलाई बुझ्दा हाम्रो परम्परागत प्रति रूचि बढ्न सक्छ । भर्खरै भूकम्पको वर्षगाठको अवसरमा ख्वप इन्जिनियरिङ्ग कलेजमा भएको अन्तराष्ट्रिय सम्मेलनमा प्रा. डा. सुदर्शनराज तिवारीले दिनुभएको प्रस्तुतिकरणमा व्यक्त गर्नुभएको विचारमा अझ मनन योग्य छ । यदि हामी आर्किटेक्ट एवम् जानकारहरूले स्थानिय आर्किटेक्टको कुरालाई (विशेषगरि नेवारि वास्तुकलाका बारेमा दिनुभएको प्रवचनमा) ख्याल नगरि अगाडि बढेमा जीवन एक तिहाई मात्र बाचे'को ठहरिन्छ, बा'कि दुई तिहाई भाग विर्सन्छौ । अर्थात वास्तुकला जीवनका संस्कार स'ग जोडिएको हुनैपर्छ । जुन हामी नेवार बस्तिमा देख्न सक्छौ ।

फ्रेम सिस्टम

घरमा पर्ने भारहरू लिने विभिन्न तरिका मध्ये विम र पोस्ट सिस्टम पनि एक हो । ढलान घरमा त्यहि विमको लोड पिलरमा जानको लागि विम र पिलर ढलान गरि एक ढिक्का बनाइएको हुन्छ । त्यसैले सम्पूर्ण घर नै एक ढिक्का भई घरको भार पृथ्वीमा पुग्न प्रत्येक पिलर हुँदै जगमा पुग्नुपर्छ । तर हाम्रो परम्परागत शैलिका घरमा दलिनको लोड 'निल' (विम) ले र 'निल'को लोड 'थाङ' (थाम) ले दिने ठाँउमा एक ढिक्का नबनाई छुट्टा छुट्टै राखिएको हुन्छ, खालि चुकुल वा विभिन्न प्रकारका जोर्निहरू बनाइन्छन् । जसले गर्दा भूकम्पले हल्लाउँदा हरेक थामको भार त्यसको खुट्टा (तल्लो भाग) मै बिलाउँछ । जसले गर्दा धेरै भार एकै ठाउँमा पर्दैन । त्यसैगरि मुख्य भार थामले नलिई पुरै गारोले लिन्छ । त्यसकारण राम्रो सँग गारो लगाइयो भने यो घर निकै बलियो हुन्छ । भर्खरै भूकम्पको वर्षगाठको अवसरमा ख्वप इन्जिनियरिङ्ग कलेजमा भएको अन्तराष्ट्रिय सम्मेलनमा प्रा. डा. प्रेमनाथ मास्के सरले दिनुभएको प्रस्तुतिकरणमा व्यक्त गर्नुभएको विचारमा स्वनाम धन्य प्रवासी विज्ञहरूले दिएको माटोको जोडाईका घर बनाउनै नहुने भन्नेहरूलाई प्रतिउत्तर दिदै विगतको अनुभव र अहिलेको उपलब्ध प्रविधि मिलाएमा भूकम्प प्रतिरोधात्मक एवम् मौलिक घर बनाउन सकिन्छ भनि जोड दिनुभयो।

मोटो गारोका फाइदाहरू

मोटो गारोको कारण गर्मि मौसममा गारोमा घरको गारोमा घाम परेपनि त्यसको ताप भित्र पस्न समय लाग्ने हुँदा गर्मिको मौसममा घरभित्र बाहिरको भन्दा तापक्रम कम हुन्छ । त्यसैले गर्मिमा घरभित्र शितल हुन्छ । त्यसैगरि जाडोमा भने भित्रको न्यानोपन बाहिर जान नदिने हुँदा घरभित्र चिसोको महसुस हुदैन । अझ त्यतिमात्र नभई दिनभरी गारोले जति ताप लिएको हुन्छ, राति त्यहि ताप बिस्तारै घरभित्र हिटरले जस्तै पठाउँछ । त्यसैले गर्दा हाम्रा परम्परागत घरहरू प्राकृतिक रूपमै जाडो र गर्मिमा क्रमशः न्यानो र शितल दिने खालका हुन्छन् । यसमा अहिले प्रतिपादन गरेका केहि हिसाबहरू जोड्ने हो भने घरलाई भनेजस्तो र हरेक मौसममा ठिक्क हुने खालको बनाउन सकिन्छ । त्यसैगरी आवश्यकता हेरि घरको गारोको मोटाई थपघट गरि किफायति समेत बनाउन सकिन्छ ।

वातावरणीय प्रभावका कुराहरू

वातावरणीय हिसाबले हेर्दाखेरि हाम्रा परम्परागत घरमा वातावरण प्रदुषण गर्ने सामाग्री इँटमात्रै हो जस्तो लाग्छ । इँट पोल्दा वातावरण प्रदुषण हुन्छ । तर आजकल नयाँ प्रविधिका माटोका इँटहरू आइसकेका छन् । माटोमा केहि मात्रामा सिमेण्ट प्रयोग गरि मेसिनले बनाउने यी इँटहरू पोलेको माटो भन्दा बलियो हुने त्यसैगरि धुँवा निस्केर वातावरण प्रदुषण पनि नगर्ने भएकोले अहिलेका इँटा व्यवसायीले यस्तो इँटा निकाल्नु अत्यावश्यक भइसक्यो । साथ साथै सरकारले पनि यो पुनः निर्माणको समयमा यो प्रविधि ल्याउन सक्योभने नेपालमै प्रदुषणको मात्रा धेरै घट्ने थियो । अरू सामाग्री काठ, माटो, भुस आदि हुन् । काठले वातावरणमा खासमा असर गर्दैन । तर बन विनास नहोस् भन्ने हिसाबले रूख काटेको भन्दा बढि रूख रोप्दै जानुपर्‍यो । अर्को विकल्प चुनको इ'ट बनाउन सकिन्छ । जुन नेपालमा सम्भव छ । किफायति, अझ बलियो र वातावरण मैत्रि छ । थप छलफल गरेर अगाडि बढेमा देशकै लागि फाइदा हुनेछ ।

