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From the Editor's Desk

The generation and timely sharing of knowledge and information is ever more critical, as vividly reminded by the impending Covid-19 pandemic. Countries are accusing each other of hiding or not sharing information on time. The scientist and researchers around the globe are currently on a race to find a reliable vaccine against the novel corona virus; however, rigorous vetting and systematic testing are equally important to prevent misuse of science and technology.

Nepal Engineering College is doing its part to contribute to the solution to this pandemic by designing, constructing and providing a food delivery robot, named as Sisters' Assistant Robot (SAR) to the Sukraraj Tropical and Infectious Disease Hospital in Kathmandu. A technology to be easily adopted by the intended users need to match the skill level of the users. The SAR is appreciated by the health workers at the hospital for its ease of use and lack of sophistication.

The challenges posed by the need to maintain physical distance has created a problem none of us contemplated before the Covid-19 pandemic. The educational institutes around the world are in a dilemma; the need to make a choice between maintaining the academic calendar by starting the classes soon and protecting the health and safety of the students and staff and preventing mass transmission of the disease is creating confusion among the decision makers. Online class is a partial solution, not a complete one. If the confusion persists for some more months several academic institutes may face challenge to survive. Let us all contribute in any way we can by being a part of the solution.

The quality of the papers in this edition of SCITECH Nepal has been improved a lot, partly due to the greater number of manuscripts submitted. With the stakeholders' support, Nepal Engineering College is poised to soon elevate the standard of its publications to an international level. The results of our dedication and persistence will be there for all to enjoy and use. The editorial team, who worked behind the scene, would like to congratulate the authors whose papers have been published and encourage others to keep elevating the output standard of their works.

Hari K Shrestha

Prof. Dr. Hari Krishna Shrestha
Chief Editor

Contents

Variational FEM Approach to the Study of Drug Distribution in Dermal Layers in Transdermal Drug Delivery System

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Abstract

Today about 75% of drugs are taken orally and are found not to be as effective as desired. To improve this, transdermal drug delivery system was emerged. Transdermal drug delivery is self-contained continuous dosage forms which, when applied to the intact skin, delivers the drug through the skin at controlled rate to the systemic circulation. The present model describes the diffusion of drugs in transdermal drug delivery system. The tissue absorption rate and drug intake rate by blood are taken in an account. The Finite Element Method (FEM) approach is used for the solution with four layers of skin which are taken as discretized elements. The numerical calculation and plotting graphs have been done by using MATLAB.

Keywords: *Transdermal drug delivery system (TDDS), Finite element method, linear shape function, diffusion equation, conservation equation.*

I. Introduction and preliminaries

A. Introduction

In the last 100 years, drug delivery system has enormously increased their performances, moving from simple pills to sustained/ controlled release. Nowadays, the drug delivery has become more specific from systemic to organ and cellular targeting [18].

The major sites of drug administration are [1]:

1. Oral: i) Buccal Cavity
   ii) Gastro-Intestinal Tract (GIT)
2. Eyes (Intraocular)
3. Nose (Nasal)
4. Lungs (Inhalation)
5. Skin (Topical/ Transdermal)
6. Rectum
7. Vagina
8. Injections (IV, IM, SC)

Here, we are concerned only about the drug delivery through skin: the transdermal drug delivery system. Oral delivery (tablets and capsules) has been considered as the most appropriate method of drug administration for many decades. The drugs that cannot be taken orally have been traditionally administered through hypodermic needles. However, the hypo-dermic injections have many disadvantages, such as the presence of pain, possibility of having infections, and necessity of medical expertise to complete the injection process.

These problems have therefore led to invention and development of new methods of drug delivery. So, transdermal drug delivery is an alternative route of drug administration.

B. Definition

Transdermal drug delivery is self-contained continuous dosage forms which when applied to the intact skin, delivers the drug through skin at controlled rate to the systemic circulation. It is a viable administration route for potent and low molecular weight therapeutic agent [2].

Drug can be delivered across the skin to have an effect on the tissue adjacent to the site of application (topical delivery) or to have an effect after distribution through the circulatory system (systemic delivery). There are many advantages in delivering drugs through skin; the barrier properties of the skin provide a significant challenge.

C. Structure of Skin

For development and optimization of effective transdermal formulation, it is important to understand the mechanism of drug permeation from the delivery device across the skin. The skin is the largest organ in the human body, highly organized structure consisting three main histological layers, called epidermis, dermis and hypodermis (subcutaneous tissues). The skin of an average adult body covers about $2m^2$ and receives about one third of the blood circulating through the body.

The epidermis is further subdivided into five anatomical layers [3]:

1) Stratum Corneum (SC)

2) Stratum Lucidum

3) Stratum Granulosum

4) Stratum Spinosum

5) Stratum Germinativum

The outermost layer stratum corneum consists of highly cornified (dead) cells.

The human skin surface is known to contain average 10-70 hair follicles and 200-250 sweat ducts on every square centimeter of the skin area.

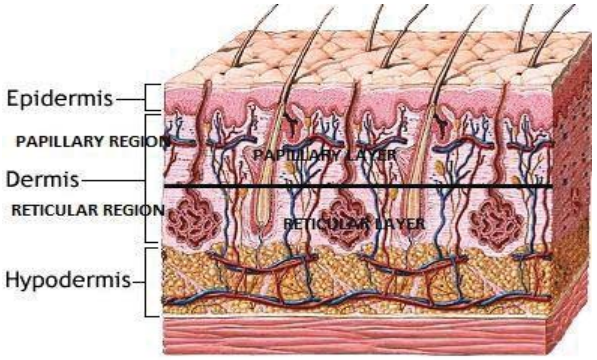

Fig. 1: Structure of the skin (Source:https://www.pinterest.com/pin/562738915914723926/)

Beneath the epidermis, the skin has another layer dermis consisting blood capillaries, sweat glands and sebaceous glands. This layer is again divided into two sub-layers: one is papillary region consisting networks of blood capillaries and another is reticular region consisting nexus of blood vessels, sweat glands and sebaceous glands. The third layer is hypodermis which attaches the skin to its underlying bones and muscles and contains blood vessels and the nerves [2].

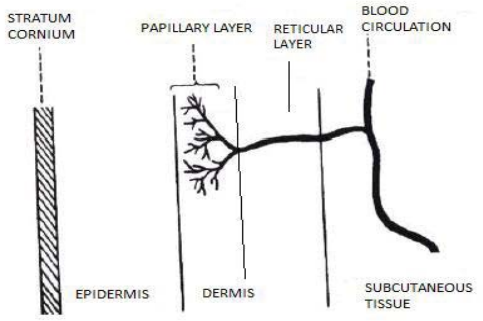

Fig. 2: Four layers of the model [2]

The skin is a readily accessible surface for drug delivery in human body. There is considerable interest in the skin as a site of drug application both topical and systemic effect. However, the outermost layer stratum corneum (SC) possess is very difficult barrier to drug penetration thereby limiting topical and transdermal bioavailability.

barrier to drug penetration thereby limiting topical and transdermal bioavailability.

D. Transdermal Patches

The skin penetration enhancement techniques have been developed to improve the bioavailability and increase the range of drug for which topical and transdermal delivery is viable option. Various types of patches with drugs and penetration enhancers have been developed nowadays. A transdermal patch or skin patch is a medicated adhesive patch that is placed on the skin to deliver a specific dose of medication through the skin and into the blood stream. The main components of a transdermal patch are [2, 4]:

a) **Liner-** It protects the patch during storage. The liner is removed prior to use.
b) **Drug-** Drug solution in direct contact with releases liner.
c) **Adhesive-** It serves to adhere the components of the patch together along with adhering the patch to the skin.
d) **Membrane-** It controls the release of the drug from the reservoir and multilayered patches.

Some drugs have an inherent capacity to permeate skin without enhancers. However, when this is not a case, chemical or physical permeation enhancers may use in the TDDS.

II. Formulation of Mathematical Model

We present a finite element model for one dimensional steady state drug diffusion with partitioning through the interfaces between the different layers of the skin in the transdermal drug delivery system. In this model we take skin structure with four layers (shown in Figure 2):

1. Epidermis (Consisting dead cells and no blood capillaries)
2. Dermis with two sub layers:
   i) Papillary region (consisting fine blood capillaries)
   ii) Reticular region (consisting blood vessels, sweat glands and sebaceous glands)
3. Subcutaneous Tissue or Hypodermis (consisting blood vessels and nerves)

It is also assumed that the concentration of applied drug has varied linearly in each layer and is defined as a function of one space variable x, which denotes the depth below the skin surface, the partition coefficients, the diffusivity and the absorption coefficient in each layer are taken constant.

In 1855, Fick recognized that the equation of heat conduction developed by Fourier in 1822 could be applied to mass transfer. Fick gave the Fick's First law of diffusion which states that the flux is proportional to concentration gradient $\frac{dC}{dx}$. Hence,

$$J = -D\frac{dC}{dx} \qquad (1)$$

Where, D is diffusivity, C is concentration of drug and x is distance of movement normal to the surface of the barrier [5, 6, 7, 8].

In the most real situations, the concentration profile and the concentration gradient are changing with time. The change of the concentration profile is given by Fick's Second law, which is combination of Fick's First law (1) and the conservation equation $\frac{\partial C}{\partial t} = -\nabla . J$ i.e.,

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} \qquad (2)$$

This equation (2) was mostly employed to study heat diffusion in dermal region. Similar equations has also been widely used by Saxena and his coworkers (V.P. Saxena1983, Saxena and Ayra1981 and Saxena and Bindra1987)[9, 10, 11]. In most of the cases finite element method has been employed in other to study the temperature distribution. Gurung and Saxena, 2009[12] have used this approach to study one dimensional unsteady state temperature distribution in human dermal parts. Saxena and Sharma (2011)[13] used this approach to solve one dimensional drug distribution problem in three layered human dermal region by using quadratic shape function. Recently Gupta et.al (Vineeta Gupta, S.S. Pandey, V.P. Saxena, 2012)[7, 14] used the same approach using linear shape function as well as quadratic shape function in three layered human skin. In viewing this, an attempt has been made here to solve one dimensional steady state drug distribution problem in four layered human skin using finite element method.

When drug is diffused in dermal layers, it is mainly absorbed by tissues and blood but tissue absorption rate is decreasing function of drug concentration and the drug absorption by other factors, is almost negligible, hence the transport of drugs in the skin is governed by the following differential equation:

$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x}\left(D\frac{\partial C}{\partial x}\right) - T(C) - B \qquad (3)$$

Where,

T(C) = Tissue absorption rate of drug depending on the concentration of drug C.

B = Drug intake rate by blood.

x = Depth below the skin surface.

The value of the parameters depend on time t and depth x where $a_{i-1} \le x \le a_i$. The thickness of four layers of the skin are respectively $a_1 - a_0$, $a_2 - a_1$, $a_3 - a_2$, and $a_4 - a_3$ (shown in Fig. 3).

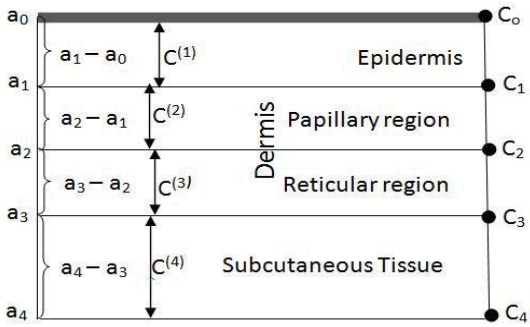

Fig. 3: Nodal concentration with field variables

The drug distribution has mild barrier effect at the interfaces. The flux of drug is generally continuous and hence,

$$C^{(i)} = \rho_i C^{(i)} \text{ at } a_i \text{ (i = 1, 2, 3)} \qquad (4)$$

where, ρ_i are the skin partition coefficients for drug at respective interfaces. In most cases $\rho_i = 1$.

The concentration of drug at outer surface (at x = a_0) is C_0 (is known). Drug is targeted up to subcutaneous tissue (Hypodermis) only and has negligible concentration beyond hypodermis. Therefore at the innermost boundary (x = a_4), the concentration is $C_4 = 0$.

The epidermis contains almost the dead cells and has no blood capillaries and vessels. So, the tissue absorption rate is very less in this layer and we consider negligible in this model. The drug intake rate by blood in this layer is also zero. After absorbing drug by tissues, the concentration of drug increases there and then the absorption rate of the tissues decreases, hence the tissue absorption rate is decreasing function of concentration. Therefore, we take

$$T_i(C) = e^{-ki}C^{(i)} \qquad (5)$$

where, k_i are absorption parameter in each layer which may be different for different drugs. Thus for marginally small concentrations i.e., $k_i \ll 1$, we can write

$$T_i(C) = 1 - kiC^{(i)} \qquad (6)$$

As the transdermal drug delivery is free from the first pass, metabolism effect, we ignore the metabolism in the skin tissues. In transdermal drug delivery system, the drug is released in the constant rate (controlled released) and hence concentration at a particular depth is always constant during the period of application of the patch. So, for this steady state case the equation (3) becomes

$$\frac{d}{dx}\left(D\frac{dC}{dx}\right) - T(C) - B = 0 \qquad (7)$$

For particular patch, the concentration of drug at the outer surface C_0 is known.

III. Solution of the Model

Comparing equation (7) with Euler-Lagrange equation, transforms to the variational form

$$I = \int_0^L \left[\frac{D}{2}\left(\frac{dC}{dx}\right)^2 + \left(B + \frac{1}{2}\right)C + \frac{T(C)}{2}C\right]dx \qquad (8)$$

where, L is total thickness of the skin ($a_4 - a_0$). For optimum value of I, L is divided into four layers of the thickness $a_1 - a_0$, $a_2 - a_1$, $a_3 - a_2$, and $a_4 - a_3$(as shown in Figure 3).

The parameters D, B, T are taken constant for each layer, then above variational form (8) can be written in the iterative form as

$$I_i = \int_{a_{i-1}}^{a_i} \left[\frac{D_i}{2} \left(\frac{dC^{(i)}}{dx} \right)^2 + \left(B_i + \frac{1}{2} \right) C^{(i)} + \frac{T(C)}{2} C^{(i)} \right] dx \quad (9)$$

The field variable $C^{(i)}$ for each layer is approximated by the linear shape function [15]

$$C^{(i)} = \frac{C_{i-1}a_i - C_i a_{i-1}}{a_i - a_{i-1}} + \frac{C_i - C_{i-1}}{a_i - a_{i-1}} x \quad (10)$$

of the one space variable x with $a_0 = 0$. Then the equation (9), for each layer is:

$$I_1 = \int_0^{a_1} \left[\frac{D_1}{2} \left(\frac{C_1 - C_0}{a_1} \right)^2 + \left(B_1 + \frac{1}{2} \right) \left(C_0 + \frac{C_1 - C_0}{a_1} x \right) + \frac{T_1}{2} \left(C_0 + \frac{C_1 - C_0}{a_1} x \right) \right] dx \quad (11)$$

$$I_2 = \int_{a_1}^{a_2} \left[\frac{D_2}{2} \left(\frac{C_2 - C_1}{a_2 - a_1} \right)^2 + \left(B_2 + \frac{1}{2} \right) \left(\frac{C_1 a_2 - C_2 a_1}{a_2 - a_1} + \frac{C_2 - C_1}{a_2 - a_1} x \right) + \frac{T_2}{2} \left(\frac{C_1 a_2 - C_2 a_1}{a_2 - a_1} + \frac{C_2 - C_1}{a_2 - a_1} x \right) \right] dx \quad (12)$$

$$I_3 = \int_{a_2}^{a_3} \left[\frac{D_3}{2} \left(\frac{C_3 - C_2}{a_3 - a_2} \right)^2 + \left(B_3 + \frac{1}{2} \right) \left(\frac{C_2 a_3 - C_3 a_2}{a_3 - a_2} + \frac{C_3 - C_2}{a_3 - a_2} x \right) + \frac{T_3}{2} \left(\frac{C_2 a_3 - C_3 a_2}{a_3 - a_2} + \frac{C_3 - C_2}{a_3 - a_2} x \right) \right] dx \quad (13)$$

$$I_4 = \int_{a_3}^{a_4} \left[\frac{D_4}{2} \left(\frac{C_4 - C_3}{a_4 - a_3} \right)^2 + \left(B_4 + \frac{1}{2} \right) \left(\frac{C_3 a_4 - C_4 a_3}{a_4 - a_3} + \frac{C_4 - C_3}{a_4 - a_3} x \right) + \frac{T_4}{2} \left(\frac{C_3 a_4 - C_4 a_3}{a_4 - a_3} + \frac{C_4 - C_3}{a_4 - a_3} x \right) \right] dx \quad (14)$$

Integrating I_1, I_2, I_3, and I_4, we get [17]

$$I_1 = \mathrm{G_1C_0} + \mathrm{G_1C_1} + \mathrm{F_1C_0^2} + \mathrm{F_1C_1^2} - 2\mathrm{F_1C_0C_1} \quad (15)$$
$$I_2 = \mathrm{G_2C_1} + \mathrm{G_2C_2} + \mathrm{F_2C_1^2} + \mathrm{F_2C_2^2} - 2\mathrm{F_2C_1C_2} \quad (16)$$
$$I_3 = \mathrm{G_3C_2} + \mathrm{G_3C_3} + \mathrm{F_3C_2^2} + \mathrm{F_3C_3^2} - 2\mathrm{F_3C_2C_3} \quad (17)$$
$$I_4 = \mathrm{G_4C_3} + \mathrm{F_4C_3^2} \quad (18)$$

Where,

$\mathrm{E_1} = \mathrm{B_1} + 1/2$ $\quad F_1 = \frac{D_1}{2a_1}$ $\quad G_1 = \frac{a_1}{4}(2E_1 - T_1)$

$\mathrm{E_2} = \mathrm{B_2} + 1/2$ $\quad F_2 = \frac{D_2}{2(a_2 - a_1)}$ $\quad G_2 = \frac{a_2 - a_1}{4}(2E_2 - T_2)$

$\mathrm{E_3} = \mathrm{B_3} + 1/2$ $\quad F_3 = \frac{D_3}{2(a_3 - a_2)}$ $\quad G_3 = \frac{a_3 - a_2}{4}(2E_3 - T_3)$

$\mathrm{E_4} = \mathrm{B_4} + 1/2$ $\quad F_4 = \frac{D_4}{2(a_4 - a_3)}$ $\quad G_4 = \frac{a_4 - a_3}{4}(2E_4 - T_4)$

Assembling these I_i, to obtain

$$I = I_1 + \mathrm{I_2} + \mathrm{I_3} + \mathrm{I_4}$$
$$= \mathrm{G_1C_0} + \mathrm{G_1C_1} + \mathrm{F_1C_0^2} + \mathrm{F_1C_1^2} - 2\mathrm{F_1C_0C_1} + \mathrm{G_2C_1} + \mathrm{G_2C_2} + \mathrm{F_2C_1^2} + \mathrm{F_2C_2^2} - 2\mathrm{F_2C_1C_2} + \mathrm{G_3C_2} + \mathrm{G_3C_3} + \mathrm{F_3C_2^2} + \mathrm{F_3C_3^2} - 2\mathrm{F_3C_2C_3} + \mathrm{G_4C_3} + \mathrm{F_4C_3^2} \quad (19)$$

To optimize I, we differentiate it with respect to each nodal concentration and equate them to zero.

i.e., $\frac{\partial I}{\partial C_i} = 0$ for i = 1, 2, 3 we get,

$$2(\mathrm{F_1} + \mathrm{F_2})\mathrm{C_1} - 2\mathrm{F_2C_2} = 2\mathrm{F_1C_0} - \mathrm{G_1} - \mathrm{G_2} \quad (20)$$
$$-2\mathrm{F_2C_2} + 2(\mathrm{F_2} + \mathrm{F_3})\mathrm{C_2} - 2\mathrm{F_3C_3} = -\mathrm{G_2} - \mathrm{G_3} \quad (21)$$
$$-\mathrm{F_3C_2} + 2(\mathrm{F_3} + \mathrm{F_4})\mathrm{C_3} = -\mathrm{G_3} - \mathrm{G_4} \quad (22)$$

This system of equation forms the tri-diagonal system

$$\mathrm{AC} = \mathrm{B} \quad (23)$$

Where, $A = \begin{bmatrix} 2(F_1 + F_2) & -2F_2 & 0 \\ -2F_2 & 2(F_2 + F_3) & -2F_3 \\ 0 & -2F_3 & 2(F_3 + F_4) \end{bmatrix}$, $C = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \end{bmatrix}$ and $B = \begin{bmatrix} 2F_1C_0 - G_1 - G_2 \\ -G_2 - G_3 \\ -G_3 - G_4 \end{bmatrix}$

Solving the equation (23), we get the concentrations and then we can compute easily the field variables of the four layered human dermal parts.

IV. Numerical Results, Discussion and Conclusion

A. Numerical Results

On solving the system of linear equation (23), we get the nodal concentrations C_i (i = 1, 2, 3), which in turn are substituted in (10) to determine the values of the field variables $C^{(i)}$. The values of diffusivity D_i, tissue absorption rate $T_i(C)$ and drug intake by blood B_i varies according as the structure of the skin in this study. The following values of the physical and physiological parameters are, feasible and fall within the admissible range and, used for obtaining concentration profile in the region. [7, 12, 16]

Table 1: Drug absorption rates of tissue and blood according to skin thickness

	Interfaces from surface(cm)				$T_i(C)(\times 10^{-4}mg.cm^{-3}s^{-1})$			$B_i(\times 10^{-3}mg.cm^{-3}s^{-1})$		
SET	a_1	a_2	a_3	a_4	T_2	T_3	T_4	B_2	B_3	B_4
I	0.1	0.2	0.35	0.5	1.0	2.0	4.0	2.0	3.0	5.0
II	0.1	0.2	0.3	0.7	5.0	6.0	8.0	4.0	5.0	7.0
III	0.1	0.25	0.4	0.9	20.0	30.0	50.0	10.0	15.0	20.0

Table 2: Set of different values of diffusivity (cm^2s^{-1})

SET	D_1	D_2	D_3	D_4
I	1.83×10^{-2}	3.80×10^{-2}	4.52×10^{-2}	6.04×10^{-2}
II	5.83×10^{-2}	6.80×10^{-2}	52.83×10^{-2}	9.04×10^{-2}
III	4.00×10^{-1}	6.52×10^{-1}	7.58×10^{-1}	9.05×10^{-1}

The values of diffusivity D_i depend on the physicochemical properties of the substances and drugs used in the patch can be changed up to the desired level by using appropriate physical or chemical enhancers. The tissue absorption rate $T_i(C)$ and drug intake rate by blood B_i vary according to the structure of skin under study.

The graphs have been plotted between field concentration C(i) and thickness of the skin x for different sets of parameters for different thickness of skin layers..

The graphs in Fig. 4 and 5 show the concentration profile for various initial concentration C_0 and different thicknesses of dermal layers and corresponding parameters and different sets of diffusivity.

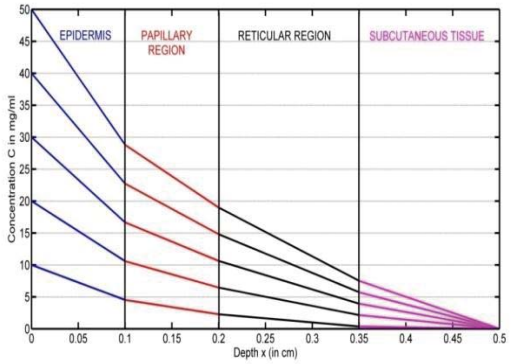

Fig.4: Concentration profile for parameters form SET I of table 1 and diffusivity SET 1 of table 2

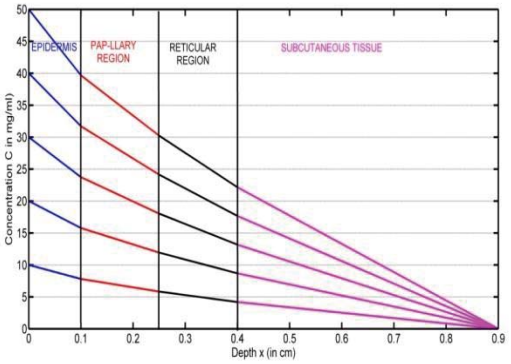

Fig.5: Concentration profile for parameters form SET III of table 1 and diffusivity SET III of table 2

The graphs in the Fig. 6 and 7 show the concentration profiles for the same initial concentration 50 mg/ml for same thickness of the dermal layers and different set of diffusivity from SET I and II of table 2.