परम्परागत घरको वातावरणमा असर नगर्ने राम्रो गुण भनेको घर भत्काउने बेलामा यसले खासमा वातावरण प्रदुषण गर्दैन । यसबाट आएको सामाग्री कहाँ फाल्ने भन्ने चिन्ता लिनु पर्दैन त्यसलाई पुनः प्रयोग गर्न सकिन्छ । तर यी सिमेण्टका घर भत्काउँदा आएका सामानलाई व्यवस्थापन गर्न सम्म समस्या पर्छ । जुन यसपालिको भूकम्पमा ढलान घरका भग्नावशेष पन्छाउन र तह लगाउन कति गाह्रो भएको थियो ।अर्को कुरा माथि भने जस्तै परम्परागत घरमा प्रकृतिबाट आएका प्राकृतिक चिजहरू मात्रै प्रयोग गर्ने भएकोले हाम्रो स्वस्थ समेत राम्रो बनाउँछ । उदाहरणाकालागी बाथका विरामीहरू परम्परागत भवनमा कम दुखाईको अनुभव गर्छन् भने ढलान घरमा धेरै दुखाईको अनुभव गर्छन् ।

यसरी हरेक हिसाबले हेर्दाखेरी हाम्रा परम्परागत घरको महत्व धेरै छ । अब भनिन्छ कि काठ महँगो भएर यस्ता घर बनाउन सकिदैन । तर काठका पनि नयाँ प्रविधिका काठ उत्पादन गर्ने शैलिहरू विकास गरिएका छन् । ती प्रविधि नेपालमापनि ल्याउन सकियो भने हामी कम मूल्यमा काठ पाउन सक्छौ । कहिलेकाहीँ त हाम्रा परम्परागत घर बनाउनेलाई निरूत्साहित पार्न पनि काठको मूल्य आकासिएको हो कि जस्तो भान हुन्छ । बाह्रौ शताब्दिमा बनेको भक्तपुर शहर हाल विश्व सम्पदा सूचिमा सूचिकृत छ। जुन नेपालिहरूको गौरव हो ।त्यसैगरि हामी प्राविधिक भएरपनि यस्तै घर बनाउन जोड दिन नसक्नुको मुख्य कारण भनेको प्राविधिकहरूले स्थानिय संरचनालाई हेय गर्ने र नया' प्रविधिलाई मात्र नक्कल गर्ने प्रवृत्ति,मानिसहरूलाई तिन तल्ले घरले नपुग्नु, ऐतिहासिक एवं परम्परागत घर मर्मत सम्भार समय समयमा नहुनु, सम्बृद्ध जिवन यापन गरेकाहरूको जिवनस्तरमा यथोचित विकास नहुनु र सरकारको गलत निति मुख्य दोषि छ । । तर बैशाष १२ को भूकम्पपछि हामीले भन्नै नपर्ने गरि सर्वसाधारणले तीन तल्ला मात्र घर बनाउने भन्न थालेका छन् । तर पनि परम्परागत भवन बनाउन मनाउन सकिरहेको अवस्था छैन । किनभने यसपालिको भूकम्पकमा पुरानो घरहरू धेरै भत्केका छन् । तर ती त कम्तीमा सयवर्ष भन्दा बढी उमेर भएका घर हुन् । ढलान घर त नेपालमा भित्रिएको भर्खर साठी सत्तरी बर्ष भयो तैपनि त केहि बर्ष मात्र भएको कति धेरै ढलान घर भत्केका छन् ।

यसरी विभिन्न कोणबाट हेर्दा हाम्रा परम्परागत घरहरू नै सुन्दर, सुसंस्कृत र स्वस्थ घर हुन् । यस्ता घर निर्माण गर्न सरकारले नै प्रोत्साहन दिनुपर्छ । किनकि यो नै हाम्रो नेपालीको पहिचान हो । हामी प्राविधिकहरूपनि पूर्ण जिम्मेवारिका साथ अगाडि बढेमा चूनौतिलाई अवसरको रूपमा परिवर्तन गरि आफ्नै मौलिकतायुक्त भवन एवं बस्ति बिकास त्यति टाढा छैन ।

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An Introduction to Expanded Polystyrene Based Light Weight Wall Panel and Its Benefits over Brick Wall

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Expanded Polystyrene (EPS) based cement panel is a lightweight construction material, with significant advantages compared to conventional one like common brick, face brick, hollow concrete block, solid concrete block etc. Expanded Polystyrene is a lightweight, rigid, plastic foam insulation material produced from solid beads of polystyrene. Expansion is achieved by virtue of small amounts of pentane gas dissolved into the polystyrene base material during production. The gas expands under the action of heat, applied as steam, to form perfectly closed cells of EPS. These cells occupy approximately forty times the volume of the original polystyrene bead. EPS beads are then molded into appropriate forms suited to their application.

The panels are made by molding special mixture called Ad-mixture. Ad-mixture is a mixture of EPS, cement, water, sand and bonding agents. Bonding agents reduces the necessity of water curing during production, ensures uniform distribution of EPS within ad-mixture, increases adhesion of ad-mixture with calcium silicate board and increases adhesion of cement with EPS.

EPS panel is light in weight. It is three times lighter than common brick. Density of brick is around 1700kg/m3 and that of EPS panel is around 650 kg/m^3. EPS Panel's custom size is 2270mm × 610 mm. It is available with various thicknesses such as 50 mm, 60 mm, 75 mm, 90 mm, 120mm, 150mm and 210 mm. Panels are joined together at their tongue and groove surfaces. Because of these surfaces installation is faster as compared to brick wall. Using these panels for external and internal partition walls, the load carried by structural members reduces considerably. Consequently, it decreases the structure cost of the house.

Fig. EPS Light weight wall panel

House wiring and bathroom fittings are installed similar with the brick wall. Plastering or wall putty can be applied over the surfaces of the panels for the interior finishing. Or panels having calcium silicate board can be used directly without plastering. Due to moisture resistant property of calcium silicate board, EPS panel can be used at exterior walls of the building. There are three types of EPS based cement panels produced in factory. They are (i.) Sandwich Panel, (ii.) Solid Panel and (iii.) Hollow Panel.

EPS panels preserves environment. For production of these panels it does not consume soil, coal and required very less amount of water thereby saving fertile land, environment pollution and water scarcity. It also requires less human resources. It uses electricity and very less diesel for the manufacturing. But for brick production it consumes abundant natural resources such as soil, coal and water. Brick kiln produces tons of black carbon thereby degrading natural atmospheres. According to Federation of Nepal Brick Association there are 750 brick kilns in Nepal with average production of 60 lakhs bricks per kiln per annum. Considering the huge energy demand and high risk of air pollution resulting from emission from the brick factories, an alternative to brick for use in the construction of buildings and other infrastructures and services must be thought of. Study shows that one square feet area of brick wall contains 7 number of bricks which requires 44.305 MJ of energy at brick kiln factory where are EPS panel requires only 1.874 MJ of energy during manufacturing processes. Similarly, the carbon dioxide emission during production is 838.241 gm for brick kiln and 81 gm for EPS panel factory.

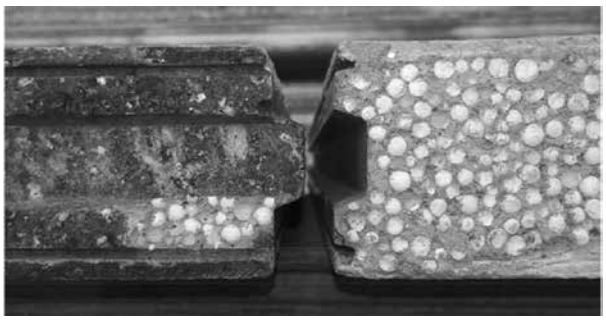

Fig. Tongue and Groove Connection

Thermal insulation of EPS panel is superior to brick wall. According to the experiment work conducted at Mechanical Department, Pulchowk Campus, Thermal conductivity of EPS based cement panel (k=0.14 W/m.K) was found three times lower than that of common brick. (k= 0.46 W/m.K).

In present, after-earthquake scenario, focus is on reconstruction of walls as as well as new construction materials that are earthquake resistant, eco-friendly and that provide better aesthetics than conventional materials. EPS based cement panel being light, flexible and elastic in nature this innovative material may be more appropriate than brick wall.

Moreover, EPS based cement panel is fire resistive, moisture resistant, dimensionally stable, light weight, energy saving, easy to install and less seismic vulnerable.

Lean Energy Philosophy for Nepal

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In 1976, Amory B.Lovins, the founder of Rocky Mountain Institute, introduced the concept of Soft Energy Path and Hard Energy Path in his paper titled: Energy Strategy – The Road Not Taken. And he actually started the paper with lines from Robert Frost's poem titled The Road Not Taken.

"Two roads diverged in a wood, and I – I took the one less travelled by. And that has made all the difference."

– Robert Frost

This article is intended to introduce readers to the concepts of hard and soft energy paths and lean manufacturing principles; and propose an apt philosophy to be understood and practiced in Nepal for an energy secured future, based on the characteristics of these paths and principles.

What do soft and hard energy paths mean? Hard energy path, roughly, is the conventional path followed in most parts of the world. It is the path that our disregard for consequences in farther future has led us to. Common symptoms include overreliance on nonrenewable resources, excessive capital and infrastructure investment, energy inefficiency, and redundancies in energy conversion processes. Soft energy path, according to Lovins, is the counterintuitive path to sustainability that focuses on energy efficiency, renewable energy matchedin scale and quality to end use needs, and special transitional fossil fuel technologies.

In the late 1940s, Toyota Production System was developed and it popularized the idea of Lean Manufacturing Principles. Lean Manufacturing is what enabled Toyota to produce more cars more efficiently than the inventors of assembly line technology – Ford Motors themselves, when they had better resources than Toyota Motors. The skeleton of lean manufacturing principles is made of: decreasing waste, increasing value to the customer, and a series of continuous improvements.

Lean principles share some features already with the soft energy path. Soft energy path focuses in eliminating redundancies in energy conversion and lean manufacturing focuses on decreasing waste. Lean manufacturing focuses on increasing value to the customer and soft energy path focuses on marching scale and quality of renewable energy to end use needs.

The third important point of lean manufacturing – continuous improvement is missed by the soft energy path. Continuous improvement is vital for modern energy systems as they need to be resilient. Energy security depends on political, economic, and technological factors among many others. Dynamics of these factors keep changing with time. Continuous analysis of changes and appropriate response (robustness) is more than desirable – it is necessary.

Discovering fire ages ago was one of our great landmarks in the history of our evolution. Invention of steam engine was another. Steam engines powered ships and trains, and enabled quick movements between distant places previously deemed impossible. This spurred trade across boundaries, and the whole planet, as an economy, grew exponentially. Then somebody invented the Internal Combustion Engine – the kind that your vehicle and generator uses. Then there was nuclear power. Then there were large dams that generated power from water. We also generated electricity from wind using large turbines. Now we can harness energy, mainly as electricity, from virtually any other form of energy.