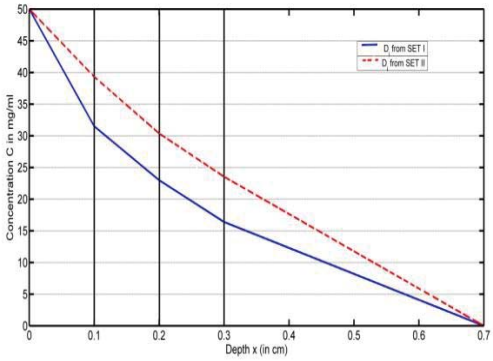

Fig.6: Concentration profile for C_0= 50mg/ml, parameters form SET II of table 1 and diffusivity SET 1 and II of table 2

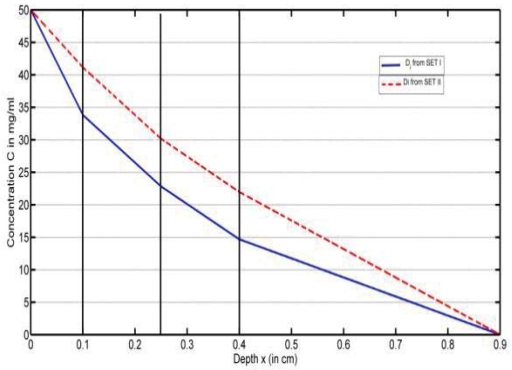

Fig.7: Concentration profile for C_0 = 50mg/ml, parameters form SET III of table 1 and diffusivity SET 1 and II of table 2

The graphs in the Fig. 8 and 9 show the concentration profiles for the different thicknesses of dermal layers but same Di from SET I of table 2

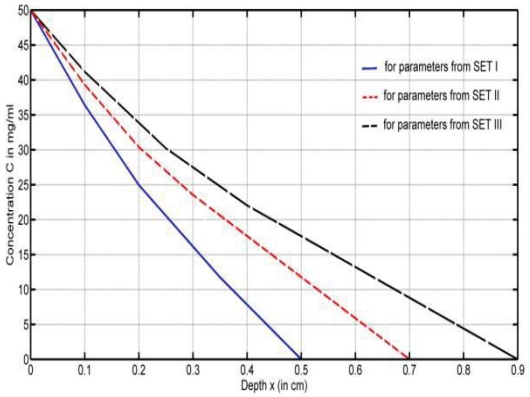

Fig. 8 : Concentration profile for C_0= 50mg/ml, parameters form SET I, II, and III of table 1 and D_i from SET I of table 2

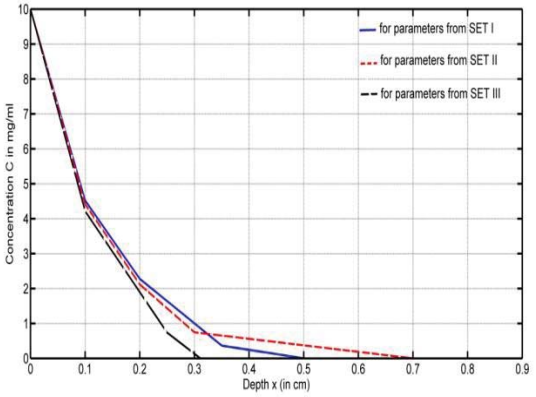

Fig. 9 : Concentration profile for C_0= 10mg/ml, parameters form SET I, II, and III of table 1 and D_i from SET I of table 2

The graphs in the Fig. 10 and 11 show the concentration profiles for the different thicknesses of dermal layers but same Di from SET III of table 2

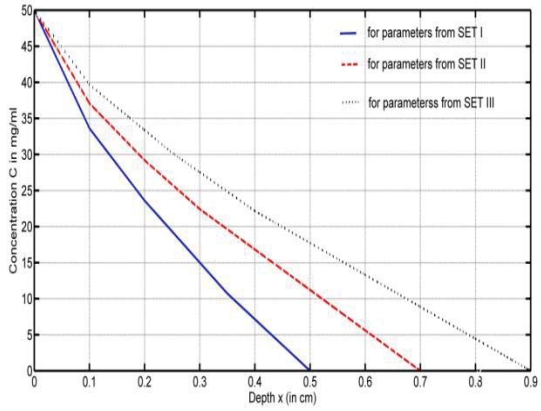

Fig. 10 : Concentration profile for C_0= 50mg/ml, parameters form SET I, II, and III of table 1 and D_i from SET III of table 2

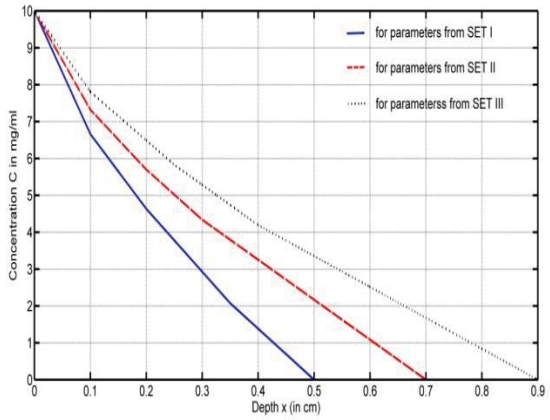

Fig. 11 : Concentration profile for C_0= 10mg/ml, parameters form SET I, II, and III of table 1 and D_i from SET III of table 2

B. Discussion

The graphs in Fig. 4 and 5 show that the increase in diffusion increases the concentration and decreases as we move towards the subcutaneous tissue from the outer surface of the skin. This is due to the effect of the absorption of the drug. The slop of the curve changes at the interfaces due to the change in properties of each sub-region.

The graphs in Fig. 6 and 7 individually show the effect of diffusivity in the concentration profile for the same thickness of the dermal layers and absorption coefficients i.e., at same part of the body. But, the simultaneous study of these two graphs show the effect of absorption coefficients (tissue and blood) in the concentration profile in the dermal layers for the same diffusivity. The rate of decrease of drug concentration in the dermal layers increases as absorption coefficient increases.

Also the graphs in Fig. 8 – 11 show the effect of different thickness of dermal layers i.e., at the different parts of the body for the same substance (drug) and same set of diffusivity. Fig. 8 and 10 show that the variation in thickness shows only slight variation in the concentration profile when the initial concentration C_0 is high. Fig. 11 shows that the variation in thickness again shows not significant effect in the concentration profile for high diffusivity but Fig. 9 shows that for low initial concentration C_0 and low diffusivity D_i, the variation of thickness shows the remarkable effect in the concentration profile.

That is, the variation of thickness shows the remarkable effect in concentration profile only in case of the small initial concentration and low diffusivity. In Fig. 9 the concentration C_0 = 10 mg/ml reduces to zero at the middle of reticular region in the skin of thickness 0.9 cm, while concentration reduces to zero only in subcutaneous tissue in the skin of thickness 0.5 cm. The presentation of the graphs plotted in Fig. 8 and 9 can be seen clearly in the thickness wise separate graphs as in the following figures:
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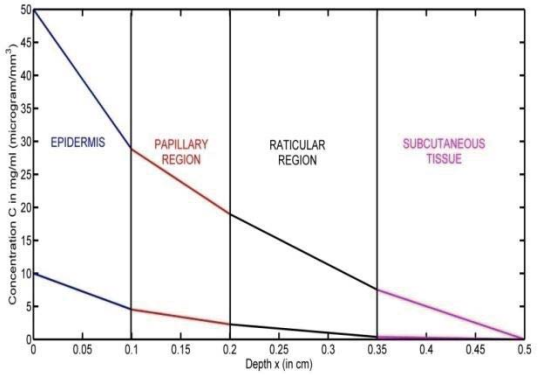

Fig.12: Concentration profile for thickness and other parameters from SET I of table 1 and diffusivity from SET I of table 2

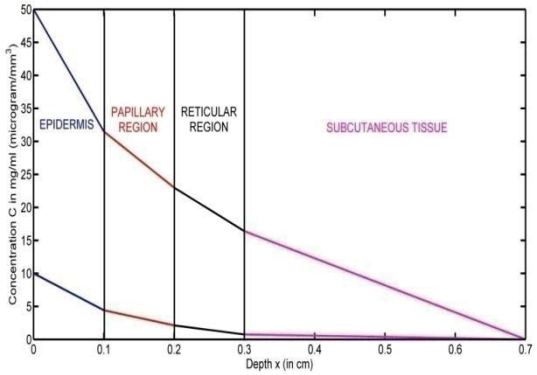

Fig.13: Concentration profile for thickness and other parameters from SET II of table 1 and diffusivity from SET I of table 2

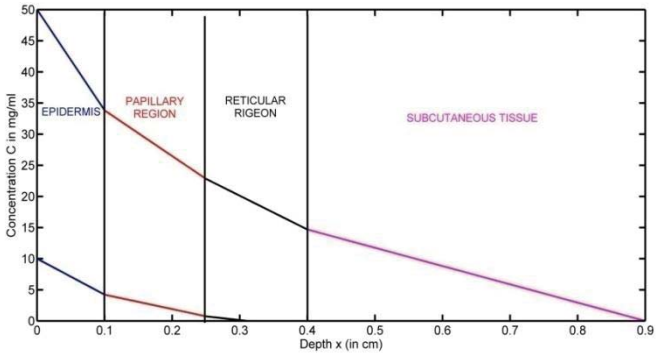

Fig. 14: Concentration profile for thickness and other parameters from SET III of table 1 and diffusivity from SET I of table 2

C. Conclusion

The exact amount of drug required depends on the physicochemical and biological properties of the compound. If these are known, the amount will be estimated. This solution predicts the amount of the drug release and individual concentration profiles in the skin. The model is useful to adjust various parameters, such as thickness, area, adhesive formulation of drug and enhancer concentrations to meet the several objectives: like drug dose, avoidance of irritation, dimension of patch to reduce cost etc. The appropriate combination of these parameters leads to develop the controlled drug delivery system. Without a precise knowledge of concentration and degree of storability of drugs, one cannot manufacture effective transdermal patch. The experiments using various combinations of parameters involve expensive clinical trials with potentially long evaluation period. This 1-D diffusion model of transdermal delivery predicts the delivery kinetics of transdermal patches and accelerates this process by enabling:

- rapid optimization of transdermal drug delivery parameters.
- insight into factors governing optimal delivery.
- reduction of number and duration of clinical experiments.
- knowledge for rapid development of transdermal drug delivery system.

This study is expected to provide a better understanding of the drug delivery mechanism and comprehend analysis of the effect of some physicochemical parameters on concentration

profile. This model will help to develop highly effective drug formulation and __accurate dosing regimens.

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Material Management System of Government Building Construction Projects in Kathmandu Valley

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Abstract

Material management is an essential element in construction projects. Improper material management systems lead to adverse impact on time, cost and quality of the construction projects. Most of the construction projects have not been completed on time, partly due to the poor material management system. Therefore, the aim of this study is to assess status of material management system (MMS) of building construction projects. Sixteen government building construction projects were selected in Kathmandu Valley for determining existing practices of MMS. Questionnaires survey, field visit and key informant interviews (KII) were used to collect the primary data and related literatures and documents available at site were reviewed for collecting secondary data. Quantitative and qualitative techniques were used as data collecting tools. MS Excel tool was used to analyse the data. From the study, it is found that manual record keeping system was used for MMS. About 71.43 % of projects did not use automatic loading/ unloading system and did not give priority to the quality of materials for MMS. Nearly 75 % of projects have implemented well managed store house in site as per material type and also focused on centralized storing system. None of the projects used any new technology of MMS in Building Construction Projects. It leads to the cost overrun on Building Construction Projects.

Keywords: *Material Management Systems (MMS), Key Informant Interviews (KII), Information and Communication Technology (ICT)*

I. INTRODUCTION

The materials which are used for the construction of building, road, dam, and tunnel are called construction materials. Construction materials cover about 30-70 % of total cost in construction projects [4]. The total cost of the project can be controlled by taking corrective actions towards the cost variance occurred in the project by material control. Materials management is an important function in order to

improve productivity in construction projects. Materials management functions include "material requirement planning and material take off, vendor evaluation and selection, purchasing expenditure, shipping, material receiving, warehousing and inventory, and material distribution". This is concerned with the planning and controlling process to ensure that the right quality and quantity of materials and equipment are appropriately specified in a timely manner, obtained at reasonable cost and are available when needed.

II. LITERATURE REVIEW

A. Construction Material

A good construction project is characterized by having right people with right skills and equipment, which are able to complete the project on time and on expected budget. Right materials in right place and at right time are important. The cash and capital flow to procure the labors and materials are also important. The materials cost on a project can vary from 30 % to 70 % of the total cost of the project, but, materials management has not received attention [5]. Construction materials can be classified into five different categories depending on their fabrication and storage system on site [6].

B. Construction Material Management

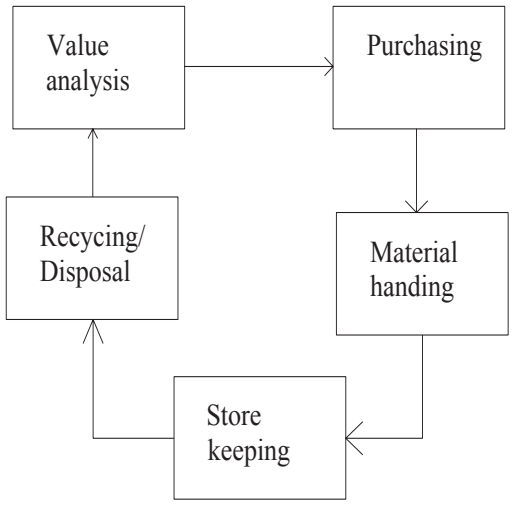
Construction project management process includes planning, organizing, executing, monitoring, and controlling. During any construction projects, three inter-related factors, time, cost and quality need to be controlled and managed. Successful completion of project requires all resources to be effectively used. Materials management is considered as a mean to achieve better productivity, which should be turned into cost reduction [1].

Survey of construction industries determined various format for construction material management, discussed the tracking system of material management and software technology developed for the process of material managements [3].

Nine different small, large & medium firms surveyed and followed five basic components of material management [2]. These components are

- Value analysis
- Purchasing
- Material handling
- Store keeping
- Recycling/Disposal

Figure 1. Components of Material Managements



System

Material management is a system which guides the way of material handling in construction industries. Vendor selection system, delivery system, storing system, and handling system are covered in material management in construction industries. Well defined material management system does not fit directly on a particular construction industry. So, material management is the critical and important task for construction projects [1].

III. METHODOLOGY

A. Research Design

This includes the research design, the research method, the population under study, the sampling procedure and the methods that were used to collect data. The reliability and validity of the research instrument were addressed by hypothesis test.

B. Study Area

This research was conducted in Kathmandu valley. Fifty governments owned building construction projects were selected as population. Out of them, only sixteen projects were selected as samples mainly based on accessibility, co-operation and co-ordination, and as required by research.

C. Data Collection Technique

1. Primary Data Collection

i. Questionnaire Survey

The questionnaires were distributed to the respondents of client/consultant (project managers/ engineers) and contractors (Store manager project manager/engineers) for survey. All the questionnaires were distributed by visiting them on construction site.

ii. Key Informants Interview (KII)

For cross reference of data obtained from questionnaire survey, the KII was conducted with the project managers (clients) of selected building projects.

IV. RESULTS AND DISCUSSION

A. Existing Practice as Per Contractors View on MMS

Table 1 shows the contractors' opinion towards existing MMS practice. Out of 16 respondents 81.25% did not use any modern technique and automatic loading /unloading system for MMS. 75% respondents said that they did not give priority towards MMS, 62.5% respondents had problem on transportation on site for MMS, and 50% respondents said procurement system is good as per PPMO (public procurements monitoring office), material delivery system and professionalism on MMS. 75% respondents said that they used well store house on site, 68.75% respondents said they focused on quality of material, and 56.25% respondents have satisfaction on works due to MMS.

So, as per contractors' opinion by questionnaire, effective and efficient material managements were not practiced on building construction projects. Material managements are much effective by using information communication technology (ICT), but, in our scenario, paper based and manually handled material management systems are practiced.

TABLE 1.Existing Practice of MMS as per Contractors

S.N.	Description	Yes (%)	No (%)
1	Use any material management system (MMS) Technology	18.75	81.25
2	Give priority /importance towards MMS	25	75
3	Well Storage system/Store house on site	75	25
4	Use material procurements as per PPMO	50	50
5	Material delivery automatically as per schedule	50	50
6	Have professionalism in MMS	50	50
7	Transportation problem on MMS	37.5	62.5
8	Automatic Loading /Unloading system for MMS	18.75	81.25
9	MMS give satisfaction on works	56.25	43.75
10	Focus towards quality of material by MMS	68.75	31.5
11	MMS include safety provision	62.5	37.5
12	Centralized store system	25	75

B. Existing Practice as Per Consultants View on MMS

Table 2 shows the existing practice as per consultant's opinion for MMS. Out of 16 numbers on going building construction projects, all 100% respondents said that there is no any modern technique used for MMS. 85.71% respondents did not give priority towards MMS, did not deliver material automatically as per schedule and have not professionalism in MMS.71.43% respondents face the transportation problem, did not use automatic loading /unloading system and decentralized store system used for MMS.57.14% respondents said that they did not focus towards quality of material and did not include safety provision on MMS.85.71 % respondents said that they use well storage system/ store house on site. 57.14% respondents said that they use material procurements as per PPMO and MMS give satisfaction on works.

So, opinions of consultants towards MMS were similar to contractors on some points, but, they said even more problem for practice of MMS on

building construction project in Kathmandu valley. Use of ICT is required for proper use of MMS on construction projects, but, as per consultant's opinion, practice towards MMS on construction site is fully based on paper based technology [3].

TABLE 2. Existing Practice of MMS as Per Consultants

SN	Description	Yes (%)	No (%)
1	Use any material management system (MMS) Technology	0	100
2	Give priority /importance towards MMS	14.29	85.71
3	Well Storage system/Store house on site	85.71	14.29
4	Use material procurements as per PPMO	57.14	42.86
5	Material delivery automatically as per schedule	14.29	85.71
6	Have professionalism in MMS	14.29	85.71
7	Transportation problem on MMS	28.57	71.43
8	Automatic Loading / Unloading system for MMS	28.57	71.43
9	MMS give satisfaction on works	57.14	42.86
10	Focus towards quality of material by MMS	42.86	57.14
11	MMS include safety provision	42.86	57.14
12	Centralized store system	28.57	71.43

C. Hypothesis Testing for Existing Material Managements System

Hypothesis test is conducted for correlation between clients or consultants and contractors' opinion.

Null hypothesis: There is no relation between the clients or consultants and contractors i.e. Ho = 0.

Alternative hypothesis: There is relation between the clients and contractors i.e. $H_1 \neq 0$.

The observed standard deviation(ρ) = 0.154 (less than critical value of ρ i.e. 0.591) and it comes in the acceptance region, therefore, not reject the null hypothesis at 10 % level of significance and reject the alternative hypothesis. Hence, it is concluded that there is significant difference between the opinion of the clients or consultants and contractors.

For the validation of these results, out of 20 projects, key informant interview (KII) was conducted on 5 selected projects. From this KII, it is understood that the perception of contractors and consultants was found significantly different regarding the importance and knowledge of MMS in construction projects.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

Existing practice of material management systems (MMS) depends on the manual record keeping system. More than 81 % respondents did not adopt the modern technique (MMS related software) of MMS. Respondents (75 %) did not give priority to MMS. Respondents, 71.43 %, did not adopt automatic loading/ unloading systems. Seventy five percent respondents said that there is well managed storage system. About 68.75 % respondents said that they focused on quality on material and 56.25 % respondents have satisfaction on works due to MMS. Above conclusion are contractor's opinion, but, as per consultant's opinion 100 % respondents did not adopt modern technique of MMS. Respondents, 85.7 %, gave priority towards MMS. So, from the findings, it is concluded that most of the government's building construction projects in Kathmandu valley did not use ICT technology, did not give importance towards MMS, did not adopt automatic loading/unloading system, proper store house is used as per material types and focused on quality of material. These conclusions were validated by KII study on selected projects, but, none of the building construction projects used automatic MMS system, which leads to the cost and time overrun on Building Construction Projects.

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Occupational Hazards in Building Construction

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Abstract

Minor injury to fatality and permanent disablement cases due to accident at the construction sites are one of the highest as compared to the other sector. Hence, there is an urgent need to mitigate this problem. The first step that should be taken is identifying the hazard to ensure a safe and conducive working condition. Therefore, this paper is intended to identify and highlight the hazards that are most commonly found at our construction sites today. The data collection was carried out through a questionnaire forms and checklist survey regarding hazards in construction. The sites include high rise commercial building projects. The study determines six major groups of hazards in relation to works at construction sites such as physical, chemical, mechanical, biological, psychological and physiological hazards. The study was conducted on 50 contractors and 5 building construction sites. The results showed that the most common hazards for the project around the study area are noise, electric shock and vibrations as the major physical hazards; cement dust and sand dust as major chemical hazard; hit by equipment as major mechanical hazard and job dissatisfaction as major psychosocial hazard in building construction projects. Thus, contractors should be responsible and accountable for documenting different types of hazards as they are implementing agent of safety during the construction and development of any project. For this, awareness level should be increased by conducting regular awareness program, along with engineering and enforcement activities.

I. INTRODUCTION

A. Background

Formal identification of hazards in the workplace is an essential basis on which successful safety management is founded. The ability of contractors to carry out this process in a formal way and document an appropriate safe work procedure is still problematic. Equally the requirement for those who control a workplace to review the content

of such procedures is also problematic in construction projects [2].

About 90% of the occupational hazards which occurs at construction sites are predictable and by giving adequate attention in planning, implementation, monitoring and control accidents could be prevented [1].

Unsafe act and unsafe condition at construction work leads to the loss of life and property. Thus, hazard identification in construction site plays a vital role to minimize the accidents and hence economic and social losses.

B. Research objectives

The overall objective of the study is to identify the occupational hazards in building construction projects in Nepal.

C. Significance of study

This study identified the occupational hazards in construction projects. This study helps to guide contractors, consultants and workers to maintain standard safety while working in construction projects. Therefore, proper hazards identification in construction projects can be significant to minimize the financial, human and social losses.

D. Scope and limitation of study

The scope of this research covers safety management in building construction projects.

II. LITERARURE REVIEW

E. Occupational hazards in building construction

Hazard can be defined as a potential situation that may cause harm, unintentional injuries, life loss damage, or loss of an item or belongings arising from occupational works. It is also known as the counterpart of safety [3].

As per International Labour Organization (ILO), there are number of hazards that can be found in construction workplace. They are:

- Physical hazards such as noise, vibration, unsatisfactory lighting, radiation and extreme temperatures;
- Chemical hazards arising from dusts, fumes, vapours and gases;
- Biological hazards such as bacteria, viruses, infectious waste and infestations;
- Psychological hazards resulting from stress and strain;
- Mechanical hazards like badly designed machinery, mechanical devices and tool [5].

Thus, formal identification of hazards in the workplace is an essential for safety management at building construction sites [2].

Figure 1 Hazards at Building Construction

B. Hazard identification in building construction

The ability of contractors to carry out the hazard identification process in a formal way and document an appropriate safe work procedure is still problematic. Equally the requirement for those who control a workplace to review the content of such procedures is also problematic in construction projects [2].

Job Safety Analysis (JSA), which is also known as job hazard analysis, is an efficient proactive measure for safety to identify hazards in construction projects. At construction sites the physical environment is constantly changing, workers move through the site in the course of their work, and they are often endangered by activities performed by other teams [4]. To address this difficulty, a structured method for hazard analysis and assessment for construction activities, called "Construction Job Safety Analysis" (CJSA), was developed. The method involves identification of potential loss-of-control events for detailed stages of the activities commonly performed in construction, and assessment of the probability of occurrence for each event identified [9].

Similarly, observation at site, hazard survey, group discussion and record analysis are also the methods of hazard identification used in construction projects [10].

C. Occupational hazards prevention and control measures

The most influential safety factor was personal awareness followed by communication [6]. The behaviours of contractors play significant role on safety management, including the provision of personal protective equipment, regular safety meetings, and safety training [8]. Similarly, the government should play a more critical role in legal enforcement and organizing safety training programs as well.

Heinrich's hierarchy of hazards prevention and control measure postulates that the effectiveness of prevention and control measures decreases from top to bottom in pyramid [7].

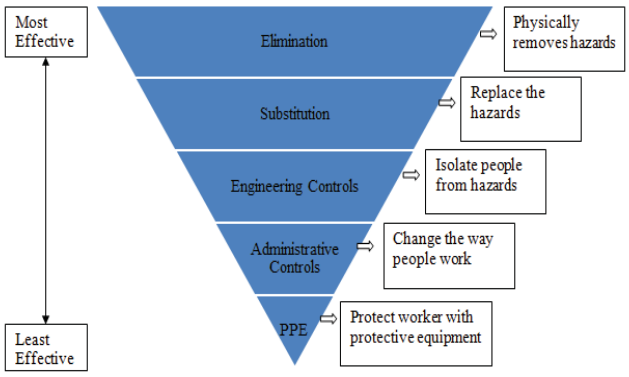

Figure 2 Heinrich's Hazard Control Pyramid

The way to control hazard at construction is elimination which means removing hazard physically. If elimination is not possible then replace the hazards by means of alternative technique of construction like engineering controls. To make effective control of hazard, the worker working in site must be trained with proper personal protective equipment.

The personal protective equipment like hard hat, gloves, feet ware are last line of defence and least effective while elimination is most effective control method.

III. METHODOLOGY

A. Research Design

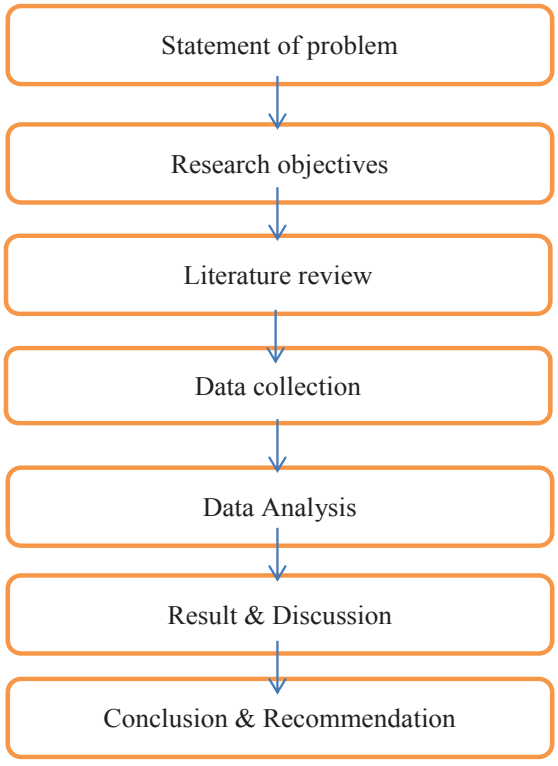

Figure 3. Research Design Flow Chart

Pre-field Work Phase

Design of questionnaire for respondents were developed in pre- field work phase.

Field Work Phase

Conduction of questionnaire survey and collection of primary data related to the hazard issues were done in the field. During questionnaire survey multiple responses from respondents are allowed.

Post Field Work Phase

Processing and analysis of data, illustrating the result, drawing conclusion and making necessary recommendation was done.

H. Study Area

The study area of this research focused on Kathmandu valley.

IV. RESULTS AND DISCUSSION

A. Physical hazards in construction project

The figure 4 shows the overall result of total respondents regarding physical hazards in construction projects. It reveals that 74% of respondents agreed noise as major physical hazard followed by 70% respondents with electric shock and vibration, 56% with lights, 52% with heat and humidity and 14% with radiation.

During case study of construction projects, it was found that noise; electric shock and vibration were main physical hazards. Actually the reason behind this was due to lack in proper care and precaution like no sound insulation, no wiring check while working in construction projects.

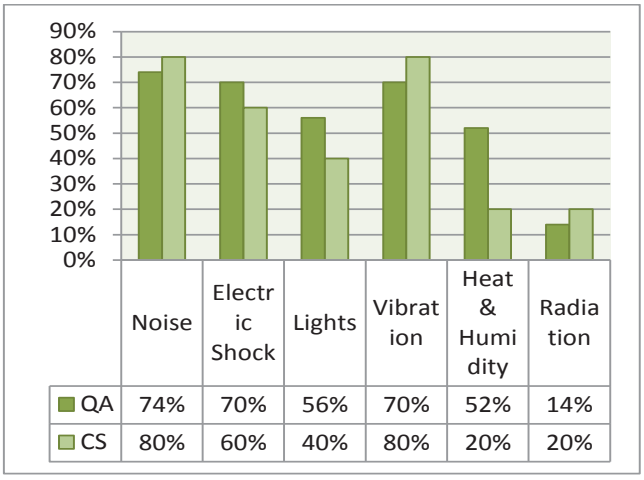

Figure 4 Physical Hazards

B. Chemical Hazards in Construction Projects

Figure 5 shows that among the respondents, 96% agreed that cement dust as major chemical hazard in the construction work. Similarly 92% agreed that sand dust as other chemical hazard and 12% agreed that toxic gases as chemical hazard that takes place in the construction work.

The result of this study also resembles with questionnaire result. Thus, prevention and control of dust at working area is essential. Sufficient amount of dust control measures like mask should be available in construction site. Similarly, water pouring system should be managed at dry working places to minimize dust.

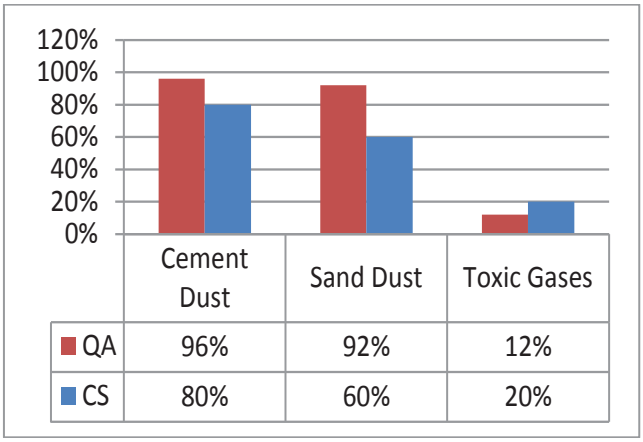

Figure 5 Chemical Hazards

C. Mechanical Hazards in Construction Projects

The figure 6 shows that among the respondents, 82% agreed that hit by equipment as major mechanical hazard in the construction works. Similarly, 60% agreed that defective equipment as other mechanical hazard and 44% agreed that untrained operator as another factor for mechanical hazard that hazards take place in the construction works.

Hit by equipment is the major mechanical hazard in building construction, so proper equipment handling with trained operator is essential to reduce mechanical hazards.

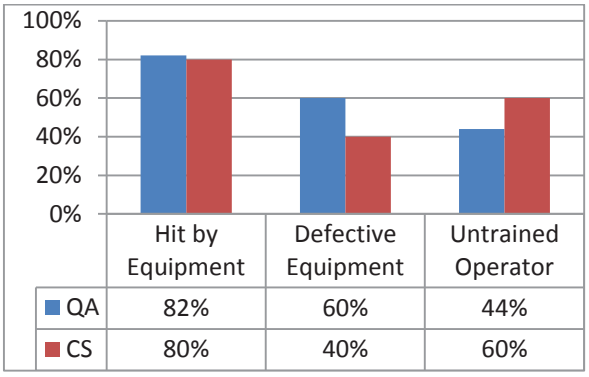

Figure 6 Mechanical Hazards

D. Psychological Hazards in Construction Projects

The figure 7 shows that among the respondents, 66% agreed that job dissatisfaction as major psychological hazard in the construction work. Similarly, 44% agreed that alcoholism and job insecurity as psychological hazard take place in their construction work.

Psychology of worker differs from each other. Every worker wants job security. High rate of worker turnover is a challenge in construction sector. So, job dissatisfaction and job insecurity are the common psychological hazards. But, according to this research, job dissatisfaction in construction projects is relatively high.

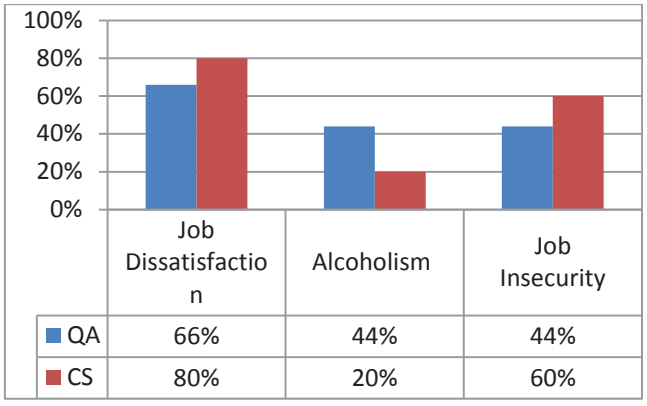

Figure 7 Psychological Hazards

E. Biological Hazards in Construction Projects

Figure 8 shows that among the respondents, 58% agreed that mosquito bite as major biological hazard and 20 % found that animal attack as another biological hazard and 16 % of respondents believed that poisonous plant as least biological hazard in the construction projects.

The result reveals that mosquito bite was the main biological hazard at construction site, so that prevention of mosquito by means of preventive and control measures like using pesticides, filling swampy areas are essential at construction sites.

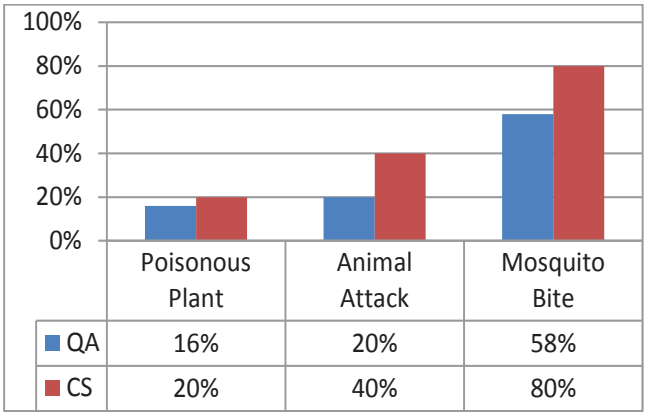

Figure 8 Biological Hazards

F. Physiological Hazards in Construction Projects

The figure 9 shows that among the respondents, 30% agreed that poor hearing as major physiological hazard, followed by 26 % agreed poor eye sight and 18% agreed old age and diseases as physiological hazards. These hazards take place in construction projects.

The manpower working in construction sites should be physically and mentally well. If workers are not fit for the work, this might lead to accident. Due to lack of monitoring, contractors' companies often hire old age person in work. But study results show the percentage is relatively low.

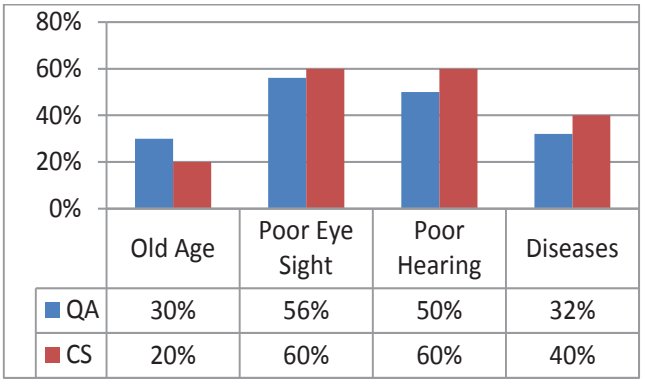

Figure 9 Physiological Hazards

V. CONCLUSION AND RECOMMENDATION

5.1 Conclusions

Based on result and discussion, it is concluded that noise (74%), both electric shock and vibrations (70%) are the major physical hazards. Cement (96%) and sand dust (92%) are major chemical hazards. Hit by equipment (82%) is major mechanical hazard and job dissatisfaction (66%) as major psychosocial hazard in construction projects.

From the result, it is concluded that construction industry is hazardous. Thus, documented and well systematic hazard identification system at every construction project is essential for the safe working environment at construction sites.

5.2 Recommendations

To maintain a safe work environment at site, commitment of a sincere and coordinated effort among all the parties involved in construction sector is needed. Contractors can contribute for the safety in workplace by adopting the following recommendations.

- Contractors should establish documented hazards identification methods for different construction activities, tools and equipment.
- Contractors should prioritize hazards elimination and substitution plan and procedures as first preventive and control measures.

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Study on Road Transportation and Their Status at Shadananda Municipality in Bhojpur

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Abstract

Road transport services assist in rising access with the rural-urban linkages. Road convenience can decrease remoteness, motivate collection, production and marketing activities, boost civic facilities and aid to technology transfer. Road construction has been seen to bring about distinguished enthusiasm and observable changes in rural life. Road structure is considered as "the infrastructure for infrastructure". Though, in the absence of notable standards and coherent guidelines, road construction is carried out in opposing manner resulting in random use and wastage of scarce funds. Municipal Transport Master Plan is arranged for gauging and scheduling the existing road transport structures and accommodations inside the municipality and the surrounding rural municipalities. This study is focused on the interventions of road networks within the municipality.

Keywords: *Infrastructure, Development, Network, Service, Connectivity*

I. Introduction

Quick development has led formation of rural spaces to urban areas in short period. The existence of things, amenities and facilities draw people from countryside areas to live in municipal areas. Even though, in past, rules were made to encourage people to reside on their native area due to random urbanization, recent study from economics and market theories support dense population over urban areas based upon accumulation and measure of financial prudence [3].

Transport services assist in mounting contact with the rural-urban connections. Road availability can shrink isolation, increase crop production and selling activities, inspire public services and support technology transfer. Road structure has been seen to bring about distinguished enthusiasm and observable changes in rural life. Road infrastructure is considered as the back- bone of the development [4]

II. Objectives of the study

The overall objective of study is to find out the present situation of road transportation of Shadananda Municipality. The detailed objectives are:

- Identify the inventory of all road networks.
- Identify the major road networks linking the municipality.
- Identify the interventions based on accessibility.

III. Study Area

Shadananda Municipality is located in the Bhojpur district in Koshi zone, Province number 1 of Nepal. It is surrounded on the west by Dobhane and Timma Village Development Committee (VDC). Kudak Kaule VDC and Nepaledanda VDC are the borders on the Northern part. On the south is bordered by Deurali, Sangpan, Boya and Helaucha VDC while on the east it shares boundary with Khadbari Municipality of Sankhuasava District [1]. It covers an area of 101.5 km². Road transport is major transport mode in Bhojpur district. An airport in district headquater Bhojpur serves domestic passengers from different cities of the country. But the closest airport to the Municipality is Tumlingtar Airport in Khadbari Municipality. Shadananda is one of the slowly developing municipalities of Nepal [5]. A neighbouring city Khandbari is on East (16 km). It is a segregated part of the district having easy access to Khandbari compared to the district headquarter Bhojpur [2].

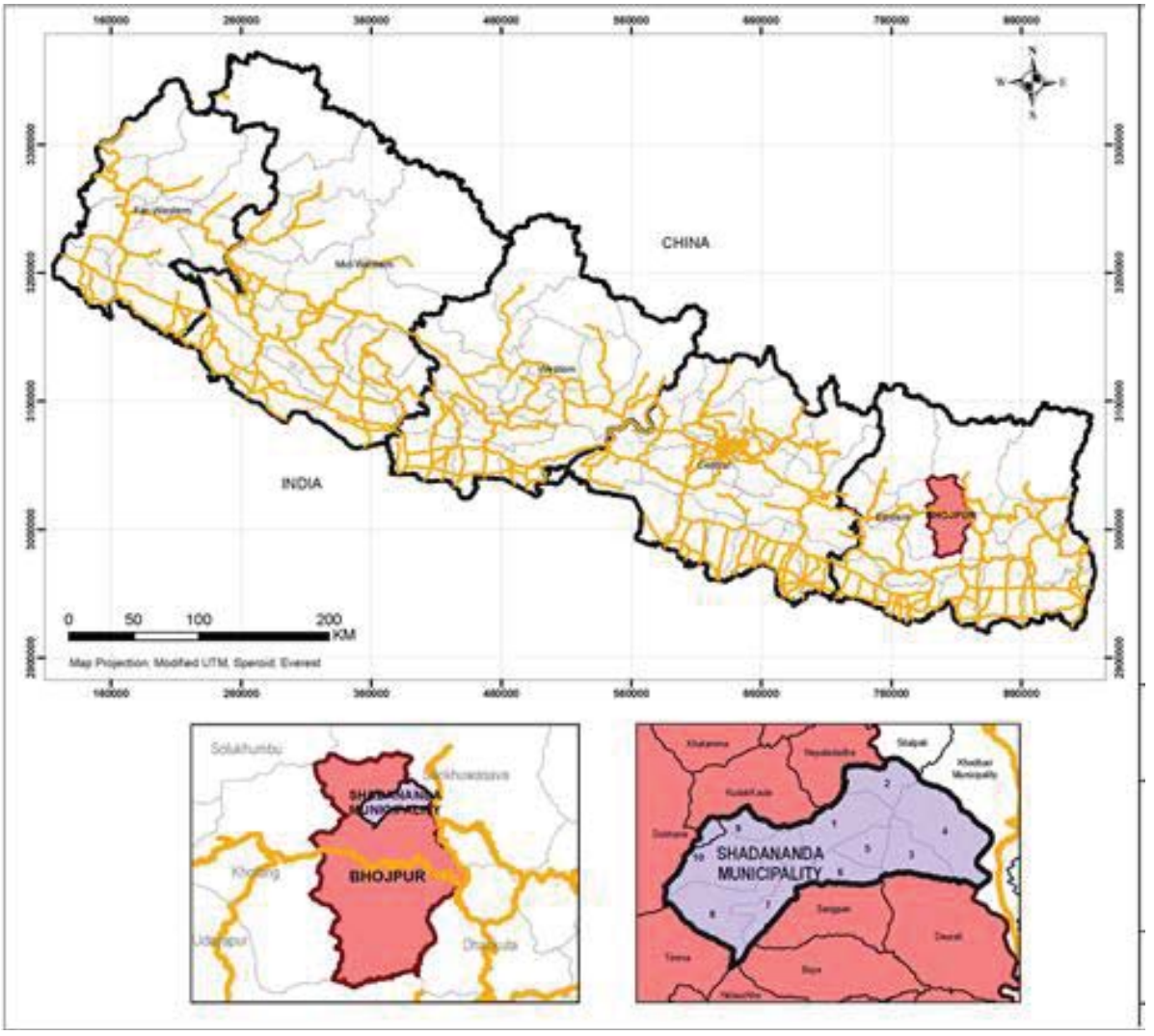


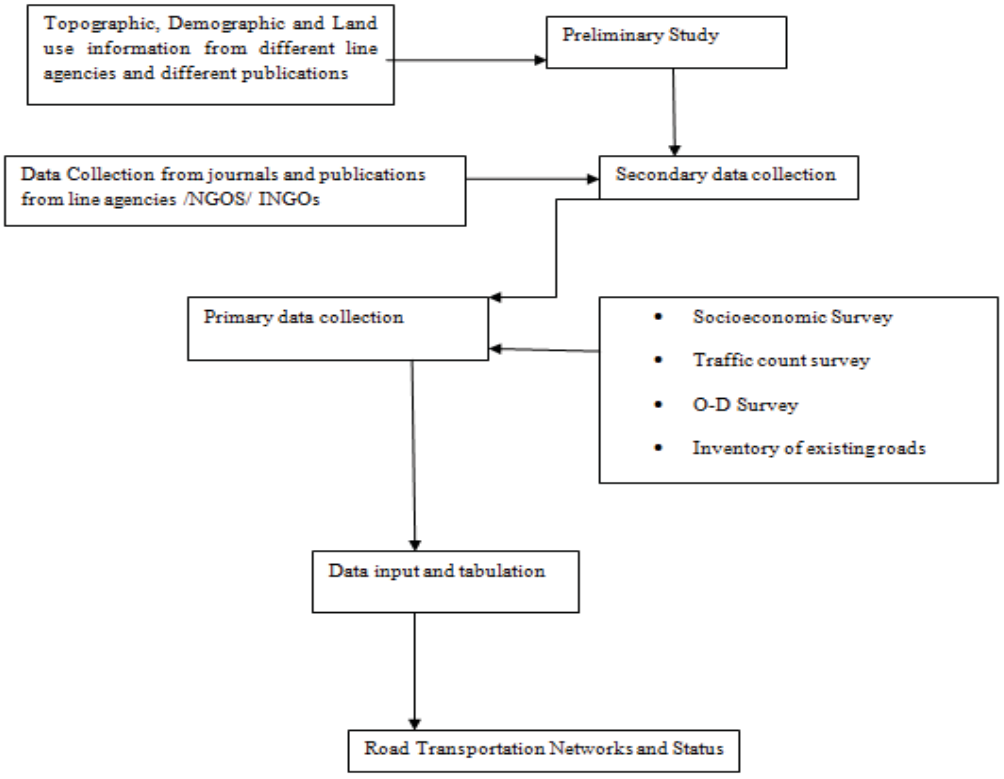
Fig1: Location map of Shadanada Municipality (Source: DDC, 2016)

IV. Methodological Framework

The study started with initial planning or desk study where basic background of municipality is studied with help of secondary data including census data, GIS data. Various field surveys have been carried out with objective of collecting primary data on transportation network, trip characteristics and service facilities. Along with the primary data, demands for various transportation projects (construction/upgrading/maintenance) have been obtained from each ward. Then, the hierarchy of road has been proposed and perspective plan of various interventions has been proposed and has been analysed based on available fund and finally physical and financial implementation plan of prioritized roads for MTMP period. The study has been come up with potential roads, that need immediate intervention and roads that need to be given consideration for effective future planning. All the above mentioned strategies adopted for data collection, processing and analysis are summarized in the following figure 2 [6].

Fig 2: Methodological Framework

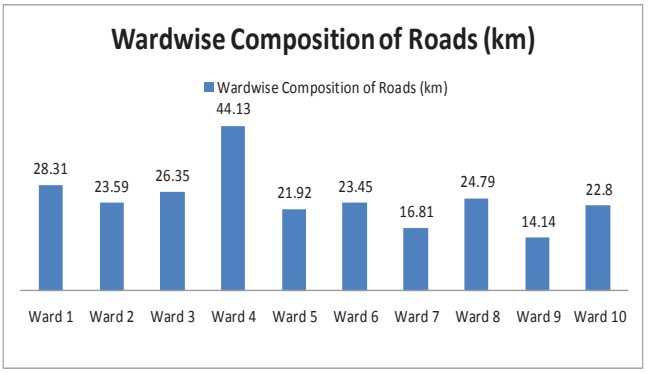
V. Data and Analysis



A. Road Inventory

Road inventory survey was done and details of all the roads and cross structures were collected. Total length of all the roads is 246.6 km of which nearly all 246.6 km is earthen.

Fig3: Inventory of roads ward-wise
(Source: Field Survey, 2016)



At present the road density is of about 2.44 km per square Km for the municipality. Similarly the road density per thousand populations is nearly 18.58km.

B. Traffic Vehicle Count

The traffic vehicle count was done at the following stations.

Table 1: Classified vehicle count stations

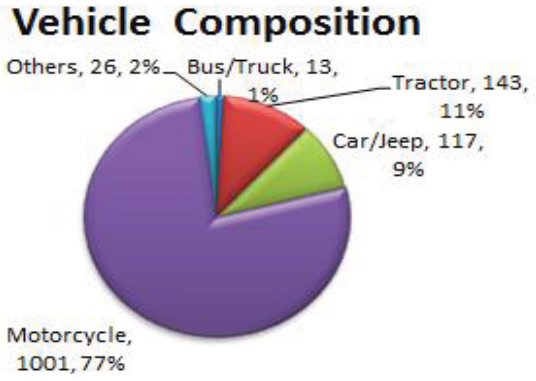
SN	Count station name	Location	Name of road Linkage
1	Dingla	Dingla	Dingla – Semeng Sadak
2	Udaypur	Udaypur	Dingla – Nepaledanda Sadak
3	Baidar Vanjyang	Baidar Vanjyang	Dingla – Bhojpur Sadak
4	Malbase	Malbase	Dingla – Khartamcha Sadak
5	Neupane Danda	Neupane Danda	Dingla – Lamsuwaghat Sadak

The composition of vehicle shows that the major vehicle that plies on the roads of Shadananda Municipality is motorcycle. Other than this, tractor has a share around 11%.