Coal extracted from mines, and fossil fuels from oil fieldspowered the world economy. These energy resources were easy to mine and useful for many things. And abundant.

Or so we thought.

Several undesired ramifications of coals and fossil fuels began to show. Come now, we are making a transition to renewable energy with all the speed we can muster. So, what changed?

Realizing that we were jeopardizing our own survival on earth did.

To put this in perspective, dinosaurs survived for 165 million years. Modern human species are only 200,000 years young. Carbon emissions are significantly massive and global warming is becoming, for the lack of a better word, too hot to handle. If we are striking an axe on our foot ourselves, we are not thatsmart as species, are we?

Hard energy path is not only about non-renewable and emissions. It is also in the way the energy reaches to the end users – us. Hard energy path can be characterized by the likes of overreliance on nonrenewable energy resources, centrally distributed transmission system, and redundant energy conversion.

Let's compare between cooking food by using electric heaters and cooking food with energy efficient cook stoves. Starting with using electric heaters, we have to consider energy conversions in total supply chain that

goes from generation to transmission to distribution to end use. Generation efficiency of hydropower is 90%, efficiency of transmission and generation of Nepal Electricity Authority(NEA) is 70%, and efficiency of common electric heaters (the red clay types with coil on top) is 40% (yes, induction cookers are more efficient but our electricity distribution system is not designed to handle inductive loads in large quantities). The total efficiency of this chain is thus 25%.Common improved cooking stoves are 25 – 35 % efficient. Gasification based cooking stoves are more than 30 % efficient. Hence,it makes more sense to replace existing traditional cooking stoves with gasification based cooking stoves, and not electric cooking stoves. Lean Energy Philosophy draws idea from soft energy path in matching renewable energy in quality and scale to end use needs, as we have matched cooking with the most efficient energy technology here.

So, centralized electricity based power systems are convenient for use in almost all purposes, but there are limitations and redundancies. Yes, a large amount of power transmission still has to happen through centralized electrical power systems. This doesn't mean we have to go all in.

But we have hydropower in Nepal, don't we? And it is renewable, isn't it? Yes, we have hydropower potential that is more than enough to fulfill all of our energy needs if properly harnessed. We cannot, however, neglect the vulnerabilities of hydropower in Nepal that can have deleterious consequences. Climate change is adding to unpredictability of our hydropower generation potential. We have seen the extent of nature's wrath in the earthquake last year that along with the lives of our brethren, claimed many infrastructure projects inflicting severe damages to some hydropower projects.

We can never rely on one energy resource, however abundant that may be. Even the Arabs are investing huge capital in solar energy nowadays. Our country is blessed with energy resources. We also have good potential for wind energy (about 3000 MW), solar energy, and biomass energy. Utilizing the potential and diversifying energy generation mix will help in reduce the need to invest in energy infrastructure, as energy produced from these resources can be used near generation site, unlike hydropower where most of the demand resides away from site of generation.

A new philosophy of energy planning is theorized by borrowing ideas from soft energy path, lean manufacturing principles, and energy resources and demand in Nepal. The way forward is matching variety of renewable energy resources in quality and scale with energy use supported by energy efficiency and eliminating redundancies in energy conversion.

Significance of Sediment Analysis in Hydropower Development of Nepal

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Abastract: *Nepal is facing severe energy crisis, not only in regard to electricity from hydropower but also with other energy sources too. If Nepal could generate enough hydroelectricity to meet its current demands, we could also replace other non renewable energy sources. Nepal has been endowed with ample water resources with huge hydropower potential. If properly utilized, water resources of Nepal can play significant role in boosting the economy of Nepal. `Though Nepal has huge hydropower potential, several hydropower projects have not been yielding expected output primarily due to sedimentation problems, which were underestimated at design stage in most of the cases. The sediment load in the Nepalese rivers is among the highest in the World. The existing sediment monitoring networks in catchments are not sufficient to understand and quantify the sediment transport as well as to assess the sediment yield of catchment in totality.*

Keywords*: Hydropower, sedimentation, sediment measurement.*

1) BACKGROUND

Nepal is recognized as the Himalayan kingdom as it has dozens of snowcapped mountains feeding fresh water to the perennial rivers throughout the year. Bestowed with 2.27% of the world water resources, 818,500 Ha of total water surface area (i.e. 5% of total surface area of country), about 6,000 rivers including rivulets and tributaries totaling about 45,000 km in length, Nepal is the second richest country in inland water resources. Nepal is land limited but water rich country. Its rivers generate 224 billion cubic meters of surface run-off annually, which translates into more than 9,000m3 of water per capita. This is far more than internationally recognized norms of 1,750 m3 as per capita. (HYDRO NEPAL VOL 1 ISSUE 1 JUNE 5, 2007 25)

1.1) Major River Basins

The major river basins on Nepal are Karnali in the west, Gandaki in the central and Koshi in the east. These rivers drain about 78% of mountainous part and about 70% of Nepal territory. Based on river discharge and their sources, Nepalese rivers are broadly classified as first grade, second grade and third grade rivers.

a) Rivers that are originated from glacier on ice capped mountains above snowline (about 5000m altitude) are categorized as first grade rivers. These rivers are perennial and carry sufficient flows throughout the year. Karnali, Gandaki and Koshi are known as first grade rivers.

b) Rivers that originate from Mahabharat hills below snowline are second grade rivers. They also do not dry up in low flow period as they meet spring and shallow underground water tables. Mechi, Kankai, Kamala, Bagmati and Mahakali are major second grade rivers.

c) Third grade rivers originate from Siwaliks hills as well as from Terai plain. These rivers contain either very less water in winter or no surface flow in dry period. Tilawa at Parsa, Manusmara at Sarlahi, Sunsari at Sunsari etc. are third grade rivers.