Fig 4: Vehicle Composition

(Source: Field Survey, 2016)

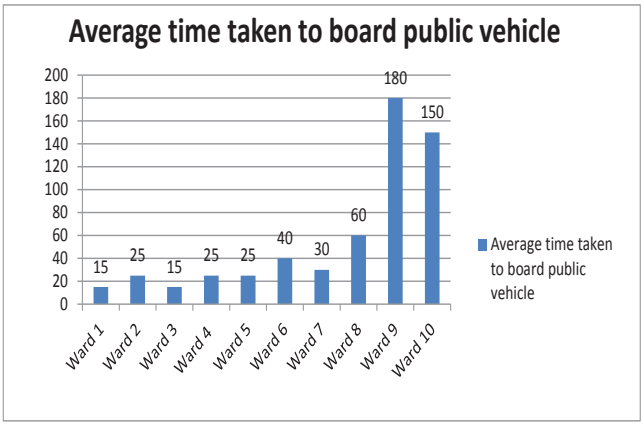
C. Accessibility and Mobility



Ward 9 and 10 suffers the most in terms of accessibility to public vehicles i.e. 180 minutes. The population of ward 1, 2, 3, 4 and 5 have easier access to public transportation service. The access to public vehicle on those wards with more time to reach the bus stop needs a consideration. The mobility of more accessible wards for public vehicles needs consideration as well. Average travel time to destination follows dissimilar trend when compared to time to bus park. Roughly people travel 30 minutes to get to their destination in other wards except ward 1 and 3 where people travel 15 minutes on average. The proportion of trips of specific length (in minutes) made by different means is shown in the figure 5.

Fig5: Accessibility time in minutes in ward-wise

(Source: Field Survey, 2016)



VI. Conclusion

Road transport is main transport mode for movement in Shadanda Municipality. Most of the rural roads are facilitated only through District Roads. Forest and bushes covered the 44.29%. Land used for residential and cultivation is 52.79%. There is high possibility for settlement development in the municipality. Entire roads are earthen with intermediate carriageway. The vehicle ownership shows that among the vehicles that ply along the roads, most are motorbikes with 25% share. All road inventories have been prepared for Shadanada Municipality having length 246.6km. The study has identified all the roads of the municipality, their status and interventions required. The study shows that majority of roads are narrow and needs maintenance and upgrading. The accessibility of roads has addressed most of the settlements but their mobility is very low. Access to services is hindered due to lack of reliable and safe transport facilities.

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Examining the Efficiency and Effectiveness of Alternative Material for the Interlocking Prefabricated Sandwich Panel

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ABSTRACT

The paper shows the effective utilization of non-degradable waste material like the hair of humans, Expanded Polystyrene Spheres (EPS), and rice husk fly ash to a final product Fiber-reinforced concrete panel. Concrete fracture, catastrophic failure, spalling of concrete and non-quake resistance, with the application of a load are major problems of the current scenario in the concrete world (Mindess, 2009). This paper tries to solve this type of problem by using the natural fibers and some additives which are under patient right. The researcher of this paper has developed a prefab panel which may be the substitute product of brick, ACC block, interlocking block, EPS panel, and local prefab panel. The utilization of industrial waste to usable products for construction is a major challenge that the researcher has taken. The paper shows that product can be made economical and able to reduce environmental challenges. Ingredients like human hair, EPS, chemical agent, cement, fly ash, water, and fiberboard are utilized in a certain time and fixed condition to complete the formation of the Fiber-reinforced concrete panel. The panel was found to have multi-function like a light in weight, fireproof, and flexibility which was its main USP (Unique Selling Point). The researcher thinks this product might change the perception of Nepalese customer, who thinks prefab as a costly and less strength product. Nepal political instability and dependent culture on foreign country shows an impossible possibility to use an artificial fiber and imported fly ash (ITC, 2017). This paper also presents the Nepalese market perception through the business model canvas, a business strategy that can be taken, hindrance, and the possibility to use human hair fiber, fly ash and recycled EPS to complete finished goods.

Keywords: *Fiber-reinforced concrete, compressive and flexural strength, prefab panel, sustainable environment*

1. INTRODUCTION

Increasing service loads, extreme loading events, and constant exposure to an ever-changing ambient environment are just a few reasons why civil structures, over extended service periods, degrade and ultimately become structural deficient (Ellingwood, 2005). The 1980s saw the advent of more cost-effective means to manufacture advanced fiber-reinforced polymer (FRP) composite materials; making the use of such materials more suitable for construction purposes. By the late 1980s, numerous researchers began investigating the possibilities of using FRPs to strengthen reinforced concrete structures. With excellent corrosion resistance, high strength-to-weight ratio, and stiffness-to-weight ratio, externally bonded FRP composites provided time and strength efficient means to strengthen reinforced concrete (RC) structures which latterly synonym into Fiber-reinforced concrete (Haber, 2007); (Bakis et al., 2002). Fiber-reinforced Concrete (FRC) was patented and developed by French gardener Joseph Monier. The concept of using fibers as reinforcement is not new, but in our country Nepal, this concept is new and no any research work has been done in this field. According to Gupta & Sharma (2018), fibers have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. Typically this type of mechanism can be seen in Bardia and Kailali of Nepal, where people are using hair, straw, and husk for making their home. In the 1900s, asbestos fibers were used in concrete, and in the 1950s the concept of composite materials came into but due to health risk asbestos was discouraged. New materials like steel, glass and synthetic fibers replaced asbestos for reinforcement. FRC consists of composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibers. Fibers include steel fibers, glass fibers, synthetic fibers, and natural fibers. Recently, organic and synthetic fibers such as acrylic, aramid, carbon, nylon, polyester, polyethylene, and polypropylene have also been used (McIntyre, 2004).

Concrete is weak in tension; to overcome this deficiency, human hair can be the best option to increase the strength of concrete. Ganiron (2014) presented the effects of human hair additives in compressive strength of asphalt cement mixture as a potential binder in road pavement. It stated that the elastic property of the hair fiber-reinforcement in an asphalt pavement may produce better stand on traffic loading i.e., increases the strength by the same fundamental mechanism of transferring the high-intensity forces imparted at the surface by the wheel loads to lower levels than the subgrade can accommodate without deforming. According to Batebi et al., (2013) the main element of hair composition is keratin which are proteins with long chains of amino acids that form the cytoskeleton of all cells of the outer shell. Several investigations stated that sulphur is the main reason for strength hair cords in front of disintegration in the face of environmental stress and these Sulphur compounds are linked with amino acids. Sulphur in amino acid molecules is adjacent to keratin protein so it forms a di-sulfide chemical chain (chains are very strong and resistant to breakage). These chains are very resistance to acids di-sulfide performance, but in alkaline solutions, they can be decomposed (Brosnan, 2014). As the alkaline environment loses the hair cords, we must be aware not to take hair cords in alkaline solutions. The outer layer of hair is called "Cuticle" which is much like tree trunks and bumps (Moll & Langbein, 2008). Hair diameter is 50 to 100 micrometers. In this study, hairs of 80 micrometers were used and bumps on hairs were of nano size. These bumps help to lock cement mortar.

2. OBJECTIVE OF THE STUDY

2.1 Main objective

The main objective of this paper was to see the feasibility of light weight ductile concrete panel by using a natural fiber like human hair, fly ash, EPS, cement and chemical additives with certain time of addition and required quantity.

2.2 Specific objectives

1) To investigate the human hair generation from Madhyapur Thimi Municipality and check the demand and supply.
2) To examine the compressive strength, flexural strength, sound test and fire test of prefabricated sandwich panel.
3) To analysis the business viability of prefab panel in Nepalese market.
4) To compare the prefabricated sandwich panel with other substitute construction material.

3. METHODOLOGY

Two research methods were focused for successful completion of this project. They were:

- Survey Method
- Experimental Method

3.1 Survey Method

The research was done to find out the total amount of hair collection from Ward No 3, 4, 5 and 6 in Madhyapur Thimi Municipality. Around 6,771 males and 6,376 females with 2,968 households are living over there (CBS, 2011). The survey was carried out in two categories, one in beauty parlor and one in the male saloon. Moreover, a questionnaire survey was carried out with the owner of those parlors and saloons. From that survey, 10 male saloons and 7 beauty parlors are taken down. After the evaluation of waste human hair in the saloon, it was observed that the hair sample was too dusty and needed more treatment than that of beauty parlors. Mixing of beards and hairs increases the complexity of processing of the hairs. The average amount of hair collection was calculated as:

Average Amount of Hair obtained =

$$\frac{\text{Total Weight of Hair Obtained from Parlor}}{\text{No of parlor}}$$

= 3.475kg

Average Amount of Hair obtained =

$$\frac{\text{Total Weight of Hair Obtained from Saloon}}{\text{No of saloon}}$$

= 10.799kg

A total of 3.475kg from one beauty parlor with 15% wastage and 10.799kg from one saloon with 35% wastage were found. Waste like beard and some unfluctuating disperse hair comes from saloon so we have taken maximum wastes percentage than that of beauty parlor obtained from 4 wards of Madhyapur Thimi Municipality. The researcher of this paper found 1,091kg of hair from the survey done on Aug 4, 2017, whereby calculation, it is enough to develop 2,100 numbers of prefab board. If (7'*2') panel of NRs 4,172 is taken then it could generate a rough number of NRs. 8,761,200. This survey shows there will be enough material and it is feasible to implement the project.

3.1 Experimental Method

3.2.1 Material Used

Portland cement with 43 grade and specific gravity of 3.15 was used. The sand used for the experiment was locally procured and sieved through 4.75mm sieve to remove any particles greater than 4.75mm and was then washed to remove dust. As for the testing for the flexural test, sand was sieved from 1.7mm sieve. The coarse aggregate used in this experiment was 25mm sieve and was crushed in angular shape. The aggregates are made free from dust before being used in the concrete. Hair of diameter 80~120 μm with a length of ongoing patented length was also used.

Table1: Hair specifications (Moll & Langbein, 2008)

Property	Value
Hair diameter	80 to 120 μm
Hair length	60mm** used for experiment
Aspect ratio	500 – 600

Water used in the experiment was clean and safe for mixing as well as the curing of concrete specimens. Rice husk used was an agro-industrial by-product with high silica content. With proper incineration and controlled burning, this husk becomes a pozzolanic material that can be used for replacement of cement at various percentages of dosage (Alireza et al., 2017). It was oven-dried and sieve in 0.075mm sieve for making the product. Expanded polystyrene is a polymer resin obtained by heating and curing the polystyrene resin to generate foams. Expanded polystyrene is white, light in weight, and has superior water resistance, thermal insulation, sound absorption and buffering properties. Its cells are not interconnected, so heat cannot pass through it easily, making it a great insulator. The mix design process was done which is a process of selecting suitable ingredients of concrete and determining their relative amounts needed to produce concrete of the required, strength, durability, and workability as economically as possible. In this study, variation of mixing has been done to achieve the strength.

3.2.2 Compressive strength test (on cubes):

The compressive strength of concrete is its ability to resist a crushing force. It is the ratio of load at the failure to the surface area of concrete specimen. The compressive strength test is the most common test

conducted on hardened concrete as it is an easy test to perform and also most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The compression test must be carried out on specimens cubical in shape of the size 150 × 150 ×150 mm (Jiang et al., 2017). The results from the compression test are obtained from the destructive test and non-destructive test (Schmidt Hammer).

Cube compressive strength (f_{ck}) in MPa, $\sigma = \frac{P}{A}$

Where,

P= Cube compression load in Newton (N)

A= Area of the face of cube on which load is applied (i.e., 150*150=22500 mm^2)

3.2.3 Flexural strength test

A flexural test is the most common procedure used to measure the tensile strength of concrete. Although concrete is not designed to resist direct tension, the knowledge of tensile strength is of importance in estimating the load under which cracking develops. The test is very useful especially in relation to the design of road slabs and runways because the flexure tension is a critical factor in these cases. The system of loading used in finding out the flexural tension is Third-point Loading Method (Mallick et al., 2014).

The modulus of rupture is calculated using the formula

$$\sigma_b = \frac{PL}{bd^2}$$

Where,

P= Breaking load in N at which specimen fails

L= Length in mm of the span on which the specimen is supported (600)

B= measured width in mm of the specimen (150)

d= measured depth in mm of the specimen at point of failure (150)

3.2.4 Sound Test

The researcher of this paper made a homemade incubator, which was enclosed by close clear glass. A clear glass of size (15”*6”*6”) was made by enclosing with hot glue and silica with 100W hot melt glue gun was used to make air gap box. The 6”*6”*4” specimen was placed into the glass box. The intensity of sound was measured by decibel (dB). Sound Meter Apps was used to note down the maximum and minimum decibel (dB) and a stopwatch was used with 2:20sec targeted time for both of specimen.

3.2.5 Fire Test

Fire test was done to check the resistance to fire. As recommended procedure done by Lukaszewska et al. (2010), surface test was done where researcher of this paper compared with local prefab panel. The main doubt was whether the hair and EPS will burn in fire or it will capture the fire but the result was positive where the material bounded by the cementations material and it is impossible to catch fire. Three tests were done to check the prefab board. 4 hours continuous fire was given in specimen so that comparison between local prefab and our panel can be made. After the evaluation, we have found that the local panel was separated from internal EPS bonding but in case of our panel, the result was completely different. We found that the surface of prefab panel has little crack. Surface spread of flame test was also done by using the petroleum product but in this test, no change was found in both prefab panels.

4. RESULTS

4.1 Compressive strength test

A test was done in RCC lab of Pokhara Engineering College (PEC), Phirke, Pokhara on 2073/12/15 (28 March, 2017) with an experiment ratio of 1:1:2 with sample name R1, R2, and R3. The study was done to know whether the addition of human hair will improve the strength of concrete. The study found that the addition of human hair can improve an average of 5% of strength than normal concrete.

Fig1: Hair sample test with addition of hair in concrete on 2073/12/15

4.2 Flexural Strength Test

A test was done in RCC lab of Nepal Engineering College *(nec)*, on 2074/4/14 (8 August, 2017), with experiment ratio of 1:2:4 with sample name (sample 1, sample 2, and sample 3) with water-cement ratio of 0.6, 0.8 in normal plain cement concrete, and 0.8 additive hair concrete. The study was done to know whether the addition of hair might increase flexural strength or not. The modulus of elasticity of hair added concrete was found to be 3.048 N/mm2 which shows there is increase of 17% strength than that of normal concrete with w/c ratio of 0.6 and 13% than that of normal concrete with w/c ratio of 0.8.

Table 2: Result for Flexural strength test in addition of hair

Specification	Date of testing	bd^2	Breaking Load (P)	Modulus of Rupture, $\sigma_b = \frac{PL}{bd^2}$
Sample 1	2074/4/22	3375000	1498.98 kg	2.61 N/ mm^2
Sample 2	2074/4/22	3375000	1548.95 kg	2.70 N/ mm^2
Sample 3	2074/4/22	3375000	1748.81 kg	3.048 N/ mm^2

Fig 2: Flexural strength test of three point loading method

4.3 Schmidt Hammer test or rebound Hammer test

This test was done in RCC lab of Nepal Engineering College (nec), on 2074/4/14 (29 July, 2017), with different sample size as sample 1 (10"*10"*4"), sample 2 (10"*10"*2"), and sample 3 (10"*10"*2" inside pipe hollow). The rebound hammer test is a non-destructive test from where the researcher of this paper expects to get the required compressive and flexural strength of the sample without deformation of the material. In sample 1, the rebound number was found 21.22 which is less than 16% of that of sample 2 and from calculation of using graph we get 60% compressive strength of 8.4 N/mm2 which was 17% less compressive strength that of sample 2 and flexural strength of 2.02 N/mm2 which was 15.34% less than that of sample 2. The compressive strength of pipe hollow prefab panel (sample 3) was 11.4 N/mm2 and compressive strength of 2.36 N/mm2 with a rebound number of 20.11. This study shows that the pipe hollow prefab panel is stronger and efficient than that of normal prefab panel.

Table 3: Result of Schmidt hammer test

Specimen	Rebound Number	Weight	60% compressive strength	Flexural strength $(0.7\sqrt{fck})$
Sample 1	21.22	4.348	8.4 N/mm^2	2.02 N/mm^2
Sample 2	24.778	2.420	11.1 N/mm^2	2.33 N/mm^2
Sample 3	20.11	3.044	11.4 N/mm^2	2.36 N/mm^2

Fig 3 : Rebound hammer and Flexural test sample

4.4 Sound Testing

Sound testing was done by comparing the sound measurement between local prefab panel and our prefabricated prefab panel in-terms of decibel (dB). The time duration to check was 2.20sec with the utilization of sound meter app in a closed glass box. The mean dB of our prefab panel was 50 dB which was 4% more sound resistance than that of locally available prefab panel.

Table 4: Result of sound test

Panel	Time	Lowest dB	Highest dB	Mean dB
Local Prefab panel	02:20sec	17dB	83dB	52dB
Our Prefab Panel	02:20sec	17dB	84dB	50dB

Fig 4: Fire and sound test

5. BUSINESS STRATEGY

There must be feasibility and viability of any project before taking it to the field. Business strategy is also one of the measurements which will show the risk factor of the project and future market perception of the customer. To see the real picture of the project through a business plan, this paper evaluates some business strategy terms. The analysis will help to find out the strategies, analytical and decision-support tools that can create value for the customers. The analysis focuses on documentation plan on how a project is setting out to achieve their goals. A business strategy contains a number of key principles that outlines how a project will go about attaining these goals. For example, it will explain how to deal with your competitors, look at the needs and expectations of customers, and will examine the long term growth and sustainability of the project. Business strategy tries to remedy the weaknesses so that the project doesn't trip up and suffer their impact too greatly. Strategies look at these future risks and help develop ways in which they can overcome these obstacles. A well-defined business strategy will offer a guide on how a project is performing internally. It will also guide on how the project is performing against competition and what are needed to stay relevant in the future. Basically this paper also addresses the issues such as, customer retention, resources and project expansion in the near future of prefab panel.

5.1 Business Model Canvas

The nine factors were used to measure the business model canvas as mentioned by Michal Porter. The business model canvas shows a clear picture of the business after the production of material and what the researcher will try to do in the future to meet the project objective. The first factor is the customer segment which means who will be the customer after the production of the prefab panel. The customer will be an executive member of the company, experienced engineers and high class of contractors. The owners are less informed than that of consultant and contractor so we haven't focused on them. Second, value proposition which means what value we are trying to give them to attach them with us. We are delivering a high strength concrete lightweight prefab panel and solving the quality-related problems of customer. The main thing is satisfying their needs, fast installation, risk reduction and cost reduction of a product. Customer relationships have a key role in business. We are focusing on long term relationships with maintenance-free service for our customers where we focus on three V's (valued customer, value proposition and value network). The customer segment will be the people working in the construction line, majorly focusing on consultant and experienced contractors. For key activities to get the desired material, we need to focus

on the design, manufacturing, delivery and quality control section. The channels, we are using will be both physical and virtual channels like newspapers, TV and YouTube advertisements. The key resources needed for us will be the specialized machines and equipment to provide effective and efficient work value to customers. Equipment like air dry segregator, 50 kg kneaded machine and some advance oven dryer will be needed. To support our business there will be a need for key partners or stakeholders. There will be a need for strategic alliances with NEA, FCAN, and the owner of crusher factories. The cost structure for the project is majorly investment on assets at first stage and production cost at the second stage. The revenue streams of the project are from the selling of the finished product implementing a manufacturing model by providing a product containing a value with lightweight, flexible and high-quality products.

5.2 PESTLE Analysis

PESTLE Analysis is a framework for assessing the key features of the external environment facing a project. The purpose of a PESTLE analysis is to identify all of the various external political, economic, social, technological, legal and environmental factors that might affect a project. For instance, a new prefab panel factory might create a problem like chemical issue in river breaking local bylaws which can be found from a PESTLE analysis. This might prompt the factory to institute a policy on environmental rules and regulation. Political factors will be fluctuation in laws, rules, and change in bylaws with the policy in 7 provinces. Economy factors can cause by labor and energy costs. The fluctuation in the price of plants, equipment and construction goods will also be a major economic factor for our project. The social factor may cause in the future may be continuous holiday by provincial rules and local strikes. The technological factor will be emerging technologies that may be competitive with our projects like new technology like interlocking brick and polystyrene sandwich panel. The legal factor that may cause difficulty in implementation will be trade union culture and 8-hour schedule work which will be a major factor to control human skills. The environmental factor may be challenging to control carbon emission and regulate the CO_2 emission of our panel between 90gm.

5.3 SWOT Analysis

SWOT analysis is a strategic analytical and decision-support tool that highlights the bases where businesses can create value for their customers. SWOT-analysis helps a project to find out the competitive strength and the nature of its external and internal environment. SWOT means strength, weakness, opportunities, and threats of the project. Strengths and weaknesses are related to the internal issue of the project and opportunities and threats are related to the external issue of the project. The strength of the project is requirement of less amount of skilled manpower. The product has more strength and less cost than that of the local prefab panel. It also has more quality and finishing than that of local prefab panel. A major strength is that all raw material needed to build a prefab panel are available in-country and flexibility of the product, so can be used for several times. The weakness of the product is that it is costly than that of normal brick and need of well-equipped factory and the major thing is necessity to change the perception of Nepalese people about the prefab panel. The opportunities for the project are rising market in Nepal and slightly changing consumer preference and government preference for the industry. Every business has a threat and the main threat of the project is the emergence of new competitors, idea circulation in negative form and migration of skilled manpower.

6. ANALAYSIS AND DISCUSSION

Fig 5: Sketch up design of Our Panel required for 1369 sq.ft

The researcher of this paper has compared the normal brick and locally available prefab panel. A calculation has been done to make a clear vision and measured it through various factors. Here in this paper, researcher has focus on product but not in structure of development. We assumed the size of area land as 1369 sq. ft. which equals to 4 anna. The number of normal prefab panels of size (7'*2.5') will be 76 no's but our panel of size (7'*2') will be of 82 no's. The requirement of brick for this project will be 9815 no's. The cost of the local prefab with 90mm breadth at the rate of NRs 450 per sq ft will be NRs 513000 which is 42% higher than that of brickwork for the project and 31% higher than that of our panel (4' breadth with the rate of NRs 298 per sq ft). It suggests that our panel will be 9% expensive than that of brickwork.

6.1 Comparison with substitute product

The comparison shows the main difference in terms of technical view. The researcher has chosen five different substitute materials to know the different qualities and strengths of the product. All result was found by an experiment done in the different lab of Nepal Engineering College *(nec)*.

6.1.1 Minimum compressive strength

The five different samples were tested in the Nepal Engineering College *(nec)* RCC lab. The result for minimum compressive strength of our panel of sample size(6"*6"*4") was found 10 N/mm2 which is 45% more than interlocking hollow brick of sample size (7"*6"*4"), 53% more than local prefab panel of sample size of (6"*6"*4"), 70% more than that of AAC block of sample size (26"*8"*8") and 4% more than that of normal brick of sample size (9"*4"*2").

6.1.2 Fire resistance

The sample was tested in 2 different places. The fire resistance of our panel of sample size (6"*6"*4") was found in category of class A and resists heat up to 4 hours where no changes were seen. The local prefab panel of sample size (6"*6"*4") was found some deformation in the sample after 4 hours.

6.1.3 Dry density

The five different samples were tested in the Nepal Engineering College Hydrology lab. The result for the minimum compressive strength of our panel of sample size (6"*6"*4") was found 721kg/m3 which was able to float on water. The dry density for interlocking was found to be 1600 kg/m3 and AAC block of sample size (7"*6"*4") was found to be 650 kg/m3, local prefab panel of sample size of (6"*6"*4") had 750 kg/m3 and normal brick of sample size (9"*4"*2") had 1800 kg/m3.

7. CONCLUSION

From this research, survey and experimental work, we have concluded that addition of human hair fibers makes concrete more homogeneous and isotropic and it will transform from brittle to more ductile material. The researcher of this paper concluded that by the collection of human hair from a certain local area, the actual requirement can be fulfilled. Researchers concluded that by the addition of human hair, there is an increase of 12.88% flexural strength than that of normal concrete. In the case of prefab panel, compared with our panel, it is found to have double compressive strength than that of existing prefab panel.. In-case of sound and fire test, our panel was more resistant than that of normal available prefab Panel. In-case of cost comparison, our prefab panel is 31% cheap than that of other prefab panel and 9% costly than that of brickwork. Our prefab panel is energy-saving, flexible, lightweight, well finished and environmental friendly. It can be used in various building additions or renovations for interior wall, exterior wall, roof and floor on steel or in the concrete structure. As a number of the experiment was done in various sizes, we can provide several sizes of the panel as per future customer requirements. We have found that microcracks form in concrete was arrested by the fibers. Thus improved strength and ductility, and under loading, reinforced fibers will stretch more than concrete. The research concluded that there will be a remarkable increment in properties of concrete such as compressive strength, modulus of elasticity, flexural strength and impact resistance, according to the exact ratio addition of rice husk ash, human hair, EPS, cement, and chemical additive.

Note: Our research based on panel size as available in market so we used random sizes for test in lab. We did not use concrete test as per standard cube size. Again our unit is based on regular using unit in practice of construction field in Nepal.

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Current Status of Assistive Technology for AAC for People with Autism Spectrum Disorders in Nepal

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Abstract

This paper is focussed on the current status of usage of assistive technology for augmentative and alternative communication (AAC) for the person with autism spectrum disorder (ASD) in Nepal. ASD is marked by core features including impaired social communication, and restrictive and repetitive behaviours and interest (Diagnostic and Statistical Manual of Mental Disorders 5th Edition: DSM 5). AAC is a specific type of assistive technology that can benefit person with autism (PWA) of all ages by promoting independence, expanding communication and increasing social interactions. The major objective of this paper is to analyse the current status of AAC assistive technology for person with autism (PWA) in Nepal. The paper first analysed the assistive technology in general and then is inclined toward the current status of its development in Nepal. The research methodology of the paper included interviews and discussion sessions. The data were further reviewed based on the reports from the relevant organizations and learning outcomes from different autism related trainings and workshops. The authors visited various organizations related to autism in Nepal, Autism Care Nepal Society (ACNS) and Special School for Disability and Rehabilitation Center (SSDRC) and carried out interviews and discussions and also participated in various autism related training sessions and workshops. The findings of this paper showed that despite the high prevalence rate of autism, there is very less progress in managing ASD in Nepal and that the usage of assistive devices is limited to low tech only.

Keywords – *Autism spectrum disorder, assistive technology, ACNS, SSDRC, AAC.*

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental disorder characterized by deficits in social interaction and communication accompanied by repetitive and

restricted patterns of behaviour and interest [1]. Autism affects how an individual communicates and relates to other people. It is a spectrum disorder which means it has many forms that affect people in a variety of ways and in varying degrees. Each person's experience with autism presents unique challenges as well as strengths, which define the type of support one needs to lead a fulfilling life.

Although autism can be reliably diagnosed as early as two years of development, most children are diagnosed at much later years [2]. Autism affects all ethnic and socioeconomic groups. Report shows minority groups tend to be diagnosed later and less often [3]. Early intervention provides the best opportunity to support positive developmental outcomes and deliver life-long benefits. However, there is no medical detection for autism.

Autism diagnosis involves three levels of categorization with Level 1: Requiring support; Level 2: Requiring substantial support; and Level 3: Requiring very substantial support [1]. These severity levels are assigned to two domains of autism symptoms which includes impairment in social function and restrictive, repetitive behaviours. Autism diagnosis, including the levels of severity, can help specialists and professionals to provide the right treatment and support.

A. Statistics

According to Centers for Disease Control and Prevention (CDC), 1 in 54 children is diagnosed with ASD with boys four times more likely to be diagnosed than girls [4]. An estimated 1–2% of children worldwide lie on the autism spectrum, with approximately 52 million autistic individuals across the globe.

Figure 1 presents the graphical overview of the rise in the prevalence of autism in the United States of America over the years (2008-2014), as reported by the CDC [5]. The prevalence estimates presented are for four years prior to the reported date (for example, 2018 figures are from 2014). The data shows 1 in 59 children in 2014 had a diagnosis of ASD by the age of 8, which is 15 percent higher compared to 2012.

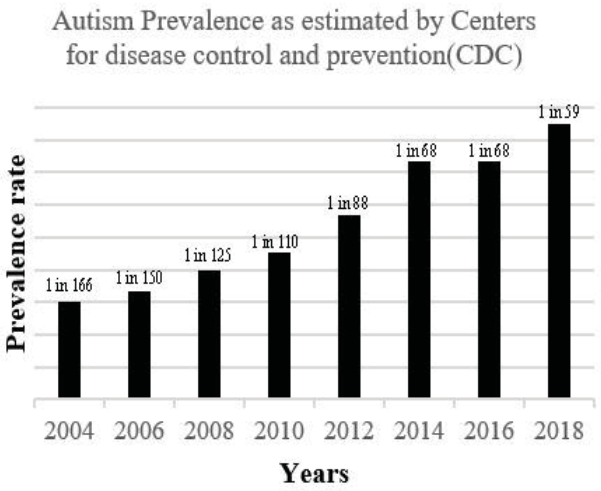

Figure 1 Autism prevalence estimated by CDC

In the context of Nepal, there isn't exact data regarding the prevalence of ASD. A survey was conducted by Michelle Heys in 2018 [6] using the Nepali- version of an autism screening tool (Autism Quotient-10) in 4098, rural children aged between 9–13 years. Fourteen children scored > 6 out of 10, indicative of elevated autistic symptomatology, of which 13 also screened positive for disability. The study estimated the prevalence of autism at 3 per 1000 (95% confidence interval 2–5 in 1000) children considering that AQ-10 screening tool is as sensitive and specific in the Nepali population as it is in the United Kingdom.

Very few autism organizations work in Nepal. Of these, the Autism Care Nepal Society (ACNS), founded on April 2, 2008, is Nepal's only active autism organization run by passionate parents, caring for people with autism [7]. The organization has been providing various kind of services related to autism like counselling, assessment and diagnosis, parent and child training program, therapies, teacher's training etc. The other establishments are Aarambha pre-primary school and Aakaar vocational unit.

Based on the recent annual report (2075-2076) of ACNS [8], the total number of cases diagnosed at ACNS since its establishment till July of 2019 is 726. The data is shown graphically in Figure 2. Within the fiscal year 2075/76, the total number of autism cases diagnosed at ACNS is 118 with a female to male ration of around 1/8.

Another actively involved organization is a Special School for Disability and Rehabilitation Centre (SSDRC) [9]. It is a non-governmental and non-profit organisation established it in October 2010 to support children with ASD from deprived family background to provide special education, therapeutic and related services. Started with two children with autism, the school currently has 45 autistic students with different severity level with age varying from 3 to 25 years. The school is run with the help of 26 staffs. To date, SSDRC has provided different facilities to 280 different autistic individuals. Of them, 36 children were admitted to regular school.

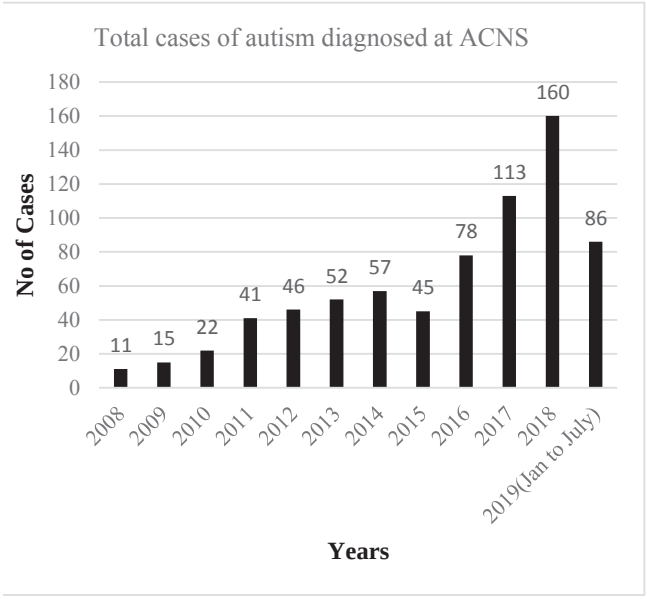

Figure 2 Total cases of autism diagnosed at ACNS

B. Treatment

Autism is a lifelong condition, but early interventions, treatment and therapy can enhance person's quality of life [10]. Every child or adult with autism has unique strengths and challenges and so there is no generalized approach to autism treatment and intervention [11]. Each autism intervention or treatment plan should be tailored to address the person's specific needs. Intervention can involve behavioural treatments, medicines or both [12]. Many people with autism have additional medical conditions such as sleep disturbance, seizures and gastrointestinal distress [13]. Addressing these conditions can improve attention, learning and related behaviours. Although there is no medication specifically for autism, doctors often diagnose other conditions in autistic people. A range of medications can help reduce the symptoms like irritability, aggression, obsessive behaviour, hyperactivity, impulsivity, attention deficits, mood changes, anxiety problems [13].

Educational and behavioural therapies can help autistic people, especially younger children [14][15]. These interventions can focus on particular areas that the child is finding challenging. For example, a specialized therapist may aim to improve social and language skills in a classroom, which can help an autistic child maintain conversations with others and develop the skills necessary to live independently. Some forms of therapy will involve family members or others who have regular contact with the child [16]. Participating in therapy can help family members and caregivers understand the condition and learn constructive ways to provide support.

According to the Agency of Healthcare Research and Quality (AHRQ) under the United States Department of Health and Human Services [17], ASD treatments categorized into four groups.

1. Behaviour programs
2. Education and learning programs
3. Medications
4. Other treatments and therapies

C. Assistive technology and AAC

According to the Assistive Technology Act of 2004 [18], an assistive technology device means any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities. Persons with ASD, by definition of their diagnosis, typically have difficulties with expressing themselves through spoken and written language. In severe cases, they may not be speaking at all and fail to understand spoken language, despite no underlying hearing problems. This can even be compounded by motor control issues that make the physical act of speaking difficult [19]. However, it's incorrect to assume that non-speaking PWAs cannot communicate or speak. As such, assistive devices as means of AAC can play an important role to support and enhance communication for them, regardless of their speech ability.

Augmentative and alternative communication (AAC) is a specific type of assistive technology that can benefit people with autism of all ages by promoting independence, expanding communication, and increasing social interactions. AAC includes all of the ways of sharing ideas and feelings without talking and one often uses all forms of AAC every day like using facial expressions or gestures instead of talking, writing a note and passing it to a friend or co-worker etc. However, people with severe speech or language problems may have to rely on AAC to help them communicate. Some may need it all of the time while others may need it only for longer sentences or to communicate with people they don't know well.

AAC uses a variety of techniques and tools, like board-markers, manual signs, gestures, line drawings, speech-generating devices, eye-gaze etc, to help the individual express their feelings, needs and ideas. It is augmentative when is used as a reinforcement for existing speech, and alternative when is used in place of speech that is absent or not functional. Also, this can be temporary or permanent depending upon whether this has been used during the intensive care only, or is used as some form of AAC throughout the lifetime. [20]

II. Assistive technology as Means of AAC for ASD

Various assistive technologies as means of AAC for ASD have been developed to promote the communicative skills of people with ASD. In recent years publications on the use of assistive technologies including the areas of ASD detection, assessment, diagnosis, intervention, training, learning, environment control, communication, mobility, and access have increased significantly.

The assistive technology for ASD has been broadly categorized into three groups [21]:

1. Low tech assistive technology
2. Mid tech assistive technology
3. High tech assistive technology

Low tech assistive technology are visual support strategies which do not include any type of electronic equipment and are usually low cost and easy to use. These includes dry erase boards, clipboards, 3-ring binders, manila file folders, photo albums, laminated photographs, highlight tape etc. Mid tech assistive are battery operated devices or the ones using simple electronic devices and often requiring limited advancements in technology. With the growth in the technology, this has become the least common form of technology being used. These include tape recorder, Language Master, overhead projector, timers, calculators, and simple voice output devices.

High tech assistive technology includes high-end electronic equipment and implements complex technological support strategies. These are comparatively of higher cost. These includes video cameras, computers and adaptive hardware, complex voice output devices etc. With the advancement in technology these are gaining higher popularity.

A. Current practices

The use of technology-based interventions for improving ASD core deficits has been growing in popularity, and a variety of technologies such as mobile computing, virtual reality or robotics have been introduced [22]. Virtual reality (VR) based training have also been found to be useful to improve the social skills [23]. A significant increase in social cognitive measures of theory of mind and emotion recognition was observed during a VR based social cognitive intervention, conducted among the eight adults with high functioning autism.

Visual Activity Schedules are often used to help children with ASD cope with the challenges posed by various activities or behaviours during an individual task or throughout the day [24]. For children with autism, they promote independence and predictability, and help with transitioning between activities [25]. There has also been development of virtual reality (VR) to improve the skills of person with ASD. A research has been done where VR is tested for teaching street-crossing skills [26]. During the research, the experimental group which included six children with ASD, showed substantial improvement in their ability to cross the virtual street safely after intervention. Also, by the end of the research, three of them made considerable improvement in their pedestrian behaviour within the protected real-street setting following the VR intervention.

Social Stories are also introduced among the children with ASD to enhance their social skills [27]. Social stories represent short stories describing certain situations, events or activities that follow a set of criteria. They aim to teach children with ASD about certain situations or events, such as dressing up, and also preparing them for new events, such as moving house. Different android applications [28] [39] have been developed to create Visual Activity Schedules [29] and Social Stories [30] to support practitioners working children with ASD.

B. High tech AAC for ASD

High tech AAC for ASD may comprise of computer-based system or mobile application that can be loaded into the devices. One of the major beneficial features of high tech AAC is that they are highly customizable and consequently can provide personalized settings. Next, they are usually adaptable to the needs of user. Currently the mobile applications are gaining popularity due to the fact that they are easily available and are comparatively cheaper. Moreover, various studies showed that these are relatively easy to operate too [31]. Due to the several advantages of using mobile apps as means of high-tech AAC, they are also replacing the low-tech AAC modalities like PECS [32]. Also, mobile apps as means of high tech AAC has helped in greater uptake of AAC with children with ASD [33].

Various researches have been conducted to test the effects of high tech AAC on persons with ASD. Those have demonstrated the positive effects of AAC for children with ASD [34][35][36][37]. However, few papers have also pointed out the need for further research in the area of such interventions involving high tech assistive devices for children with ASD and the potential impact of its long-term effect on their communication skills [38].

C. Current assistive technology for ASD in Nepal

Regarding assistive products in Nepal, as per Nepal's Priority Assistive Product List [40], assistive technology is defined as the application of organized knowledge and skills related to assistive products, including systems and services. Also, it has defined assistive products as any external products (including devices, equipment, instruments or software), especially produced or generally available, whose primary purpose is to maintain or improve an individual's functioning and independence, thereby promoting their well-being. Assistive products are also used to prevent impairments and secondary health conditions.

Forty-five different devices have been categorized under six different heads. It also mentioned the usage of high-tech devices for augmentative and alternative communication (AAC). Besides, it also encourages the use of high-tech devices like smart phones, tablets, personal digital assistants (PDAs) etc for the cognitive and communicative assistance. However, the assistive technology being used in Nepal has been confined to low tech assistive devices.

The frequently used low tech assistive technology includes:

1. Social Stories
2. Social Scripts
3. Turn Taking cards
4. Social Rule cards
5. Sign language
6. Gestures
7. Visual schedules
8. Compartment Object Communicator
9. Paper Communication Cards/Books – pages of symbols organized by topic
10. Picture Exchange Communication System (PECs)
11. E-Tran Frames – the student uses eye-gaze to indicate word or symbol

While low technology systems are convenient and portable, they limit the user's vocabulary, preventing the user from conveying abstract thoughts. Although it offers some limitations, low technology devices are a great starter system for an AAC user and can be created or purchased at minimal cost. The user can also continue to use his/her low technology device even if more complex technologies are introduced.

D. Popular low-tech assistive technology for ASD in Nepal

The most popular low-tech assistive technology and found being used at both ACNS and SSDRC are Signs and gestures, PECS and Visual Schedule.

Signs and Gestures are also referred as no tech assistive technology. Research demonstrates that signs/gestures and the PECS are effective in helping some children with ASD communicate more effectively [41]. Some children with difficulty learning to talk may use their hands to communicate more easily. Children with ASD may be taught signs or gestures similar to "Baby Signs". For example, a child may learn to bring his fingertips to his mouth to indicate hunger. Signs/gestures are portable, can incorporate an unlimited number of words, and fast-paced as well.

Children with ASD usually respond well to visual information [42]. They can easily learn PECS. PECS makes communication more concrete, visual, and lasting than spoken messages. Further, PECS requires minimal initial communication skills and only simple motor movements. Initially, a child learns to give a picture of a desired object or activity to a communication partner in return for access to that object or activity. Over time, the child learns to use PECS to communicate increasingly complex messages through systematic PECS instruction for a variety of functions (e.g., requesting, protesting, and commenting). Children with ASD may improve spoken language abilities, requesting, joint attention, and problem behaviours.

Since most children with ASD are visual learners, visual schedules can use this strength by adding images to help children with ASD understand language more easily. As a result, children can successfully complete daily activities. ACNS and SSDRC have been using mostly visual schedules to teach the children with ASD.

E. High tech assistive technology for ASD in Nepal

Currently, there is no any high-tech assistive technology for ASD in Nepal. At ACNS, few years back, the team of engineering students developed an android app named, "Beautiful mind" that could aid the children with ASD at ACNS, with support from UNICEF. The android application had parent section and child section, with login system for parents. Within child section, there were different activities like drawing board, colour fillers etc that were supposed to be engaging for the children. One of the important features of the application was the evaluation graph which could keep track of the time that children spend in specific section and thus could be helpful in knowing the likes and dislikes of the children. However, administrative staffs at ACNS reported that development of this app couldn't reach its full potential as developers were not able to figure out the way to implement it across different devices. Right now, ACNS does not have any such working app.

III. Need of research on high tech assistive technology in Nepal

Both ACNS and SSDRC reported the need of high-tech assistive devices and they also think about building one. But the lack of resources, including human resources and enough budget held them back. Both organizations said that the current trend of low-tech assistive devices could be replaced well by high tech assistive devices and that this will help a lot in managing the cumbersome works such as preparing paper schedules, searching for appropriate pictures, then printing and laminating them. All these works require a good amount of time as well as a lot of waste papers. So, the use of high tech can help manage those. High-tech assistive devices could facilitate both time and waste management.

ACNS and SSDRC also reported that autistic children at their centres seems very inclined towards technology like using smart phones. So, the same interest could be used to ease their lives and get along with social rules.

IV. CONCLUSION

This paper discussed possible assistive devices for people with ASD and the current practice of their usage within Nepal. The findings show two actively involved autism organisation (ACNS and SSDRC) in Nepal have been using low tech assistive devices in their intervention programs. However, the use of high-tech assistive devices is negligible. Since using such high-tech devices could help a lot in easing their life style as well as helping in their learning attitude, it is a prime time to initiate the study and research on these as early as possible. This could be initiated with the literature review of ongoing practices of such devices around the

globe and then modulating those according to the need of people with ASD of Nepal.

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Cause of Failure of Municipal Waste Water Treatment Plant in Narayanghad

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Abstract –

Constructed wetland (CW), combined with other physical treatment units, is considered as an environmentally friendly and sustainable option for waste water treatment of varying scale. The absence of mechanical system makes the CW a low maintenance system but not maintenance free. The maintenance free treatment plant concept was observed in municipal waste water treatment plant in Narayanghad, Nepal largely because of its poor maintenance. Due to the absence of maintenance for a long time, sludge from the primary treatment units started to flow to the wetlands which, in turn, caused the reed plant to wither. From different literatures it was found that high organic solid load was the prime cause for the clogging of the filter medium. Clogging triggered oxygen deficiency at the root of the plant and hindered its growth.

Keywords – Constructed wetlands, reed plant, waste water

I. Introduction

Constructed wetlands (CWs), similar to natural wetlands, are environment friendly and sustainable waste water treatment technology since they are designed considering natural environmental phenomenon [1]. Based on the water flow, CWs are divided into surface flow CWs in which water flows above the filter medium, and subsurface flow CWs in which water flows below the filter medium. Subsurface flow CWs are again divided into horizontal flow (HF) and vertical flow (VF) CWs. However, CWs are not complete systems by themselves. For the proper functioning of CWs, it is necessary to combine CWs with other physical treatment units so they are widely used as tertiary treatment units [2]. The application of CWs can range from single household to large scale municipal waste water treatment system [3].

In spite of easy maintenance due to the absence of mechanical systems, the consequences of insufficient maintenance practices of the CWs are seen in reality. Lack of sufficient maintenance may not be visible in the system initially but in the long run the performance of the system plummets due to continuous deterioration of its components [2]. Vymazal[4] also emphasizes the importance of

maintenance in CWs by separating operation problems into two categories: one due to poor maintenance and another due to improper design. He further argues that natural treatment systems are not a "build-and-forget" type of system.

A similar perception was evident in the municipal waste water treatment plant in Narayanghad, Nepal. Constructed wetland was first introduced in Nepal in 1997 with the construction of the water treatment system at Dhulikhel Hospital [5]. According to Shrestha [6], one of the challenges in the successful operation of the constructed wetlands in Nepal is the misconception of CWs as zero maintenance system.

So, this paper examines the maintenance issues and their consequences on the performance of the municipal waste water treatment plant in Narayanghad, Nepal. The paper also attempts to relate the maintenance issues and consequences to the existing literatures from different journals. In doing so, this paper does not, however, examine the design criteria, design parameters, and performance parameters of the existing treatment plant.

II. Study area

The study area is located on the bank of Narayani River. Three horizontal flow CWs were constructed on the bank of Narayani River that receive and treat waste water of about 12,000 population residing in the core market area of Narayanghat. The treatment plants are designated as C1, C2 and C3. Bharatpur Municipality is responsible for the operation and maintenance of each plant.

Fig. 1 Location of treatment plant (Source: Google Earth)

Out of the three units, problem first began to appear in treatment plant C3. The major complaint was that the reed plant (Phragmites Australis) started to wither and the growth of reed plant continued to decline. The plant C3 had been operating for the last 9 years and its performance, as informed, had been quite satisfactory until then.

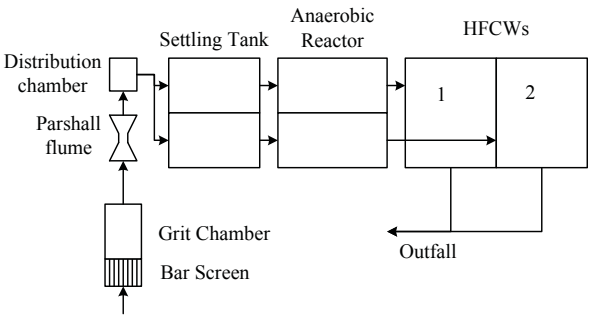

Fig. 2 Components of treatment plant

The major components of the treatment plant C3 are shown in the schematic diagram (Fig. 2).

III. Observations and Findings

In order to assess the problem, site visit was carried out; the responsible engineer and maintenance staff were interviewed; and drawings of the existing system were analyzed. Based on these, following observations were made on the following components:

A. Bar and screen

There were two screens-coarse and fine. As can be seen in Fig. 3, the finer screen is completely damaged and hence is not able to segregate floating particles and objects.

Fig. 3 Bar and screen

B. Grit chamber

Although it was constructed, the grit chamber was not in function. As shown in Fig. 4 the grit chamber was full of debris and the sewage from the bar and screen was made to pass to the Parshall Flume through a pipe. That resulted in the failure to remove inorganic waste from the sewage thereby allowing travel of inorganic matter to further treatment units.

Fig. 4 Grit chamber

C. Settling tank

As informed, no desludging process had been carried out on the site since the plant's operation. The collection of sludge in the tank was so high that there was no sign of clear effluent deposited on the top part of the tank when observed through manhole (Fig. 5). A long bamboo was immersed to check the consistency of the sewage and it could be felt that the sludge was already thickened and quite high in level. As a result of this there was reduction in effective volume of the septic tank which would reduce the detention time of sewage. Clearly, there will be decreased BOD removal efficiency.

Fig. 5 Checking consistency of sewage in settling tank

D. Anaerobic reactor

The consequence of lack in desludging at the septic tank is seen in the anaerobic reactor. Sewage in this reactor unit was not clear as shown in Fig. 6.

Fig. 6 Anaerobic reactor as seen through manhole

E. Horizontal CWs

Out of the two parallel units of horizontal flow constructed wetlands, wetland 1 was on the verge of total dysfunction. Certain sections of the bed were overgrown by foreign plants and the remaining reed plants were withering. There was deposition of thick sludge on top of the filter bed. As shown in Fig. 7, the influent feeding perforated pipe from the anaerobic filter to the reed bed was completely dry and hence the reed bed was being deprived of effluents.

Fig. 7 HFCW -1 (Dry inlet pipe, withered reed plant and deposition of sludge)

Fig. 8 HFCW 1 and 2

IV. Discussion

The major problem initially noticed was the withering of reed plants in the wetlands. One of the possible reasons for this could be the clogging of the filter medium since a thick layer of sludge deposition was observed during the site visit. Clogging is the most critical operational issue of HF wetlands [1]. A series of problems were observed that triggered clogging. As the effluent coming to the wetland component has not fully met its hydraulic retention time (HRT) in the ABR unit, there is a possibility of high concentration of pollution. This directly affects the rhizome growth as nitrifying bacteria are sensitive to toxicity. Further, the reduced permeability will cause ponding of waste water and bypassing of untreated waste water as effluent [7]. One of the factors that lead to the clogging

of CW is inefficient upstream treatment process [8]. Similar effect was also observed in this study. As informed by the staff, desludging of settling tank and anaerobic reactor had not been carried out at all since the plant's operation. So, it was observed that the primary treatment units were full of sludge and, as a result, sludge was flowing down to the wetlands.