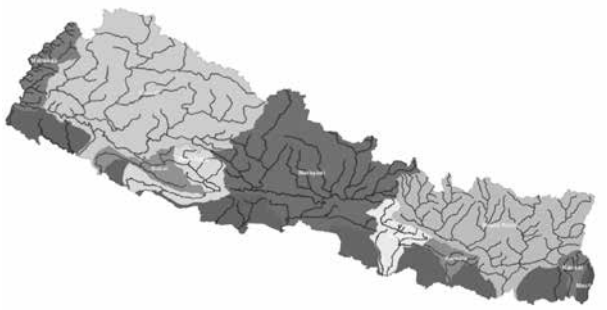


Figure: Major river system with their catchment area (Galay et al., 2003)

1.2) Hydropower potential and current scenario of Nepal

Nepal has a huge hydropower potential. In fact, the perennial nature of Nepali rivers and the steep gradient of the country's topography provide ideal conditions for the development of some of the world's largest hydroelectric projects in Nepal. The average annual precipitation is approximately 1700 mm (80% of which occurs during the monsoon season - June to September).

Theoretical hydropower potential of the country in terms of megawatts is estimated at 83,290 MW,(Dr. Hari Man Shrestha in 1966 "Cadastre of potential water power resources of less studied high mountainous regions, with special reference to Nepal") of which half i.e. 42,133 MW is considered to be technically and economically viable.

However, Nepal till date has been able to develop only approximately 680 MW of hydropower. Therefore, bulk of the economically feasible generation has not been realized yet.

Energy Gap (2011 Figures)	
Annual Peak Demand	946.10 MW
Dry Season Generation	450 MW
Deficit (Gap)	500 MW

Although bestowed with tremendous hydropower resources, only about 40% of Nepal's population has access to electricity through the grid and off grid system. Most of the power plants in Nepal are run-of-river type with energy available in excess of the in-country demand during the monsoon season and deficit during the dry season.

The annual peak power demand of Integrated Nepal Power System (INPS) was 946.10 MW in 2011. There is a power deficit in the country resulting in daily load shedding (the situation improving in the wet season and becoming bad in the dry season). The electricity demand in Nepal is increasing by about 7-9% (approximately 80 MW at least) per year.

2) SEDIMENTATION: CAUSES AND IMPACTS

2.1) Causes of Sedimentation in Nepal

Sedimentation is one of the major challenges in hydropower development of Nepal. Sediment loads are both a design challenge and an environmental challenge for hydropower development throughout the southern slopes of the Himalayas. Ecologically Nepal is divided into lowland, midland and highland regions. Mountains and hills occupy about 80% of total land. Himalayan mountain range in Nepal is considered as young and geologically active. Since the Himalayan mountains are the youngest mountains of the world, they are also the biggest source of sediment that is transported by the rivers. The geological instability of Himalayas and the mountain areas, dynamic nature of rivers and intensive precipitation during monsoons create favorable environment for large scale erosion and sedimentation in Nepal. Major causes of sediment production in Nepal are sheet and rill erosion, stream channel erosion, gully erosion, flood plain scour. Catastrophic occasional GLOFs and avalanches, massive deforestation, heavy pressure of grazing, methods of cultivation, haphazard development activities etc also contribute for soil erosion and sedimentation.

Physiographic Region	Erosion and Sedimentation	Erosion rate Tons/km2/yr
Siwaliks	High erosion with torrent flows and mass wasting, storage of sediment occurring in valleys	2,000-20,000
Middle Mountains	Significant sediment problem due to deforestation. Mass wasting in mountains with moderate to steep slope.	2,700-57,000
High Mountains (Mahabharat Lek)	River channel degradation slides low but rockfall common.	3,000-42,000

Erosion rate and sedimentation pattern of major land types in Nepal (Source: CWC, 1981)

The sediment load in the Nepalese rivers is among the highest in the World. Karnali watershed of Nepal (see Table) produces more sediment per square kilometer than most others rivers in comparison with some of the larger sediment producing watershed in the world (Galay et al., 2003). As an example specific sediment yield in Karnali river (about 4,362 t/km^2/yr) in Nepal is higher compare to sediment yield in Yellow river (about 2,470 t/km^2/yr) in China (WECS, 2003). Hence these rivers pose an immense challenge with regard to sediment management.

Table 1.1: Comparison of specific sediment loads (Galay et al., 2003)

Name of the River	Fraser river in B.C.,Canada	Karnali River, Nepal	Mekong River, Vietnam	Yellow River, China	Indus River, Pakistan
Area, km^2	250,000	43,560	800,000	770,000	960,000
Mean annual flow, m^3/s	3,410(Mission)	1,389 (Chisapani)	15,000(mouth)	4,000(mouth)	6,400(mouth)
Annual sediment load, tonnes/year*10^6	18.4	190	80	1,900	400
Specific sediment yield, tonnes/km^2/year	74	4,362	100	2,470	417
Sediment yield per water volume, tonnes/m^3*10^6	170	4,300	170	15,000	2,000

2.2) Impacts of Sedimentation

2.2.1) Storage Projects:

Deposition of sediment into the reservoir is a major challenge to the life of existing reservoir and its future development for the purpose of hydroelectricity and other use of water. With annual sediment deposition rate of 1-2%, Himalayan region is the worst sufferer of depleting storage capacity. Among varieties of consequences, erosion to hydraulic structures, damage to hydro-mechanical and electro-mechanical parts and forced outage of power plants is annually causing huge loss of revenue. The problem is severe with medium sized reservoirs and dams without bottom outlets. Sedimentation in reservoir has both upstream and downstream consequences. Deposition of sediment in the river upstream of reservoir can increase flood levels whereas downstream of reservoir can see the effect of severe bank erosion.

The 90 MW Kulekhani Hydropower Project which was commissioned in 1982 is the only project offering seasonal water storage in Nepal and the project plays a vital role in the national electric power system in the country. This project has lost more than 25% of its capacity in a little over 20 years. In as much as this is the only project offering seasonal water storage in Nepal, such a loss of capacity is a matter of serious concern to Nepal. The total original storage capacity of the Kulekhani Reservoir was 85.3 million m3 in which 73.3 million m3 belongs to the live storage The current total storage capacity is about 64 million m3 in which 59 million m3 belongs to the live storage. (Sthapit, 1994; Galay, et al., 1995; NEA,2004)

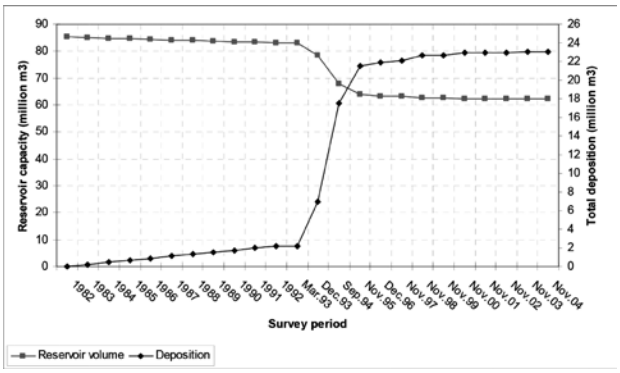


Figure: Reservoir capacity and deposition variation of Kulekhani reservoir (Sthapit, 1994; Galay, et al., 1995; NEA, 2004)

Economic analysis of reservoir sedimentation

For hydropower silting, the annual cost of replacement is estimated to be 13.6 billion $/year (including annual loss of power supply due to loss of storage about 6 billion $/ year) in global scale (ICOLD, 2009). Including the annual loss of storage of irrigation reservoir (5 billion $/year) and the cost of downstream damages, losses of power supply, maintenance cost of turbine wear etc.(5-10% of cost of hydropower plants), the total annual lost linked with sedimentation problems is about 21 billion $ and deserves great care. Comparing with annual overall cost and benefits of dams, the annual cost of reservoir sedimentation (in terms of replacement cost) is thus about 37% of the overall cost which is not insignificant. However, much less than 37% is currently spent on sedimentation mitigation measures and the problems are therefore postponed to future generations in many countries and Nepal is not the exception.

2.2.2) Run-off-River Projects

The major design criteria for RoR project is that these types of project shall allow 100% of the sediment load in the river to pass by intake dam. High degree of erosion/ cavitation damage is caused to hydraulic structures (under sluices, spillway etc.) and hydro-mechanical equipments.

Passage of highly silt laden water through turbine change the profile of the runner and guide vanes which reduce the machine efficiency. Sometimes, the degree of damage is so high that it goes beyond the economic limit of repair and need to be changed much before its normal life.

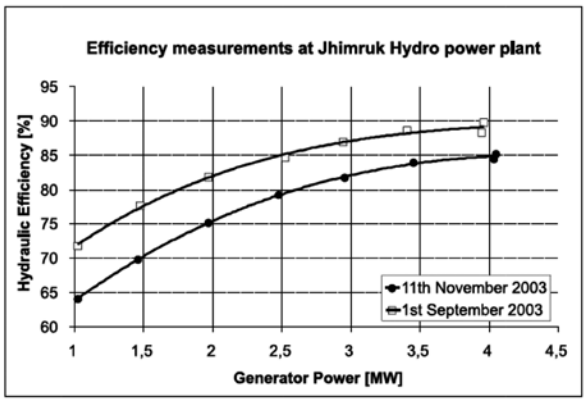


Figure 2: Results from the themodynamic efficiency measurements in Jhimruk (Pradhan et al., 2004)

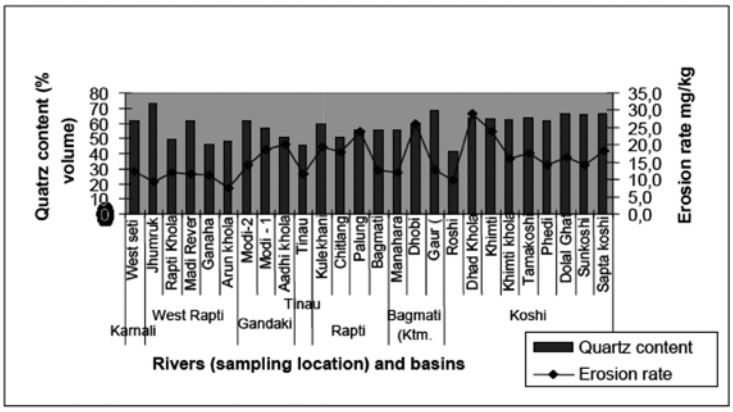
Sediment induced abrasion in water turbines due to silt is a major problem in Nepal. The various components of hydraulic turbines operating in silt-laden water suffer from extensive abrasion damage. Many run-of-the-river schemes in the Himalayan region are affected by this problem, frequently forcing them to shut down for repair work. This has a negative effect on availability and efficiency of the plants. Besides large revenue losses, there are often high maintenance costs involved, since spare parts are not readily available.