Withering of reed plants due to clogging can be the result of oxygen deficiency at the roots of reed plant due to formation of algae [9]. Moreover, hydrogen sulphides produced due to anaerobic decomposition of organic waste depletes the dissolved oxygen in water and thus cuts of the level of oxygen transported to the root zone [10].

V. Conclusion

Withering of reed plants in the study was due to the overloading of organic solid matter originating from the unmaintained settling tank and anaerobic reactor. The rehabilitation of the system includes the removal of accumulated solids from all the components. Removing solids from the wetland cell is difficult but can be done by changing the filter medium.

This case is a good example of the prevailing misconception that constructed wetland is a maintenance free system. It is not a "build-and-forget" type of system as suggested by Vymazal [4]. Little but periodic maintenance of constructed wetland and its primary treatment units is therefore mandatory for its sustainable operation.

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Constructed Wetland as a Leachate Treatment Option in Nepal

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Abstract–

Leachate is a complex and toxic liquid generated in a landfill site that is detrimental to the environment if not managed properly. Constructed wetland is considered as an environmentally friendly and low maintenance cost option for treating leachate. The performance of constructed wetland in the treatment of leachate depends on climatic condition, type of wetland and type of vegetation. Generally, it is observed that high content of organic waste generates leachate of high BOD concentration. Constructed wetland without pre-treatment and ***Phragmites australis*** *as vegetation can be a possible option for treating leachate.*

Keywords –Constructed wetlands, solid waste, leachate

I. Introduction

Leachate is a liquid generated in the landfill site during the course of percolation of moisture through the waste, accumulating dissolvable and suspended impurities. The composition of impurities of leachate is diverse and toxic therefore it poses a potential threat to the environment. The prime environmental problem of the leachate is often long term and is evident in contaminated groundwater, surface water and the expulsion of obnoxious gases to the environment [1]. The conventional concept of solid waste management where disposal of solid waste to the landfill site is characterized as the final step is actually the point of generation of harmful leachate, the negative impact of which is even more detrimental to the environment and hence needs to be addressed. The diverse characteristics of the leachate pose a challenge in its treatment process. The treatment plant is designed considering the characteristics of the leachate. The common practices of leachate treatment include gravel filtration, constructed wetland and the waste stabilization pond [2].

Literature indicates, of all the treatments available as a solution, constructed wetland is a low maintenance and environmentally viable option for leachate treatment. However, the governing factors of plant efficiency are the composition of the leachate, climatic condition where

the treatment plant is installed and the condition of the treatment plant itself.

This paper aims to gather literatures on leachate treatment using wetlands and tries to examine the distinctions in terms of the treatment plant configuration and the removal efficiency. The findings can be used as a guideline in recommending wetland as a municipal solid waste (MSW) leachate treatment in Nepal.

II. Literature review

A. Lagoons as a pre-treatment unit

An integrated treatment system containing four stages of treatment units for treating leachate of MSW was developed and operated in June 1993 in a cool temperate continental climate. The first treatment unit is the anaerobic pond where sedimentation and anaerobic decomposition of organic matter takes place. The mean hydraulic retention time (HRT) of the anaerobic pond is 3 days. High volume aerated lagoon with a high HRT of about 30 days is the second unit of treatment in which atmospheric air is continuously forced into the aerobic pond and mixed by a rotating propeller. The objective of this aerated lagoon is to achieve about 50% of nitrification. Owing to the fact that nitrifying bacteria are relatively sensitive to the low temperature and toxicity, a low loading rate is necessary. The treatment units in stage 3 are two horizontal subsurface flow wetland systems with the filter units consisting of (i) washed gravel and (ii) Light Expanded Clay Aggregates (LECA) in the size range of 10-20 mm. Proper drainage system of about 2% gradient and mulching is provided. It is designed for HRT of at least 5 days or more. It is important that raw leachate with high concentration of pollutants does not enter the wetland as it may affect rhizome growth and reduce the permeability of the medium. Finally, the stage 4 is free surface flow constructed wetlands with a depth of 1 to 1.2m. planted with Scirpus and Typha. sp.

Samples at six different points were collected during the study period of one year and observations were made for different parameters like Chemical oxygen demand (COD), Biological oxygen demand (BOD)7 (The test was carried out for 7-day BOD) total organic carbon (TOC), N-total, P-Total and E Coli. The removal efficiency of these parameters appears to be most significant from the aerated lagoons (60-95%) [3] in comparison to the effects of anaerobic pre-treatment pond (Stage 1) and the horizontal flow wetlands.

This finding was further verified with the fact that in the course of operation during winter when the aerator froze, there was an increase in the concentration of COD and N-total.

TABLE 1 OVERALL REMOVAL EFFICIENCY [3]

Parameter	Removal rates (%)
Chemical Oxygen Demand (COD)	88
Biological Oxygen Demand $(BOD)_7$	91
Total Organic Carbon (TOC)	71
N-tot	83
P-tot	88
E-coli	95

The findings of the study carried out by Maehlum [3] showed that the aerated lagoon is by far the most effective treatment unit.

B. Constructed Wetland with cyerus haspan

Akinbile et. al. [4] conducted a study for leachate generated in Pulau Burung Sanitary Landfill (PBSL) in Penang, Malaysia. The leachate was treated by constructed wetland consisting of sand and gravels as its substrate material and *cyperus haspan* as the plant. There is no pre-treatment unit in this plant. Based on the result of an experiment performed for 3 weeks, the characteristics of the sample pH, turbidity, color, total suspended solid, Chemical Oxygen Demand, Biochemical Oxygen Demand, ammonia nitrogen, iron (Fe), Magnesium (Mg) and Manganese (Mn) concentration were examined. The removal efficiencies are as shown in TABLE 2.

TABLE 2 OVERALL REMOVAL EFFICIENCY [4]

Parameter	**Removal rate, %**
pH	7.2-12.4
Turbidity	39.3-86.6
Color	63.5-86.6
Total suspended solid	59.7-98.8
COD	39.2-91.8
BOD_5	60.8-78.7
NH_3-N	29.8-53.8
TP	59.8-99.7
TN	33.8-67
Fe	34.9-59
Mg	29-75
Mn	51.2-70.5
Zn	75.9-89.2

In reference to the overall removal efficiency of the system, it can be concluded that wetland without any pre-treatment unit results in an appreciable removal of impurities.[4]

C. Constructed Wetland with phragmites australis

The treatment was introduced for landfill leachate treatment generated at the Oragonja landfill site located on the Adriatic coast, Slovenia. The system consists of two interconnected beds as a subsurface flow constructed wetlands and the plant used in the wetland was phragmites australis at a density of 4-5 per sq.m. This treatment plant does not have any primary treatment units.[5]

TABLE 3 PERFORMANCE PARAMETERS

Parameter	Average Removal rate, %
COD	68
BOD_5	46
NH3-N	81
Fe	80
Bacteria	85

The removal efficiency of the treatment plant was fluctuating which is attributed to the fact that there was weather variation-heavy rainfall flashing high amount of organic impurities, poor plant establishment due to toxicity and the fluctuating dissolved oxygen.

D. Factors affecting performance of constructed wetland

Bulc [6] performed a study on a combination of two subsurface flow wetlands- 2 units of Vertical flow (VF) and 1 unit of horizontal flow (HF)- as interconnected beds used to treat leachate from one of the old landfill sites in Slovenia. Test on parameters - COD, BOD5, ammonia nitrogen, nitrate, total phosphorus, sulfates, sulfides, chlorides, and iron in connection with the amount of precipitations was performed. The study evaluated performance of the wetland for 7 years (1997-2003) and showed that overall performance of the system of wetland is well dependent on the variable condition of the system itself, variation in the inflow parameter of the pollution and the environmental factors - primarily temperature and rainfall. The removal efficiency of the system (TABLE 4) showed that this CW can serve as a good treatment for leachate as a tertiary system (after treatment by screening and reactors) or as an independent system.[6].

TABLE 4 AVERAGE REMOVAL EFFICIENCY

Parameter	Average Removal Efficiency, %
COD	50
BOD5	59
NH_3-N	51
TN	Negative
TP	53
Sulphate	Negative
Sulphide	49
Chloride	35
Fe	84

E. Examination of Green House Gas Emission in Constructed Wetland

A study was conducted to evaluate the removal of organic carbon and nitrogen of young and partially stabilized Municipal Solid Waste (MSW) leachate along with the emission of greenhouse gases (CH4, CO2 and N2O). In terms of organic removal efficiency of young leachate, the value was upto 90%, with significant COD removal within the inlet part. The removal of Total Kjeldahl Nitrogen (TKN) was moderate (36–43%). In case of the stabilized leachate, BOD5 removal efficiency was less and moderate whereas TKN removal was about 40%. The wide difference in removal efficiency of BOD5 is attributed to the fact that the young leachate consisted of high degradable carbonaceous organic matter in comparison to that of partially stabilized leachate. The emission of greenhouse gases was maximum at the inlet zone for the young leachate following the removal rate as that of carbonaceous organic removal while for the stabilized leachate higher emission was observed in the middle zone [7].

F. Treatment by series combination of constructed wetland.

The performance of surface flow wetland to treat leachate was studied for a period of 4 months. The parameters analyzed were TPO, NH3, NO3, NO2, TKN, TPO4, BOD5, chlorides, and alkalinity. The average removal efficiency was as shown in TABLE 5.

TABLE 5 AVERAGE REMOVAL EFFICIENCY

Parameter	Average Removal rate, %
BOD_5	97.7
TOC	94.6
TPO_4	69.5
TKN	79
NH_3	98.3

These studies show that constructed wetlands can be a cost-effective and efficient approach to the treatment of landfill leachate with high TOC, BOD, nitrogen, and phosphorus.[8]

G. Treatment using an aerated, horizontal subsurface-flow constructed wetland

A subsurface-flow constructed wetland operated in Jones County Municipal Landfill near Anamosa, Iowa in August 1999 was studied to find the removal of the high concentrations of organic matter and NH4–N present in the landfill leachate. In order to maintain DO content of the treatment process, the plant was equipped with aeration process facilitating nitrification and aerobic removal of organic matter. Since the study was carried out in a cold climate, algal photosynthesis method alone could not meet the oxygen demand. So, air was delivered for 12 hrs a day to enhance the microbial process; however, at night when the supply of air was cut off the decomposition process could switch to anaerobic condition. The major challenge observed in the plant was clogging of the aeration tubing due to precipitation of ferric hydroxide. For some time period of about 6 months, aeration was taken off and the plant operated without supplemental air. It was observed that BOD5 removal efficiency was up to 90% until the time when there was supply of air. As clogging started and the plant operated without supply of air, the BOD removal was sporadic ranging from 0 to 100%. The variation in the removal of BOD is related to the air supply. Similarly, the removal of ammonia nitrogen was about 90% in the startup time and the performance was poor and inconsistent as clogging started and the plant operated without supply of air. The system was then renovated by installing a pretreatment system to oxidize the iron present in the leachate, and to settle the precipitate out of solution before pumping the leachate into the wetland system. The pretreatment unit was also supplied with air by an air blower. Following the renovation work, improved oxygen supply and pretreatment system for iron removal, treatment efficiency of BOD5 and ammonia nitrogen was greatly improved.[9]

H. Comparison of Horizontal and Vertical Constructed Wetland Systems for Landfill Leachate Treatment

The study was conducted to observe the removal efficiency of subsurface flow wetland of both vertical and horizontal type, focusing on removal efficiency of the impurities NH4-N, COD, PO4.

The effect of different bedding material for the vertical flow CW (gravel and zeolite surface) was investigated. A pilot-scale study was conducted on the subsurface flow constructed wetland systems operated in vertical and horizontal mode. Two vertical systems differed from each other with their bedding material. The systems were planted with (cattail typhalatifolia). The findings showed better NH4–N removal in the vertical system with zeolite layer than that of the vertical 2 and horizontal system, while COD was better removed by horizontal flow wetland [10].

III. Summary of Different Cases

From the comparative study of the wetlands performing leachate treatment, following are the key information drawn

1. Performance of wetland can be enhanced by use of pre-treatment units such as anaerobic lagoons and aerated lagoons. This combination is significant in cold climatic zone where required dissolved oxygen content cannot be fully met by algal photosynthesis process.

2. Constructed wetland with *cyerus haspan* as the plant is suitable for tropical zone which does not require any pretreatment units.

3. Condition of wetland, variation in the inflow parameter of the pollution and the environmental factors primarily temperature and rainfall affect the removal efficiency of the plant.

4. There is a concern of green house gas emission like CH_4, CO_2 and NO_2 while treating leachate from wetland.

5. In the cold climate zone, supplemental air to the wetland will maintain DO content thereby helping in nitrification process. The problem observed with this system is precipitation of ironoxide which will cause clogging of aeration pipe, this problem can be taken care by installing pretreatment unit for iron removal.

6. The common findings from all the study showed that vertical flow wetland is more effective in removing nitrogen, phosphorous, BOD_5 while COD is better removed by horizontal flow wetland.

IV. Leachate composition, prevailing treatment condition in Nepal

Analysis made on the composition of leachate carried out in different landfill sites of Nepal-Kathmandu (Sisdole), Pokhara and Dang (Karaute Dada) showed very high organic impurities in waste composition (>60%), consequently, the leachate collected from these sites have high organic content [11]. A study conducted in Gokarna landfill site showed that there is no collection of leachates, generated causing a direct threat to public health and the environment. Similar condition was observed in Bishnumati dumping site where the leachate generated through MSW is directly discharged into the Bishnumati river [12].

V. Final remarks

Landfill site, a final destination of MSW, is the point of generation of leachate. Growing economy and population is a driving factor of increasing solid waste. While there are ample efforts made in handling solid waste, the concern towards leachate treatment and its disposal seems to get little or no interest. The immediate consequence is pollution of land and water bodies paving a path to a series of negative environmental and public health impacts. Various studies conducted across the globe have verified the effectiveness of treating leachate through wetland system. From the point of economic viability - land footprint and other resources, vertical flow wetland with phragmites australis with no pre-treatment units can be the best option in specific context of Nepal.

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Base Isolation Method for Earthquake Resistant Buildings

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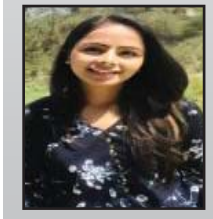

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ABSTRACT

The field of engineering is as dynamic as the world we live in and so is the requirement of innovation in construction industry. One such innovation is base isolation method. From the result of the study, base isolation method is found to be highly optimistic for the safety of structures.

We met with different engineers regarding structure engineering and earthquake engineering. Through their recommendation, we visited National Society of Earthquake Technology (NSET) and Earthquake Safety Solution (ESS) which gave us chance to meet with Daniell King and Harry Toward who were researching in Nepal about base isolation method. We visited a village named Sankhu ward No.4 near Nepal Engineering College. We asked people how feasible this project can be. Many people showed positive responses towards it. Then we went to Sankhu Municipality for the collection of secondary data. So especially in developing countries like Nepal, this project will give a lot of benefit. Further it is expected to give better results than other resistive methods.

I. INTRODUCTION:

Massive destruction of houses, buildings and property in the recent earthquakes in Nepal has led property buyers to question if the structures being bought for residential or commercial purpose by them are quake proof [1]. Base isolation, a means of protecting a structure from earthquake forces. Simply it is a collection of structural elements which decouples a structure from its substructure resting on a shaking ground thus protects buildings integrity and reduces the overall impact of blast on structures.

Base isolation is one of the most powerful tools of passive structural vibration control technologies. It is meant to enable a building to survive a potentially devastating impact through a simple initial design [2]. It helps to modify the seismic sustainability considerably. It consists of isolation units which refer to the basic element of base isolation system which are used to provide the decoupling effect to a building [4]. As earthquake load is not controllable and it is not practical to design a structure for an indefinite seismic demand, we can modify the demand on structure by reducing the motion being transfer to structure from foundation. Base isolation is also useful for retrofitting important buildings. Increasing the ductility or elastic strength of the building is the most conventional method of handling seismic demand which is the main significance of our study [4].

A. Purpose of study:

To modify the building such that the ground below is capable of moving without transmitting minimum or no motion to the structure above and implementing the base isolation method in newly forming houses or buildings.

II. FIELD OBSERVATION AND DATA ANALYSIS:

We visited a village name Sankhu ward No.4 near Nepal Engineering College. We asked people how feasible our project is by explaining it and got positive responses towards our project. And we collected data through Sankhu Municipality which is given below:

Table 1: Sankhu Municipality [6]

S.N.	No of completely destructed houses	No. of partially Destructed Houses	Total	Death	Victims	Public Property destructed		No of houses made after earthquake		No. of houses made after earthquake	
						Completely	partially	By the government fund	By own fund	constructing phase	un-built
1.	646	3	651	11	15	1	8	9	53	54	533
2.	498	1	500	18	59	2	8	11	38	52	398
3.	617	0	619	9	9	2	7	17	46	68	486
4.	586	6	592	4	0	-	4	14	38	56	484
5.	554	1	555	1	0	2	7	14	39	51	451
6.	299	2	299	10	6	-	3	6	23	35	235
7.	439	144	553	0	4	-	5	17	36	59	441

After observing the data, we concluded that there was a great chance for construction of many buildings. So, to be safe from destruction caused due to earthquake implementation of base isolation method is the one.

Then, we designed a prototype of the building using sun board as roof and bricks, plywood as the base, and other materials as isolator. We made the base

by fixing four helical springs in between using two plates, and fixed the isolated base with the designed structure. Then we consider a normal house as next prototype. A brief discussion about foundation used, types of isolators used and types of truss are presented in the section below.

A. Foundation used:

For the foundation, we used shallow foundation which was founded near the finished group, generally where the footing depth is less than the width of the footing which is usually less than 3m. They can sometimes be called as spread footing. They include pads or isolated footings.

B. Types of isolators used:

There are different kinds of isolators that can be used in making buildings. They are discussed below: [3]

a) Spring bearing

b) Lead Rubber bearing

c) Elastometer bearing

The main mechanism of the isolator is to damp the vibration caused due to the earthquake. So, the devices that have such mechanism can be used between two plates either lead plate or tectonic plate and a cylindrical lead is used inside the bearing which help in fixing of isolator and the plates [5].

C. Type of truss:

It can be applicable for both types of truss that were mainly used i.e. pitched truss and parallel chord truss. Pitched truss is a common truss that is characterized by its triangular shape. It is most often for roof formation. And the parallel chord truss or a flat truss gets its name from its parallel top and bottom chords. It is often used for floor construction [3].

D. Model overview:

The isolators were placed at the end of column. Isolators from 12 to 60 inches in diameter with capacitance of up to tons are manufactured. Custom dimensions are available for special applications. They are of height 25.4 cm.

The properties of spring are calculated and the data obtained is below:

*Density =7850kg/m^3 Young's modulus =2*10^7 pa*
Poisson's ratio =0.3 Stiffness =64680N/m

III. ANALYSIS AND DISCUSSION:

Talking about the analysis of the project, if we can implement in the society then the cost required for making an earthquake resistant building will be less than double brick methods, raft method and RCC method.

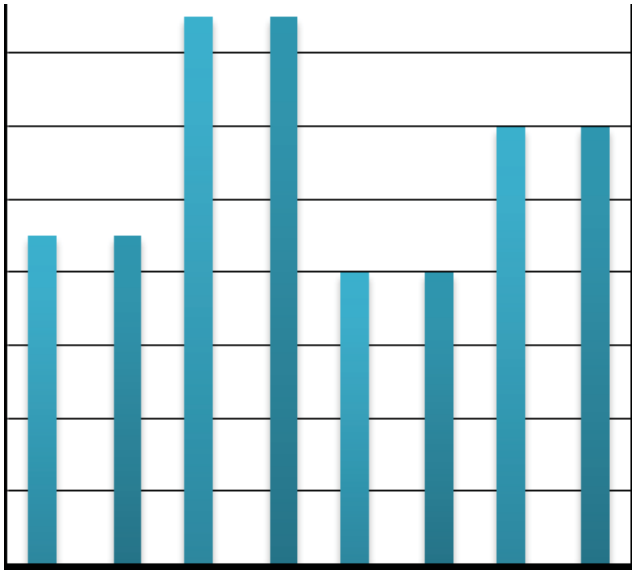

Fig 1: Cost estimation at the base (in million)

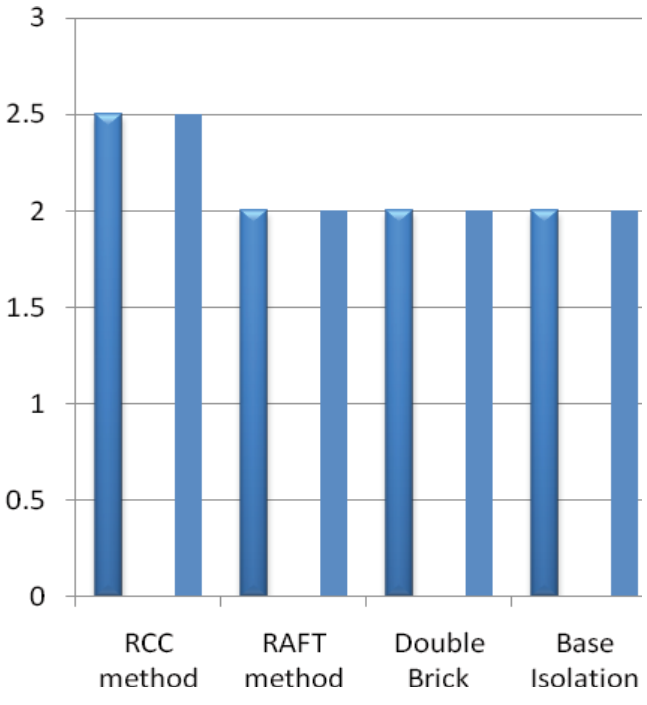

Fig 2: Cost estimation for the structure (in million)

Now the cost comparison between a normal house and isolated house for one storey is given below:

Table 2: Government norms for Municipality [6]

SN	Materials	For normal house	For isolated house
1.	Pebble, sand & stones	3,10,000	3,20,000
2.	Cement and bricks	6,30,000	6,40,000
3.	Rod and plumbing	5,10,000	4,70,000
4.	Wood and pipes	1,70,000	1,70,000
5.	Paint	1,00,000	1,00,000
6.	Marbles	80,000	80,000
7.	Electricity materials	60,000	60,000
8.	Map & Municipality charges	50,000	60,000
9.	Wage for construction	5,80,000	6,00,000
10	Isolators	------	1,76,000
	Total cost:	24,80,000	26,76,000

IV. APPLICATIONS:

Advantages:

1. It takes limited time rather than that of normal buildings.
2. It is cheaper than other resistant methods.
3. When used in normal building, it reduces the seismic frequency of earthquakes by 50 Hz.
4. Along with the increase in life time of building, it saves the life of people and properties
5. It also saves from GSA blast loads.
6. Its reliability is very high than others.
7. It also helps in increasing bearing capacity of soil.

Disadvantages:

1. It is not suitable for structure resting on soft soils but can be used together with soil stabilization method for making soft soil harder.
2. It can't be applied for building more than sixteen storeys.

V. CONCLUSION AND RECOMMENDATION:

This project is highly optimistic to achieve the primary goals of enhancing the earthquake resistant house which will protect the lives and property too. This project is fully confident in improving the safety of structures. And, if simple changes in base cause a great save in life and property then that would probably be the matter of concentration of all.

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Vernacular Newar Dwelling- Its Construction Technologies and Vertical Functional Distributions

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ABSTRACT

This research examines the construction process and the techniques of vernacular residential dwellings of core area of Bhaktapur city. The physical characteristics of the buildings are rich in their heritage. The investigation mainly concentrates on assembly of building structures, scientific justification behind the technologies and the vertical functional use of the building. The paper takes an integrated view of building technologies and materials assembled by builders. This research attempts to improve the technologies applied by the builders by emphasizing the cultural context which enables us to provide an integrated explanation. The behavior of structure and material is kept as the focus of investigation. The different case study buildings are selected from upper Bhaktapur (East) to lower Bhaktapur (West) with an assumption that the knowledge may be generalized to the other buildings as well.