Lack of sediment data in Jhimruk river and cases of severe sedimentation at the very beginning of the operation phase of Jhimruk Hydropower Plant causes severe abrasion of turbines and subsequently loss of efficiency. The results from the thermodynamic efficiency measurements are shown in Figure. The efficiency loss is 4% at best efficiency point and 8% at 25% load (Pradhan et al 2004). These losses have occurred in the period 1 September to 11 November 2003. The shifting of the curve in Figure from upper to lower indicates loss of the turbine efficiency.The loss in efficiency of the turbine unit no.3 in Jhimruk is attributed to the abrasive erosion of various parts of the turbines. This is due to the abrasive action of mainly hard minerals present in the sediment

passing through the turbine. The presence of more than 80% of hard minerals (quartz + feldspar) in the sediment is considered responsible for this erosion.

3) INFLUENCE OF MINERALOGICAL COMPOSITION ON EROSION RATE

Mineralogical composition of sediments also has significant effect on the severity of erosion of mechanical and hydraulic components of power plants. Hard materials like quartz and feldspar cause severe abrasion of hydro-mechanical and electro-mechanical elements. Compared to east, quantity of quartz in western part of Nepal are varying, but certainly less than that of east. Some of these rivers originate in Middle Mountains and hence local geology may have great influence in the quartz contents.. The result (Thapa et al 2004) shows some trend along length of the country, for instance the erosion rate is almost equal for all the samples in their respective basins in east and west. Eastern basins have higher erosion rate compared to western basin, which can be justified by higher quartz content. This study hinted that besides quartz content in sediment, the shape of particles could also have significant influence in erosion rate.



(Thapa et al., 2004)

4) PRESENT STATE OF SEDIMENT MEASUREMENT IN NEPAL

Department of Hydrology and Meteorology (DHM) is a government agency responsible for all the hydrologic and meteorological monitoring activities including sediment in Nepal. It has about 25 sediment sampling stations (only 20 stations are in operation) located mostly in the middle mountain region in the major rivers of Nepal (Bhusal, 2005). The first flow gauging station in Nepal was established on January 1st, 1961 in the Asara Ghat of Karnali River whereas sampling of the suspended sediment was started in the same gauging station in 1964 by DHM (DHM, 2004).

Besides DHM, NEA, BPC, Hydrolab Pvt. Ltd, and HPL are also involved in several aspects of sediment studies. The quality control of the data gathered is inadequate and the data products are insufficient to match user's demand on quality information on river sediment and transport of matter.

5) CONCLUSION

From current scenario of energy crisis, most people realized the importance of hydropower development for sustainable development of our country. Now the time has come to think and act for the sustainable development of hydropower which is quite incomplete without proper sediment analysis and management system. No doubt, Nepal is one of the richest countries in the world on inland water resources. But we should not forget the bitter fact that Himalayan rivers are also the giant source of sediment loads. Sustainability of hydropower projects depends upon proper study and management of sediments. In planning a hydropower project on a river carrying relatively high sediment loads, appropriate attention should be given to the sediment management aspect. Hydro power engineers must be 'sediment conscious' during investigations, design, operation and maintenance. More research and development is needed into the causes and mitigation of sediment erosion impacts

Sediment in river is considered as hurdle for development of hydropower in Nepal. On the other hand its economic value is never thought of. The mineral analysis of sediment samples indicates the possibility of its use for industrial purpose. So the burden can be converted to byproducts if properly utilized.

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Hydropower Development in Nepal

Er. Basanta Pancha

Hydropower has been recognized as a sustainable source of energy with almost zero input cost. Availability of abundant water resources and geo-physical features provide ample opportunities for hydropower production in Nepal. The average annual precipitation is approximately 1700mm (80% of which occurs during the monsoon season- June to September).The total annual average run- off from the nation's 600 perennial rivers flowing from high mountains is over

200 billion cu.m. Nepal's storage potential is estimated at 88 billion cu.m. The estimated theoretical power potential is approximately 83,000MW, however, theeconomically feasible potential has been evaluated at approximately 43,000 MW, of which only 780.25 MW has been harnessed.

Power Situation in Nepal-Past and Present

Wisconsin (USA) was home to the world's first hydroelectric power plan named Appleton of capacity 12.5 kW on September 30, 1882. After 29 years, first Nepal HYDEL, Pharping (500 kW) was commissioned in 1914.Sundarijal(640kW) was second hydro plant commissioned in 1936. By 6th 5 year plan 1980-85 Panauti, Trishuli, Devighat, Sunkoshi built with grants; more importantly NEA was formed. During 7th 5 year plan 1985-90, Marsyangdi and Kulekhani-I were built .During 8th Interim plan 1990-1993, existing policy reformed and gate was opened for private sector and hence BOOT projects PA and PPA were signed .During, 9th 5 year plan 1997-2002,Khimti, Bhotekoshi, Chilime, Kaligandaki, Modi, Puwa etc were built which was considered as the most successful period.

Sectors	Installed Capacity (MW)
NEA Hydro ROR Grid Connected	381.394
NEA Hydro Storage Grid Connected	92
NEA Total Hydro Grid Connected	473.394
NEA Total Hydro Isolated	4.536
Total Hydro-NEA	477.93
Total Hydro- IPP	302.3164
Total Hydro-Nepal	780.25
Total Thermal(NEA)	53.41
Total Solar (NEA)	0.1
Total Installed Capacity	(787.451+46.31)=833.76 MW

After that political instability began and hence pace of development slowed down. The 11th Interim plan 2007-10 saw 556 MW installed capacity while the 12th Interim plan 2010-13 saw 705 MW installed capacity with 149 MW added. Today INPS has 833.76 MW Installed capacity with 477.93 MW from NEA (hydro) 302.3164 MW from IPP (hydro), 53.41 MW from Thermal (NEA) and 0.1 MW from solar (NEA).