The main findings reveal that Newar residential dwellings are constructed of brick masonry with mud mortar and timber. The architecture of traditional dwelling is a product of different professionals. Different structure assembling techniques in different parts of the building, detail information on building materials and functional space allocation and terminologies used in building construction are described because each terminology is a meaningful invention of our past tradition on building construction technology.

Key words : *Newar residential dwelling, traditional, construction, technology, techniques, terminology*

I. INTRODUCTION

This research stems from an observation of buildings in the core areas of Bhaktapur (Figure 1) which has the stock of the traditional buildings rich in physical and cultural expression. The city is rich in heritage expressed through harmonized building materials and construction techniques. The magnificent artistry of Nepalese woodwork is renowned and is a prime essence of traditional Nepalese architecture. Historical buildings, including residences, palaces, temples and monasteries (bahals and bahils), priest house (Matha) display structural as well as decorative use of timber as evident in the skill and artistry of the medieval period.

Most of the world monuments are built in their own local technologies, using their own local materials yet these have not been well studied and well documented. Because of these reasons, it is very important to understand the use of traditional building materials and technologies and document them for future reference.

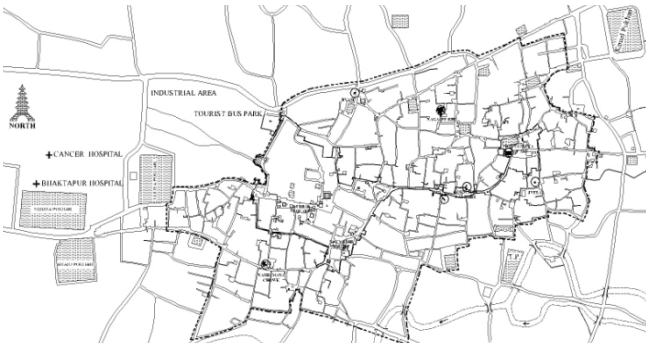

Figure 1. Map of the Bhaktapur city

From a detailed observation of the building structure and its design function, the traditional buildings like temples, mathas, satals, dyochhens, patis, palaces or the private dwellings all are of great importance to national heritage. The identity of any place or the location is reflected by its built environment, the people living there-in, their socio-cultural activities and their religions.

The system and the scientific justification behind the technologies of national heritage at present exist mainly in an oral version (BDP, 1986). This has to be documented in a written form. This paper covers only the traditional Newar residential dwelling of Bhaktapur city. Though monuments are elements open to public exhibition, the residential dwellings are less visible but no less important to the sense of harmony in all aspects of the life of the city.

The town has also suffered much from earthquakes. The worst of them occurred in 1808, 1833, 1934 and 2015. They destroyed a considerable part of its building stock, a few of which are now older than 150 years. In spite of these destructions, the external appearance of the city does not seem to have altered greatly. Temples were rebuilt in their original form, although some were changed in size and shape. The sizes of bricks, tiles, or windows have also changed. Many buildings have collapsed and have been rebuilt. All these changes have not led to a substantial change in architecture; the basic structure of the town seems intact.

Houses constructed in this century, especially those from after the great earthquake of 1934, were quite often four storeys till early 1970. Subsequently, the heights of the buildings were significantly raised, in some cases overextended from an original room height of 1.61.9 m to 2.52.9 m. From 1970 inwards new building styles crept in, mostly modern elements from western architectural styles. Such modern contemporary building styles often depart significantly from traditional building methods, especially in the number of floors, floor height, use of new materials and in the overall architectural expression.

It is evident that the original building regulation as to height limitation served an obvious regulatory purpose. It is also manifestly cleared that this regulation is no longer observed today. It is thus possible that a modern five or six storey building is planted next to an old three storey house, towering above all the neighboring houses in an already very densely built environment, with negative effect on buildings safety as well as sunlight and ventilation is concerned.

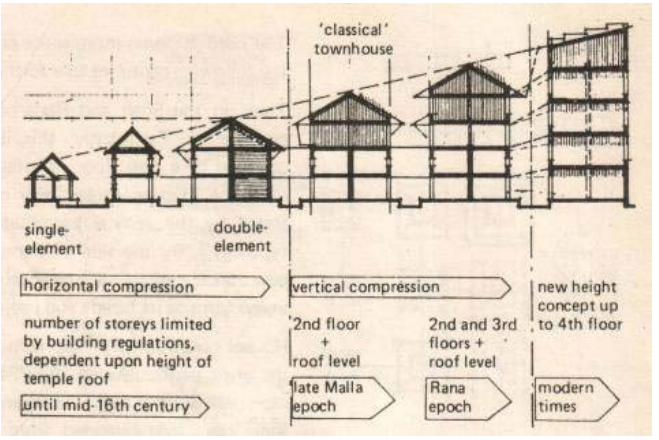

Figure 2. Development of building height (Scheibler, 1988)

Figure 2 illustrates the historical trend in the increment in the number of floors in conjunction with the simultaneous horizontal expansion from a single bay to a double bay construction. This was probably first introduced during the Rana period. Precise details as to their architectural history are lacking.

II. INTRODUCTION TO TRADITIONAL NEWAR DWELLING

In contrast to the well documented descriptions of religious buildings, the historical information concerning private dwellings is almost non-existent. A

Jesuit traveler, Father Giuseppe who visited Nepal nearly 200 years ago gives probably the earliest description of dwellings: "The houses are constructed of brick, and are three or four storeys high; their apartments are not lofty; they have doors and windows of wood, well worked and arranged with great regularity."

The simple description of the Newar house can be stated as "small entry doors that require the visitors to bow their head when entering a Newar house, signifies a symbolic offering of respect to the place where they dwell. Newar houses were built with great care, imagination and creativity to make one feel the warmth around its coziness and richness of art. A Newar house is characterized by the use of natural materials, the intricate wood carving and brickwork, low ceilings and welcoming atmosphere".

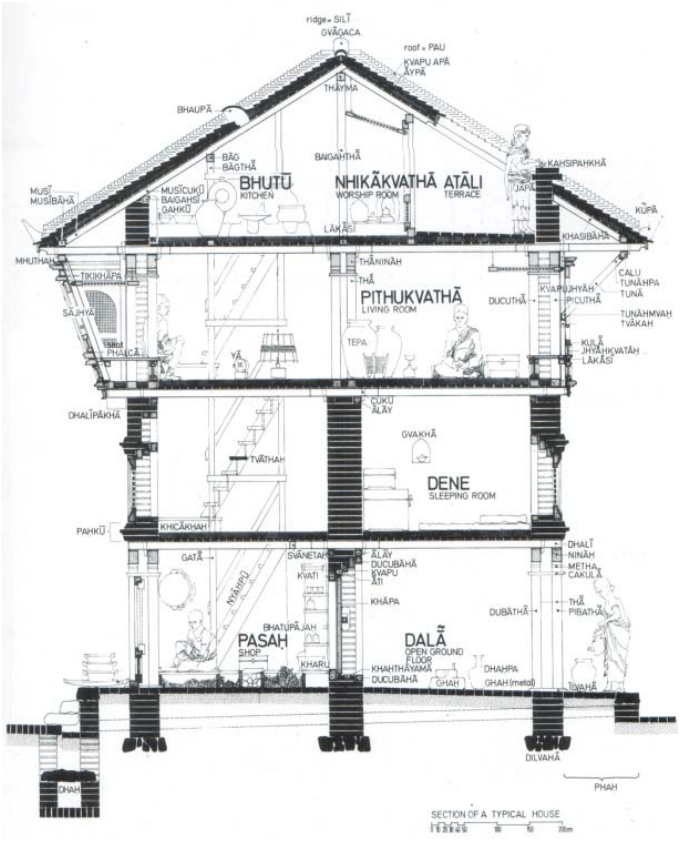

Figure 3. Section of a traditional Newari Building with space use at different levels (Gutschow, 1987)

The traditional building from Malla period differs from the building of Shah and Rana period. The major differences, which can be observed visually, are floor height, window style, ornamentation, and carving on the wooden members. However, in general, traditional buildings are considered to be three to four storeys high with floor height between 1.60m to 2.40m connected by a narrow (approx. around 0.45m - 0.60m) and steep (at least 60 degree) wooden staircase (Figure 3). The plan is usually of a simple rectangular shape with a depth of about 6m and length varying from 3m to 10m. The buildings are constructed in brick masonry structure and the materials for the superstructure is locally available sun-dried or burnt bricks with mud-mortar as the binding material while the material for the foundation is stones or brick. Timber is used for window/ doorframe and carved elements, staircase, beam, strut, purlin. The roof is a special architectural feature of the whole building, which is usually in slope with pola aapa (tile roofing), locally called 'Jhingati'. It is constructed with wooden beam over which wooden boards are placed and then a thick layer of mud topping is applied as the base for Jhingati (Figure 4).

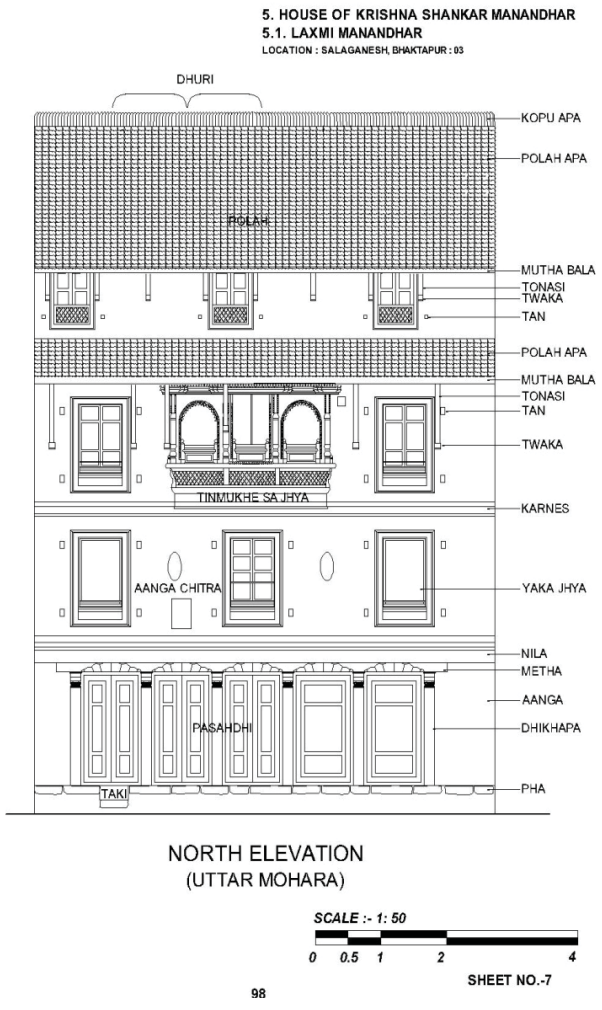

Figure 4. Elevation of a traditional Newari Building with terminologies of the elements at different levels (Author, 2012)

Wolfgang Korn (1976) also elaborated that a characteristic and universal feature of this design is the vertical room arrangement, which is not dependent on the size of the house. Security considerations, and the need to use as little irrigable land for building purposes, caused the Newar house to be vertically orientated. Generally it is threestoreyed, but twostoreyed houses occur among the poorer inhabitants on the town's fringes, and four storeys in the centre of town. The uniform depth facilitates the building of additional floors on to existing ones, to form blocks of houses. The extensions were of equal height, the depth being determined by that of the main house, and either the full depth of 6 meters or only half that depth was used.

Common lifestyles within each habitation, together with similar building methods, led to uniformity in architectural style, with only superficial variations.

III. PHYSICAL STRUCTURE

The development of urban settlements and the street patterns within these settlements usually meant that domestic dwellings are either groups of interlocking courtyards in the more dense developments, or linear contiguous buildings facing the street or access road. In the latter case a less controlled form of courtyard development may grow up of inferior structures interlocked by a series of enclosed passages running at ground level beneath the dwellings, which link the various courtyards.

The buildings that overlook the main access roads and those that occupy key positions in large enclosed spaces are usually of architectural importance. Their facades are generally symmetrical and contain finely detailed and carved windows and doors. Symmetry is achieved on a central axis on each succeeding floor, with the central window of each floor emphasized by both its size and quality of detail. The houses are usually of two to three storeys set above a ground floor (Figure 4).

IV. THE INNER STRUCTURAL FORM OF THE NEWAR BUILDING

Because of the limitation in the spans of the timber beams, a central support of either a Dhathu Anga (central wall) or a row of supporting Tha (timber post) is placed systematically through the building.

The roof and floor structures of residential buildings are well integrated with the wall structure. The floor Dhalins (joists) rest on Nuss (wall plate) and are held in position by si chuku (wooden peg) through holes on either side of the plate. The Dhalins (joist) are supported on the Dhathu Anga (central wall) which reduces the overall span of the timbers and over this central support, the Dhalin are set side by side and span alternately to the front and back walls; the spacing between the Dhalin is equal to the breadth of a Dhalin. The Dhalin are laid flat with the depth being less than the width; occasionally the Dhalin sections are of square shape.

Sipu (Boarding) is normally laid over and runs transverse to the Dhalin. Occasionally these boards are substituted with a purpose made brick or tile which is laid between the Dhalin. The Ba: (floor finish) is laid over thick bedding consisting of either brick and clay or clay alone. If the floor is part of an external terrace then a greater thickness of special Kasi Pachha will be selected and laid by flimgimg from above with force. Over the clay bed, Chhikan Apa is laid which are glazed but they are not burned as bricks. In some interiors the tiling is replaced by a firm beaten clay base that is sealed over with clay slurry (Figure 5).

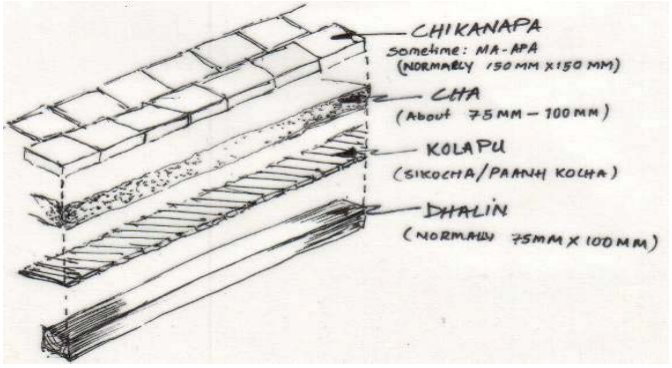

Figure 5. Ba: (Floor) Construction details and design (Author, 2012)

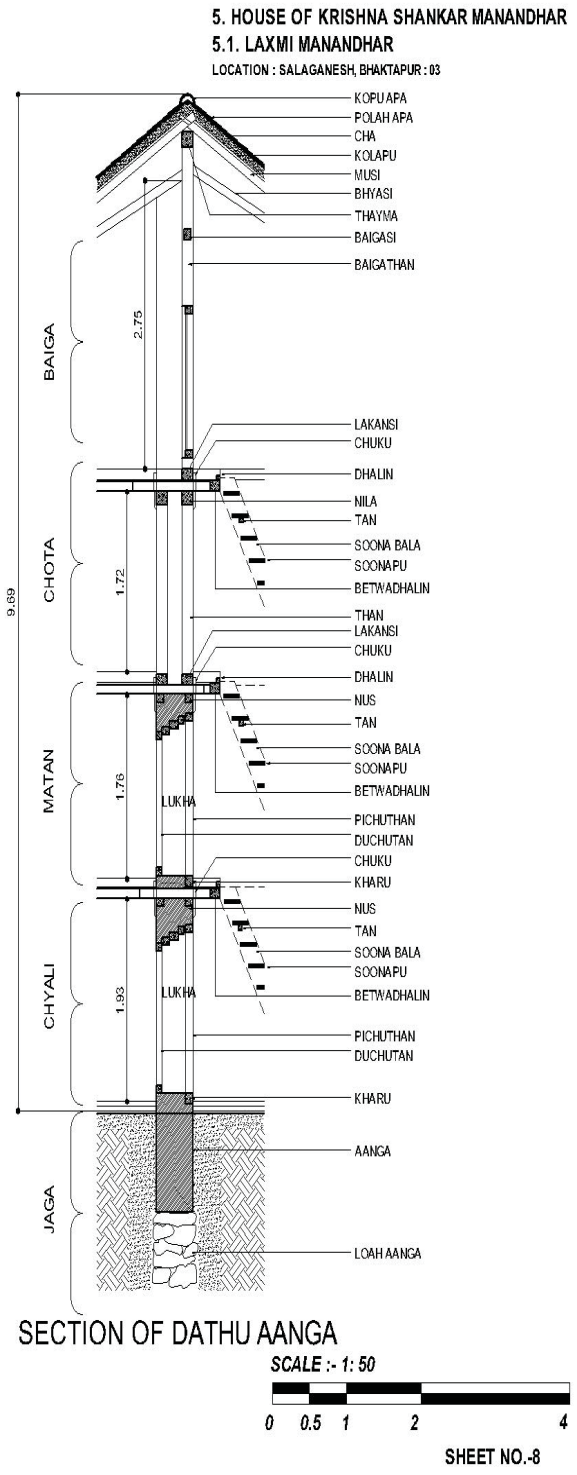

Figure 6. Section of Dathu Aanga of a traditional Newari Building with terminologies of the elements at different levels (Author, 2012)

When a large area for gatherings is required in these dwellings, the upper floor is opened from front to back and Dathu Aanga (the central spine structural wall) is replaced with than (timber posts) and nila (beam) construction. The posts are stub tenoned into a floor plate and a long tenon passes through the supporting brackets into the beam above. The beams are usually two timbers of sizeable sections set side by side and the Dhalin are again Si chuku pegged on both sides of the beam. (Sandy, 1978)

A. Jaga (The Foundation)

The Jaga (foundation) is an underground structure which is strong enough to transfer load of superstructure to the ground. It is a longitudinal structure made of masonry stone blocks in trenches 0.60 m wide and 1 m deep in average. It is usually extended above the ground level by about 0.45 m in order to preserve and protect the base of the brick walls from rain water. There are also cases where these are stopped below the level of the ground (Figure 6).

B. Chyali (The Ground Floor)

Normally the Chyali (ground floor) is raised onto a platform of approximately 0.6m to 1m above the main street level outside (Figure 3). The practical reason for this is an attempt to protect the lower walls and floor against rising damp. As a result of the lack of proper DPC, the buildings are very vulnerable to dampness both from direct penetration through the wall and by capillary action up through the foundations. Even though the floor level is raised, there is still considerable dampness and these areas are mostly used for storage or as work-shops. The floors are generally solid and either finished with a clay tile, or when they are used as a workshop, a boarded floor is laid.

Where the ground floor is not used as shop or a workshop, it is used as store room or stable. The elevation remains simple and unadorned with a low door flanked by two small windows to admit light (Korn, 2007). Irregularities that may occur in this storey are never repeated in the more formal layout of the upper storeys. The entrance door is closed by two heavy wooden planks that slide under wooden hasps (Bagah) at the back of the door leaves (Figure 7) (Sanday, 1978).

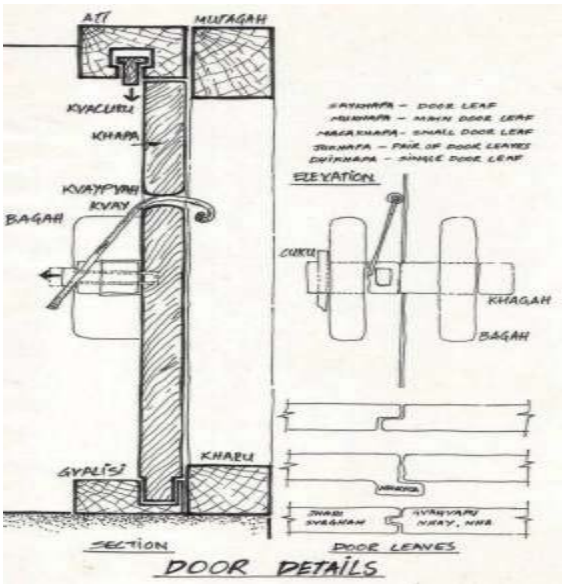

Figure 7. Wooden door detail (Author, 2012)

C. Matan (The First Floor)

The Matan (first floor) level is used both for sleeping accommodation and, at the same time, security. Depending on the size of the house, the two rooms created by the Dathu Aanga (central wall) are further divided by either solid masonry brick or light timber/ bamboo partitions to form sleeping quarters (Figure 8) for family members, or for married sons, who remain in the parental home with their own family (Korn, 2007). Safety is reflected in the massive wall construction, in the Tikki jhyas (tiny windows) enclosed with latticework and the dhalinkhapa or kochukhapa (horizontal trapdoor) placed above the stairs. Subdivision into many small chambers provides private and individual rooms. Jewelry, valuables and clothes are stored here in wooden trunks and tin chests (Scheibler, 1982).

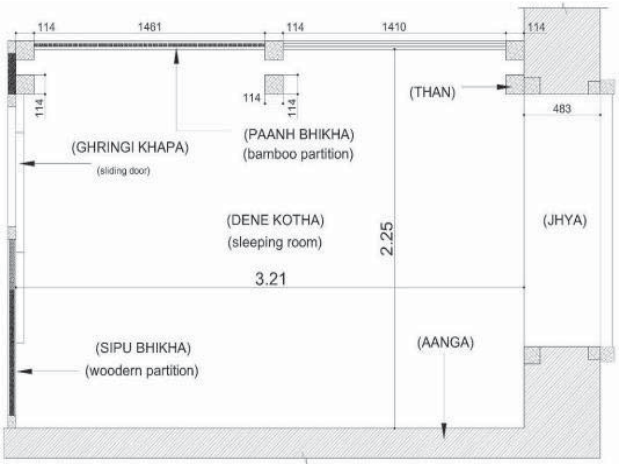

Figure 8. Plan showing different bhikha (Partition wall) (Author, 2012)

D. Chota (The Second Floor)

The Chota (second floor) is one large undivided room where the whole family gathers and visitors are received in accordance with one's class, and where there is ample room for the frequent large banquets to be carried out and enough space for the voluminous domestic chores to be done while from the benches on the balcony one can follow the events taking place below on the street (Scheibler, 1982). In this floor, Than (a row of twin columns) replaces the Dhathu Aanga (central wall), so that the room becomes a hall. The large windows (sajhya) which lie opposite each other in both outer walls facilitate through ventilation and allow sufficient light into the room. By these means, a pleasant internal atmosphere is established, purely by natural means (Korn, 2007).

E. Baiga (The Third Floor)

The Baiga (attic storey) comprises the kitchen, the dining area for the family's daily meals and the Puja kotha (place of worship) with its house altar. In most cases there is also a Kausi (flat roof terrace) directly adjoining the kitchen and the dining area (Figure 3). There many social activities take place in the sunshine; many household chores are performed such as the washing and drying of fruits and vegetables. Old people, convalescents and newly delivered mothers can enjoy sunbathing undisturbed in peace and quiet (Scheibler, 1982). Because of their religious significance, strangers and members of lower castes should never enter the kitchens or the precincts of a higher caste shrine. Room divisions seldom occur except for an elementary separation of the shrine (Korn, 2007). The Kausi is specially constructed to prevent water seepage during rainy season.

F. Polan (The Roof)

The Polan (traditional roof) structure is a simple pitched timber roof. The most striking architectural feature in the traditional Newar buildings is the huge projecting roofs which, in the religious buildings, are stacked one above the other with, in a few cases, up to five diminishing tiers. The projections are large in order to protect the walls of brick and mud mortar from the driving rains and strong sunlight (Sanday, 1978).

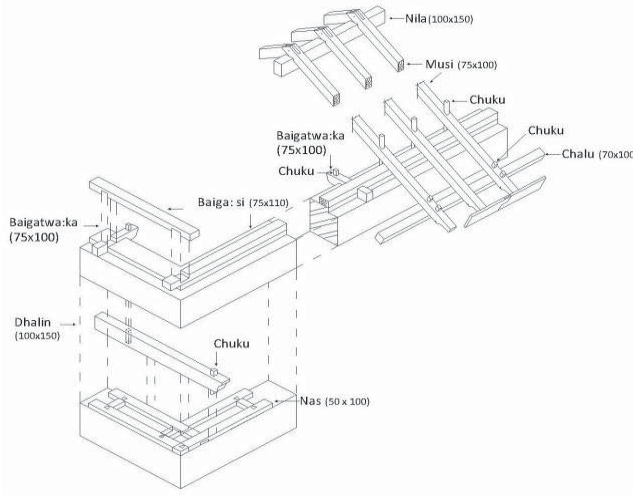

Figure 9. Assembly of structural members. (Author, 2012)

The design and details of the Polan (roof) construction as well as the traditional roof covering are basically the same in all buildings. The pitched roofs of large spans are of Musi (a rafter) construction, either set off a supported Thayma (ridge beam) piece in the case of Newar buildings, or off a Nus (wall plate) in the case of the lower tiers of the temples. The Newar building roofs are supported off a central ridge piece which is carried by a row of simple Baigahthas (vertical posts) that follow the line of the structural spine wall below. Over the external walls or supports on a row of pillars, as extensions of lower walls, there is an intermediate support for the Musis (rafters). The outer support is usually from a further Garbha Nus (wall plate) that is supported on Tona si (inclined wooden struts) which, in the more prestigious buildings and in nearly all religious buildings, is carved with representations of various divinities. The Musis (rafters) and Thayma (ceilings beams) are set very close together, the distance apart often equaling the width of the timbers. Over the central wall or over the ridge piece they are set tightly together and run alternately to the front and rear walls. All the joints employed are complex interlocking scarf joints and the components making up the roof structure are kept in place with Chukus (wooden pegs). Dhalins and Musis (rafters) are always laid flat over the supports, contradicting the principle that the strength of the timber section lies in its depth rather than its width (Figure 9).