Demand VS Availability

Power system is like a balance and hence the effort made should be to strike the balance. When one of the pans touches the ground, the system collapses and hence to save from being collapsed, some material is to be thrown out which is called loadshedding. Today INPS has 833.76 MW Installed capacity but the peak demand is 1291.8 MW. 9 big projects with 2177 MW capacity are

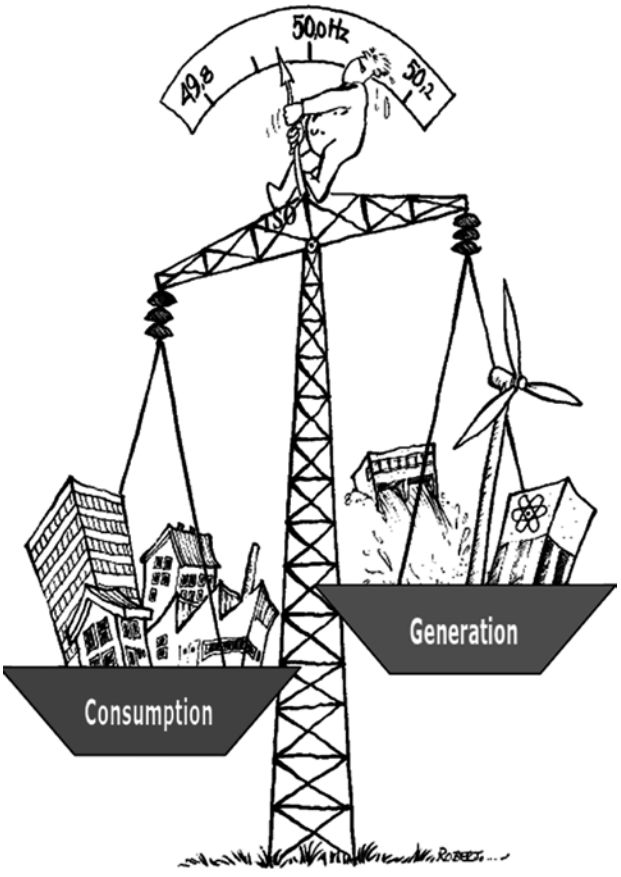

Fig: Generation Vs Consumption

planned and proposed. 11 big hydropower projects with capacity 1044.1 MW are at construction phase. 112 IPP projects of total 2188.885 MW capacity that have signed PPA with NEA are at construction phase of which 33 projects of 542.532 MW capacity are at advanced stage of construction . Since most of the projects are ROR scheme, the dry season demand will not be met and hence load shedding is inevitable.

Annual Energy Demand – 6334.7 GWh

Out of which 2366.88 GWh was contributed by NEA generation, 1268.93 GWh was purchased from IPP, 1369.89 GWh was purchased from India and 1329 GWh was managed by loadshedding.

ISSUES AND CONCERNS

The pages of history clearly indicates the political instability as the responsible factor for slowing down the pace of development. Frequent changes in internal procedures, too much discretionary power and too many agencies involved in approval process have brought hassle for IPP/FDI. Stable policies, proper regulation and harmonization of laws are essential. The mechanism of royalty distribution to the local level must be firmed up and implemented while Government of Nepal must decide on fixed reasonable rate of investment by developer for community development to avoid disruptions.

WAY FORWARD

For the development of country, utmost stability in politics and policy is essential. The "water selling syndrome" embedded in the leaders of big party in the government should be cured. Realistic demand forecast should be emphasized which paves path for additional generation capacity and hence way for new projects developments. Domestic sector should be focused and "export mania" should be cured. Instead of depending on foreign investment, a mix of storage and ROR for domestic requirement should be developed with own investment. Being self-sufficient domestically, will improve our bargaining power and we can sell our seasonal surplus at market rate. In that case, we can develop plants with seasonal surplus guaranteeing market and price in advance. Similarly, the generation augmentation should be synchronized with the transmission line and distribution line development. Efforts should be made from government level to introduce a competition in the market to minimize NEA monopoly by electricity sector restructuring. Despite the non-conducive environment, there has been a lot of new addition to INPs. However, the power produced is not sufficient to meet the current demand of the country. So, the government sector should put more efforts in energy sector to uplift the current power situation of country, otherwise, it is sure that we have to live in dark phase more than ever.

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Prajwol Tamrakar	Civil
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Sanat Kumar Karmacharya	Civil
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Bikash Budhathoki	Computer
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Poojan Shilpakar	Computer
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Suresh Shilpakar	Computer
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Suraj Bhuju	Electrical
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Rajan Nhemaphuki	Civil
Rajeeb Manandhar	Civil
Sonia Barakoti	Civil
Sunil Subedi	Electrical
Ayush Manandhar	Electronics
Binyul Bajracharya	Electronics
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Shova Darlamee	Mechanical
Subin Shrestha	Mechanical

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Rujan Shrestha	Civil
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Satish Tamrakar	Civil
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Sudip Subedi	Civil
Sujin Yakami	Civil
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Prabesh Shrestha	Computer
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Rajan Bhandari	Electrical
Ramesh Adhikari	Electrical
Saroj Dhungana	Electrical
Umang Karki	Electrical
Daya Sagar Dhungana	Electronics
Dinesh Ghemashu	Electronics
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Kebin Manandhar	Mechanical
Sabin Bati	Mechanical
Shiva Gopal Bhuju	Mechanical

67 Batch

Rajendra Shrestha	Mechanical
Ravi Manandhar	Mechanical

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Ayurusha Karmacharya	Architecture
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Suresh Twanabasu	Architecture
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Bikesh Lakhe	Civil
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