However, the safety factor in all these traditional timber structures is in excess of that which is necessary. In these traditional structures, it is not normal to find even the crudest form of truss and only in the larger and probably later buildings is any further intermediary supports to be found. Over the main structure is laid either Sipu (boarding) or a Kolapu (tight mesh) of split battens with a rough upper surface to act as a key to the mud bed for the tiling. The mud or clay should be free of any vegetative growth and it should traditionally be dug from below a depth of 1.5m (5 feet), i.e. well below the topsoil. Tradition also dictated that the roof needed to ensure that there was no growth on it. The Polan Apa is then bedded onto the clay bed while it is moist. These tiles vary in size between 20cm and 25cm in length and of an average 10cm width. These tiles are loosely bedded on a clay base that is laid directly over the boarding of the roof. The eaves and hips are covered with Kopu Polan Aapa (vertically stacked tiles) that stay in position due to friction. The corner tiles are usually Gonga (decorative tiles), diamond shaped and measuring as much as 60cm in length. These tiles are nailed into the Musi (hip rafter) and often act as the "Book-end" to the vertically stacked tiles.

V. CONCLUSION

This research work was carried out to find out the construction technologies of the traditional Newar residential dwellings constructed of brick masonry with mud mortar and timber elements located in the historical city of Bhaktapur. This research made case studies of the dwellings constructed between the periods from 17th century to 20th century and analyzed them in a time sequence. The research found out the various technical details and techniques of the traditional buildings and the changes that occurred over time.

The Newar dwellings are easy to construct, as all the construction materials like aata (brick), aapa (brick), cha (mud), si (timber) or the product of cha (mud) are easily available within the surrounding areas. These materials have emotional attachment and provide comfort.

The technology innovations developed by the Newars are scientific and logical. The building technologies are not rigid in structure, i.e. the building construction elements like dhalin (joist), nila beam), than (post), musi (rafter), kolapu (wooden pieces), aanga (wall), thayma (ridge beam) and other can be replaced if damaged or decayed. The structural elements can be replaced without much difficulty.

The traditional buildings are well assembled and show harmonized combination of the materials. The structures in the building are well fixed by means of chukus (pegs) and sa: (joints), and the means of tightening materials like tei kachi (rope of bamboo), or pu. Ata or apa (brick) used on the buildings are also flexible in nature. The single piece can be removed or replaced whenever materials are damaged or decayed. The method of dhalin phyakyagu is another technology which holds the whole weight of upper part of building. Gwaneh, an inclined timber post is provided to support the building from collapse when bulging. This gwaneh rests on ki, a long chuku which is bigger than the normal chuku used on the buildings. The upper peg is called bilay which transfers the load of the bulging part of the wall. This is only possible in the wall structures of traditional buildings.

However, the Dhalins (timber joints) used in the buildings are found to be similar though the time period of construction is different. The different types of Dhalins (timber joints) are used for different parts of the building for the specific location and particular members. Also the brick layout joint, though it is a composite massive structure, is well compiled and well bonded with mud mortar.

This research, in addition, has brought forth a considerable extent of terminologies used in the building construction, which are not found in the existing literature. This is important because each terminology is a meaningful invention of our past tradition on building construction technology.

ACKNOWLEDGEMENT

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Reflecting the Scenario of Earthquake (2015) Affected Communities in Historic Cities of Kathmandu Valley; Hassles or Delays?

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Abstract

Along with the establishment of Nepal Reconstruction Authority (NRA) vigorous discussions in bringing attention of communities as major responsibility in heritage conservation had been done in relation to earthquake affected cultural heritage areas in 2015. Likewise, numbers of reconstruction projects had also been forwarded and are been undertaken at different levels of implementation by respective authorities. In a figurative interpretation, NRA is at the verge of completion of reconstruction works in substantial numbers. However, the process of reconstruction still remained ambiguous to the communities of major cultural heritage sites plundering to dilemmas in implementation, of which many are still in disputes. Apart from the monument reconstruction in these areas, reconstruction works of private heritages have plunged into a prime concern on economic development through tourism promos unlikely to keeping cultural heritage essence, while the latter seems awful in fulfilling their basic demands of livelihood. This paper assumes either of these deeds is rampant on the long run of heritage conservation major goals.

Thus, it considers major 3 areas concentric to Kathmandu valley heritage sites i.e. Bungamati, Sankhu and Panga that are in the process of reconstruction and identify probable consequences brought over by ongoing enigmas among the communities and authorities in due course of reconstruction. It also seeks to assess them through the prism of authenticity criteria and sustainability measures of heritage assets based on community participation in reconstruction process. Ultimately, it highlights the necessity of instant and rapid reconstruction as well as conservation measures in Kathmandu valley by identifying the real owners, authorities and beneficiaries responsible for keeping intact the heritage resources.

Keywords : Reconstruction; Cultural heritage; Local Community; Authenticity and sustainability

I. Introduction

All 52 traditional settlements of Kathmandu valley are culturally rich and interwoven with Newar lifestyle, of which most of the peripheral historic settlements are overshadowed from policies of prime heritage discourse and development. Smaller in sizes, these settlements are equivalent to other principal Newar towns of the valley in terms of culture and heritage resources. A blindfold towards heritage sensitivity is seen not only into peripheral historic settlements but entirely over Nepal and predominantly in Kathmandu valley. It is evident in case of Sorhakhutte Pati relocation (Joshi, 2017) and in road widening amidst Sunakothi historic settlement (Waise, 2017).

Sympathetically, the 2015 earthquake greatly ravaged the cultural heritage sector along the country including main historic areas in Kathmandu valley. The impact seems severe into not only the monuments, but also into private buildings and other amenities. In the broader context of Nepal Earthquake, 498,852 houses have been collapsed and 256,697 houses were estimated to be partly damaged in the extent of 31 affected districts claiming approximately 9000 lives and 22000 injuries (GoN, 2015). According to the Department of Archaeology, of 691 historic buildings, 131 were completely destroyed and the remaining 561 were damaged from the 16 affected districts of the country (Taylor, 2015). The government report states the total of 1733 casualties and 13,303 injured people in Kathmandu valley alone. Only in the valley, around 73000 buildings collapsed and 67000 buildings were partially damaged. Looking at these figures of rampancy, it can easily be assumed that, to reconstruct and rebuild the losses is not just complex but also urges for instant and meticulous planning mechanism in the post-disaster programs of national policies.

A. Study Methodology

This study is based on critical literature review, interviews and physical reconnaissance survey on major 3 settlements lying in the periphery of Kathmandu valley namely; Bungamati, Sankhu and Panga supported with opinions from key informants. The key informants for this study comprise the general community members, professionals involved in reconstruction, volunteers, expertise and representatives from local authorities within these settlements. The collected information is revisited with the prism of authenticity criteria and sustainability measures to signify community involvement in the reconstruction process of heritage settlements.

B. Review of Literature

What is a heritage?

Heritage at the very first is just the physical entity and now it has become the entangled relationships of social, cultural, economic activities reflected into the built environment and landscapes in its broader context. It can be understood in two dimensions; intrinsic values like sentiments, collective memory, etc. and instrumental values like socio-economic importance (Dumcke et.al. 2013). It is where people anchor to their roots, build self-esteem and restore dignity. Therefore, identity matters to all vibrant cities and its people. However, in "the past is a foreign country", Lowenthal (1985) discusses the nostalgia for lost unity, harmony and authenticity as a part of historic cities. He further argues that the pace of change and development tends to attenuate the legacy that is integral to identity and well-being. In addition, Kawan (2013) argues for the concept of authenticity, which emerged at the time when conservation was thought no greater than to an extent of a monument or heritage area. Along with the broadening of heritage notion, the assessment of authenticity also grew complicated; from physical parameters to the spirit of place and relation to the values that community epoch to their place (UNESCO, 1978: 2005).

The cross-cutting nature of heritage not only affects the cultural policy but also various sectors like planning, agriculture, sustainability, etc. creating a difficult situation for any government to deal with (Dumcke et.al., 2013). Moreover, the experts from EUROMED (2011) argue that cultural heritage is most often overlooked into the national policy unless its influence in social, economic, local and international domain is made clear unlikely to its essence as engine for economic growth. So, the community involvement significantly plays role for over-lasting results in the long run as the conservation and reconstruction works in historic areas have high job potential and requires highly skilled and potentially rare skills.

"A million dollars spent on new construction generates jobs but 1 million dollars spent on rehabilitating a historic building generates 40 jobs." (quoted from EUROMED, 2011)

C. Impact of 2015 Earthquake in Study areas

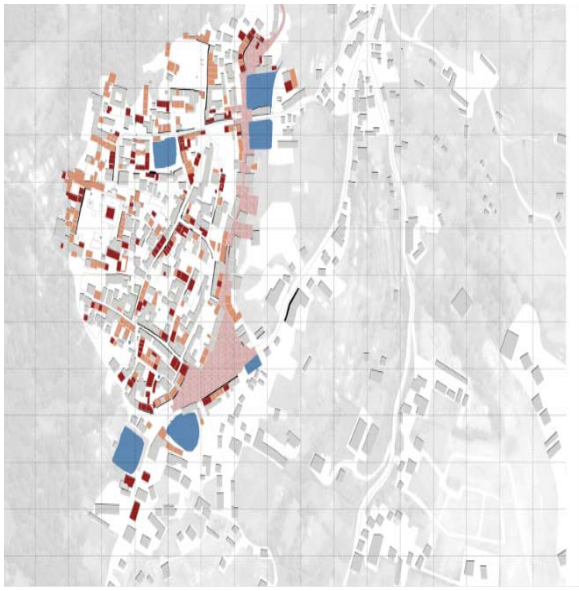

Figure 1: Damage Assessment Map of Bungamati (Source: KU Leuven, 2015)

The first settlement, Bungamati lies in Lalitpur metropolitan city around 10 km on the southern side of the Kathmandu valley. It is culturally very rich and probably one of the potential world heritage site regardless of the mega-earthquake 2015. Out of 1351 houses documented, 851 houses were completely

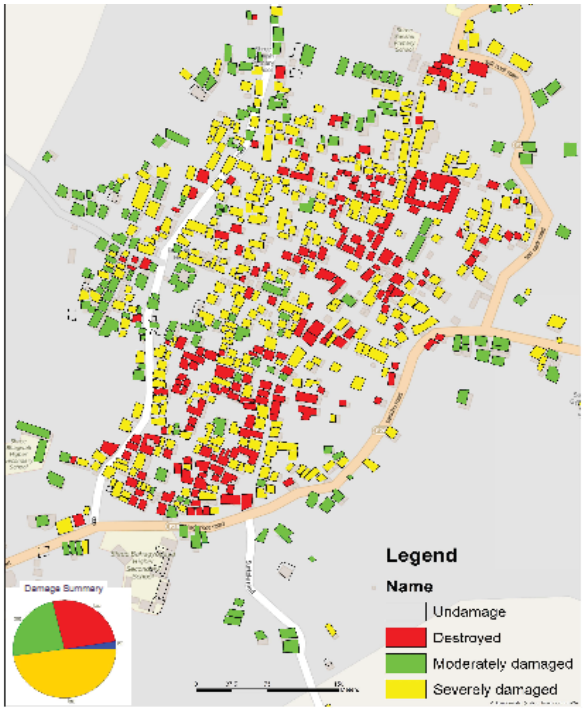

Figure 2: Damage Assessment Map, Sankhu (ICIMOD, 2015)

Figure 3: Damage assessment map, Panga (Source Author, 2015)

destroyed, including the Rato-Machchhendranath temple in Bungamati (Shrestha, 2016). The second settlement, Sankhu lies in Sankharapur municipality on the North-east side of the Kathmandu valley and probably the most attention drawn settlement after the earthquake. The municipality states that; out of 1416 houses, 1051 houses were completely damaged and 365 were partially damaged. Similarly, Panga lies 7 km far from Kathmandu to the south-west direction of Kathmandu valley in Kirtipur Municipality. This should be the least exposed settlement from the beginning of recovery phase after the earthquake 2015. Out of 788 houses surveyed, 342 houses were destroyed, 220 were damaged and remaining 226 had no significant damages (Kawan, 2015). The figure urges instant rehabilitation and reconstruction of damaged built environment in all the study areas. But the condition is contradictory for the community with compulsive displacement from their inhabitation. At the initial years after earthquake, most of the affected families sheltered in temporary structures which have shortly overturned into the remnants and their own buildings have now been converted into RCC buildings. Despite of the casualties and property loss recorded in these settlements, infrastructure development and cultural revival are yet other issues that remained undetermined.

II. RECONSTRUCTION ATTITUDES AND APPROACHES

NRA is established with extraordinary jurisdiction to consider various development sectors in earthquake affected areas under the *Reconstruction of earthquake affected infrastructures act, 2015* (NRA, 2016).

Initially this national body at its establishment had to suffer because of political conspiracies and squabble among the leading parties of Nepal (ibid). It has now been able to configure a significant progress on reconstruction and rebuilding stature with more than 80% beneficiaries registered for agreement (NRA, 2019). Following attitudes among the community and authorities including expressions from various key informants are noticed during the visit.

A. 2.5 Million Mindset and financial support

Along with the establishment of NRA, with denunciation, a public affirmation of 2.5 million rupees and 1.5 million rupees as a soft-loan was assured to the earthquake affected families in Kathmandu valley and remote areas respectively (Bhattarai, 2018). The decision proved to be blunt since it came with no consultation with concerned authorities like NRB and Ministry of Finance regarding the economic crisis caused during the time of national trauma. Around 1300 people somehow managed to get this soft loan for reconstructing their houses that ended soon blaming the inefficiency of the incentives and leaving anonymity in the selection procedures (Giri, 2018). Another denunciation was also made for providing financial incentives of Rs. 200,000 later increased to Rs. 300,000 for reconstruction works to the affected families in condition to adhere with standards proposed by DUDBC for earthquake safety.

People have started rebuilding their homes in these settlements in whatever capacity they have. The reason behind this hassle is not to risk their lives but to secure the family from additional natural adversities like rain and wind in the years to come. The key-informants from these settlements mentioned that the rebuilding initiatives would have already been started from the community level as such, if 2.5 million loan schemes had not flourished. The financial support dissipated in three phases to the beneficiaries is yet in its initial levels to more than half of the community nevertheless NRA has argued for significant progress of this support initiative.

B. Inundating Approaches of Reconstruction

Along with International Donors' Conference, the government of Nepal had pleaded for support in various ways to the international community. As a result, different NGOs and INGOs got involved into these areas for recovery, rehabilitation and rebuilding of heritage structures. Despite controversies of indulging their vested interest by the support organizations in the beginning, some few like UN-Habitat, UNESCO, NSET, OXFAM, Lumanti, USAID, Action-Aid, etc. are still into action in uplifting various sectors of the study areas. UN-habitat along with Lumanti, CIUD and Sabah Nepal are involved in Bungamati for institutional capacity building and inclusive neighbourhood approach. While in Sankhu, a collaborative community-based approach was adopted. The first two have formulated their respective Reconstruction Committee with the inclusion of local political leaders, community representatives into the work force namely BARDeC and Sankhu Reconstruction Committee (SRC). In the latter, the community revived the already existing community disaster management committees (CDMC) to deal with post-earthquake reconstruction.

Coordination other than competition is vital, in reconstruction and disaster mitigation activities, to build back better. The lack of coordination among various agencies and institutions ultimately defies their role of being responsible for developing and decision making in their respective precincts. All of these settlements have a complaint of duplication and overlapping projects to imply by organizations in the field regarding post earthquake activities. Most importantly, during the time of involvement, these projects basically concerned in revitalization of open spaces, infrastructure development and capacity building passes overhead of the community.

C. Heritage: a commodity?

Public monuments are the core heritage resources in all of the settlements in Kathmandu valley but the present state is about reconstruction of private residential buildings, which are yet not considered into heritage discourse. Nevertheless, majority of the community members were in favour of the RCC buildings, while very few sought for traditional building technology in all three study areas. In another perspective, their urge to this intervention is safety, which they interpreted from the neighbouring standing concrete buildings. According to the key informants, only few if not negligible community members showed

interest in rebuilding their houses in traditional way provided, they will have incentives while rest witnessed the demise of old buildings.

The present ongoing reconstruction projects in the study areas demonstrate many opportunities to invest, innovate and explore in the field of heritage conservation and tourism sectors. The trend is to seek instrumental values and enhance the quality of built environment. Unfortunately, the post-disaster context is deterrent with every single individual, organization and institution turning into an opportunist.

D. Volunteerism and Reconstruction

It has been clear that instantly after the earthquake, volunteerism was highly appreciated for their unconditional effort in rescues, recoveries, and support campaigns in almost of the affected areas. These three settlements had numbers of organizations helping in the early recovery phase but only few remain active in taking their campaigns for making longer impact in the reconstruction. Volunteerism, which was flourished rapidly, is now a matter to sustain for many of the volunteers who have worked for the rebuilding projects. The rebuilding in Sankhu and Panga has almost come to a halt because of the cease of volunteering activities. While in Bungamati, the rebuilding process is still under consideration, however, volunteers there too are feeling tired of volunteerism. Volunteers generally are among the local community members and many of them are interested because of complying field of interests and self-esteem. They should be mobilized properly through effective communication and guidance. Some of the volunteers in Bungamati and Sankhu argue that; they are capable of handling things in their local community as they know much about their place, culture and identity.

III. Reconstruction: Authenticity and Cultural Identity

The study areas are definite Newar settlements based on the agrarian lifestyles and culture. Their identity lies among the cultural heritage attributes associated into their urban morphological characteristics. Though these settlements have a common base of cultural activities, their identity is distinct in terms of their urban patterns, city image and respective symbolic meaning along with socio-cultural activities of the people residing there.

Bungamati is an ancient 7th century 'Newari' settlement enriched by the natural resources, compact built form and with Hindu and Buddhist socio-cultural values. It is believed that 100 people from each principal cities of the Kathmandu Valley - Kathmandu, Lalitpur and Bhaktapur - were brought into this area at the time of King Narendradeva and housed them around 'Machendranath' [Bunga-dyo] in three different directions with construction of three artificial ponds corresponding to each community (Shrestha et.al., 2008).

Sankhu is believed to be established by the Lichhchhavis in the 4th century A.D. and was historically important trade port on the way to Tibet. Sankhu is termed as Sankharapur because of its conch shaped urban layout of the settlement. The Vajrayogini temple to the north of Sankhu has its prominent influence on the land surrounding the settlement since the land is devoted to the maintenance of the temple (SRC, 2015).

Panga is believed to be established by Ratna Malla in 621 N.S. in order to secure from the frequent looting by the northerners in Chobhar Adinath temple. The literal meaning of Pa: (Guarding) and Gan: (village) comes from the reason for establishing this town. According to the inscription mentioned in Gopal Vanshawali (CDMC-9, 2015), this settlement was initiated by residing 300 houses in the year 629 N.S. households.

A. Lacking entitlement and ownership

Many of the community members in these settlements lack the entitlement, i.e Lalpurja of their respective land and houses. So, getting reconstruction facilities to the community members is a long way unless they get the entitlement. In Panga and Bungamati, the local agencies and reconstruction committees have initiated and applied for the formal procedures. Even though the government has argued to simplify the process of issuing entitlement for community members from earthquake-affected settlements, the people have not felt satisfactory outcomes due to series of hectic formalities that they faced in government offices. Thus, they are yet forbidden from the reconstruction felicitations. Besides, the multiple ownership of an ancestral property is making the process further complicated and caused delay in reconstruction.

According to the municipality authorities, one of the major problems at the moment in reconstruction is entitlement and ownership issues.

B. A state of planning crisis

The communities in these settlements have experienced the difficulties in adopting the bylaws and guidelines set for heritage settlements after the earthquake. In case of building heights and traditional construction technology, they felt un-applicable and non-contextual to community's modern space aspiration. Therefore, the communities have disregarded the implication of heritage settlement plans and policies compromising the antiquity of historic towns at the cost of their present lifestyle demands.

As the implication of the planning guidelines and building bylaws got harsh into these settlements, the built environment is eroding continuously. The traditional urban spaces and surroundings are affected with stinging skylines, non-linear building edges, non-contextual building materials and technology. More importantly, negligible records of issuing the building completion certificates can be seen in all of the respective municipalities. Also, a significant number of buildings are seen constructed without following the regulations to get rid of complexities regarding entitlement, ownership and persuasive need of housing.

C. Parasitic attitude towards rebuilding

Just like the monuments reconstruction, majority of the responses from communities, unable to rebuild their houses in the study areas, are economically deprived and do expect some external support to construct their houses. When asked about reconstruction, they urged for a complete concrete house rather than a shelter built in their own capacity. The local resources like the masons and carpenters in Panga and the technical man-power in Sankhu and Bungamati explained not being consulted in the reconstruction activities. Some of them even recall the earlier reconstruction works in 1934 and the self-recovery mechanism then.

IV. Reconstruction and sustainability

A. Tourism: a turmoil solution

Tourism is considered as an only economic source in these settlements except for CDMC in Panga. Newar settlements are meant for expressing cultural edifices and tourism is unavoidable into them. The community representatives in Panga argued cultural entity as their poise and then tourism as their economic activity. While the other two settlements are enriching their building stock with apparent tourism curios into their brick faces. Along with space congestion, additional tourism space is felt a burden by the community members in the settlements where tourism development plan is proposed. The community members also did state that outer beautification will not be significant to drive tourism into their respective settlement but it is the intangible part, that can at least drive the domestic tourism.

B. "Bun: Chalan:, Chhen: Dhalan" paradox

In Newari language - "Bun: Chalan:" literally means *"agricultural land gone"* and *"Chhen: Dhalan"* means *"house concretised"*. Most profoundly, ongoing constructions into these settlements after the earthquake are with remittances and else selling the ancestral agricultural land from the vicinity. Agriculture being the prime measure of sustainability for these settlements according to NUDS 2015, agricultural land is under a threat of rapid conversion. This paradox is seen desperate among the communities in Panga where the urbanization rate had exceeded even before the earthquake, while other two abide the need for agriculture with gradual conversion.

C. Inadequacy of local resources

Experts and representatives of the local authorities and agencies argued for the reason of RCC construction of entire heritage settlement is the inadequacy of local resources like traditional construction materials, technology and craftsmen. Whatever is there is being used up in the reconstruction of monuments only. It is mentioned that it has become very hard to identify the sources of construction materials to be used in traditional construction techniques and so the price for materials have already gone high esp. timber, mud and bricks. It is not only the scarcity of traditional construction materials but the workers too, who state their familiarity into concrete technology as it is a source of easy earning.

V. Conclusion

Very clearly a generalized approach towards reconstruction is predominant in the bureaucracy at present. In one way, the general community members in these study areas are unaware about the cultural values and local identity of their settlement and in the other the authorities from national to local levels have given less intension in conserving the local heritage while restoration. The present scenario of less priority to the private heritage buildings still prevails since these are the buildings, where the living traditions evoke. Intentions of heritage professionals and perceptions of public are different in cities. What public perceives heritage is different from what the heritage professionals do. Conservation works seem to be just limited in academia whereas in the present scenario it seems to be difficult in practice. Motivation is felt less in the reconstruction works, especially the volunteers and local resources that had been significant role-players from the initial phases of recovery till now. Incentives for heritage building owners, heritage conservation works should highly be prioritized. The present state is the cumulative effect of being indifferent towards the heritage resources in Kathmandu valley. Had there been clear policies and guidelines for heritage conservation, we would have different strategies to deal with. First, we ignored heritage buildings, second, we started forgetting our identities, third we don't know how to rebuild our heritages and now we lack resources during the time of reconstruction.

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